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CHALLENGES OF SUSTAINABLE WASTEWATER MANAGEMENT IN PAKISTAN: A CASE STUDY OF FAISALABAD

Dissertation

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LIST OF ACRONYMS AND ABBREVIATIONS

AARI	Ayub Agricultural Research Institute
APTMA	All Pakistan Textile Mills Association
BOD	Biochemical oxygen demand
COD	Chemical Oxygen Demand
DCO	District Coordination Officer
EPA, Punjab	Environmental Protection Agency, Punjab
EPD	Environment Protection Department (Punjab)
FAO	Food and Agriculture Organization
FCCI	Faisalabad Chamber of Commerce and Industry
FDA	Faisalabad Development Authority
FIEDMC	Faisalabad Industrial Estate Development and Management Company
GoP	Government of Punjab
JICA	Japan International Cooperation Agency
IDD	Irrigation and Drainage Department (Punjab)
IWMI	International Water Management Institute
MoCC	Federal Ministry of Climate Change
NCS	National Conservation Strategy
NEQS	National Environmental Quality Standards
MoE	Ministry of Environment
MPA	Member of Provincial Assembly
PND	Planning and Development Department (Punjab)
Pak-EPA	Federal Environmental Protection Agency
PCRWR	Pakistan Council of Research in Water Resources
PCSIR	Pakistan Council of Scientific and Industrial Research
PHED	Public Health Engineering Department

PIDA	Punjab Irrigation and Drainage Authority
RSC	Residual Sodium Carbonate
SS	Suspended Solids
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
UAF	University of Agriculture, Faisalabad
US EPA	United Sate, Environmental Protection Agency
USAID	United States Agency for International Development
WAPDA	Water and Power Development Authority
WASA	Water and Sanitation Agency
WB	World Bank
WHO	World Health Organization
WSP	Waste Stabilization Pond System

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EXECUTIVE SUMMARY

For several decades, achieving global development goals that reflect community needs has been the focus of development and conservation approaches; currently, special attention has been paid to water- and sanitation-related goals. Sustainable wastewater management, a target under the Sustainable Development Goals (SDG 6, 6.3) has fostered a debate on its complex role in sustainable development. Exploring the gaps between the real situation and the proposed one regarding sustainable wastewater management (zero pollution) would guide the developing world towards the right steps for improvements in the water and sanitation sector. Gaps exist in the literature about sustainable wastewater management, particularly with reference to developing countries.

Against this background, the aim of this study was to investigate the challenges in sustainable wastewater management in Pakistan, more specifically in Faisalabad. These challenges, which require the attention of policymakers in Pakistan, include the following: untreated dumping of wastewater (domestic or industrial); overexploitation of groundwater; lacking clean drinking water and sanitation facilities; a weak legal framework to prosecute polluters; governance challenges in administrative agencies; and public health concerns. The study was conducted in urban and peri-urban areas of Faisalabad, Pakistan. Faisalabad is located in a semiarid region and is facing water scarcity issues. Industrial development, particularly in the textile sector, and rapid urbanization within this region, are posing threats to groundwater sources (due to intensive pumping), surface water sources (due to untreated dumping of wastewater), human health, and the environment (due to untreated reuse of wastewater). While these problems are widely recognized, there are major knowledge gaps on how to address them so as to ensure a sustainable wastewater management.

The case study examines four main aspects of wastewater management: the interaction of wastewater with human health and the environment, existing formal rules for wastewater management, the institutional framework that governs wastewater management, and future development schemes and policies for better management. The first objective of the study was to evaluate the influence of poor wastewater management on the community and natural resources (at the micro-level). For this purpose, wastewater-irrigated areas were selected. The second goal was to evaluate gaps in the legal framework of wastewater management in Faisalabad. Identifying the challenges in urban wastewater management in Faisalabad was the third objective. The last objective was to review the current and potential future policy interventions within the context of the study area.

Applying a case study design, this in-depth study explored the role of all stakeholders (administrative departments, individuals, industrialist, wastewater irrigators, etc.) linked with wastewater management. A multiphase data collection approach using mixed methods was used for the in-depth investigation. A framework was developed, which enabled the researcher to evaluate the current state of wastewater management and to identify the gaps to achieve sustainable wastewater management. The first phase of data collection comprised a household survey and a chemical analysis of soil, irrigation water and groundwater across three categories of different sources of irrigation water: industrial wastewater, domestic wastewater, and canal water. Data was collected in the peri-urban areas of Faisalabad. The household survey data were analyzed using descriptive analysis, statistical comparative analysis, and econometric analysis techniques. For the review of the current legal framework, desk research was carried out with the aim to critically analyze regulations, based on secondary sources. The second phase of data

collection incorporated qualitative data collection tools, specifically in-depth interviews, focus group discussions, and a participatory mapping tool called net-mapping. These data collected from diverse stakeholders were evaluated using a content analysis approach to explore and identify the challenges in wastewater management. The institutional analysis was based on a conceptual framework, which was derived from the Institutional Analysis and Development (IAD) Framework. In addition to institutional analysis, historical developments of institutions (historical institutionalism approach) and their governance failures (discourse analysis of newspaper articles) were also analyzed. Finally, on this basis, possible policies to improve the current situation of wastewater management in Faisalabad were derived.

The review of secondary data of wastewater management in Faisalabad showed that only 20 percent of the wastewater generated in Faisalabad was treated. A single treatment plant treated only domestic wastewater. The study showed that mostfarmers preferred to apply untreated domestic wastewater because the treated wastewater was more saline and had less organic content as compared to untreated domestic wastewater. During the last decade, without any drastic change in demographics and industries in Faisalabad, the volume of generated wastewater doubled. Most industry plants dilute their effluents by adding saline groundwater to their effluents before dumping it to drains. Evidence showed that wastewater reuse and dumping of untreated wastewater in Faisalabad increased. The evidence indicates that, despite all efforts to resolve the problem,wastewater management (generation, collection, treatment, and reuse) in Faisalabad has deteriorated in recent years.

The results from the household survey across three categories of water (industrial wastewater, domestic wastewater, and canal water) in Faisalabad confirmed the problematic use of untreated wastewater for irrigation and its impact on human health and the environment. Irrigation with domestic wastewater was associated with a higher income and therefore contributed to food security, which underlines the farmers preference for this type of water. On the contrary, industrial wastewater negatively affected farm households. Thus, the results showed that there is a demand to reuse wastewater in agriculture, which needs proper management to reduce the risks involved. It was concluded that policies required for each site will be different depending on the quality of the wastewater and local conditions of the sites. No single model is fit for all conditions.

The review of the current legislation led to the identification of several gaps, which favored violators or rules and polluters. Although sustainable wastewater management had been addressed through scattered clauses in various pieces of formal legislation, rules were not comprehensively legislated or enforced. The study showed that the difficulty in timely testing disposed wastewater and the lengthy legal process made proper law enforcement practically impossible. Therefore, violators used these implementation gaps to avoid fines and punishments. Local awareness and presence of a local pressure groups at the time of legislation could have reduced gaps in legislation and in law enforcement.

Using governance and evaluative criteria (derived from the IAD framework), social and governance challenges regarding wastewater management in Faisalabad were comprehensively assessed. Furthermore, the historical institutionalism approach helped to identify the in-built challenges of administrative institutions. The most important challenge identified in the study was the low capacity of implementing agencies due to human, technical, and financial limitations. Moreover, the urban planning of Faisalabad completely failed during the previous decades, which resulted in scattered industrial clusters throughout the residential areas. Such poor planning restricted proper management, treatment, and reuse of effluents. In addition, the institutional analysis showed that the public organizations and agencies had weak administrative linkages among each other. The study also indicated that a problematic institutional environment, including nepotism and interference in office affairs, influenced how the public organizations operated.

It was concluded that a comprehensive strategy is needed for improved wastewater management, which needs to address simultaneously issues of institutional and technical feasibility, economics, social acceptability and environmental sustainability. Future studies could further explore such comprehensive strategies within the context of developing countries.

ZUSAMMENFASSUNG

Seit mehreren Jahrzehnten steht die Erreichung globaler Entwicklungsziele, die den Bedürfnissen der Gemeinschaft entsprechen, im Mittelpunkt der Entwicklungs- und Erhaltungsansätze; derzeit wird den wasser- und sanitärbezogenen Zielen besondere Aufmerksamkeit geschenkt. Die nachhaltige Abwasserentsorgung, ein Ziel im Rahmen der Ziele für nachhaltige Entwicklung (SDG 6, 6.3), hat eine Debatte über ihre komplexe Rolle bei der nachhaltigen Entwicklung angeregt. Die Untersuchung der Lücken zwischen der tatsächlichen und der vorgeschlagenen Situation in Bezug auf eine nachhaltige Abwasserentsorgung (Null-Verschmutzung) würde die Entwicklungsländer zu den richtigen Schritten zur Verbesserung des Wasser- und Abwassersektors führen. In der Literatur gibt es Lücken in der nachhaltigen Abwasserentsorgung, insbesondere in Bezug auf Entwicklungsländer.

Vor diesem Hintergrund war es das Ziel dieser Studie, die Herausforderungen einer nachhaltigen Abwasserentsorgung in Pakistan, insbesondere in Faisalabad, zu untersuchen. Zu diesen Herausforderungen, die die Aufmerksamkeit der politischen Entscheidungsträger in Pakistan erfordern, gehören unter anderem: unbehandelte Einleitung von Abwasser (ob in Haushalten oder in der Industrie); Übernutzung des Grundwassers; Mangel an sauberem Trinkwasser und sanitären Einrichtungen; ein schwacher Rechtsrahmen für die Verfolgung von Verursachern; Herausforderungen für die Verwaltung von Verwaltungsbehörden und Belange der öffentlichen Gesundheit. Die Studie wurde in städtischen und peripheren Gebieten von Faisalabad, Pakistan, durchgeführt. Faisalabad liegt in einer semiariden Region und ist mit Wasserknappheit konfrontiert. Die industrielle Entwicklung, insbesondere im Textilsektor, und die rasante Urbanisierung in dieser Region stellen eine Bedrohung für die Grundwasserquellen (durch intensives Pumpen), die Oberflächenwasserquellen (durch unbehandeltes Einleiten von Abwasser), die menschliche Gesundheit und die Umwelt (durch unbehandelte Wiederverwendung von Abwasser) dar. Obwohl diese Probleme allgemein anerkannt sind, gibt es große Wissenslücken, wie man sie angehen kann, um eine nachhaltige Abwasserbewirtschaftung zu gewährleisten.

Die Fallstudie untersucht vier Hauptaspekte der Abwasserentsorgung: die Wechselwirkung von Abwasser mit der menschlichen Gesundheit und der Umwelt, bestehende formelle Regeln für die Abwasserentsorgung, den institutionellen Rahmen, der die Abwasserentsorgung regelt, sowie künftige Entwicklungsprogramme und -strategien für eine bessere Bewirtschaftung. Das erste Ziel der Studie war es, den Einfluss einer schlechten Abwasserentsorgung auf die Gemeinschaft und die natürlichen Ressourcen (auf der Mikroebene) zu bewerten. Zu diesem Zweck wurden abwasserbewässerte Bereiche ausgewählt. Das zweite Ziel war die Bewertung von Lücken im rechtlichen Rahmen der Abwasserwirtschaft in Faisalabad. Die Identifizierung der Herausforderungen in der städtischen Abwasserentsorgung in Faisalabad war das dritte Ziel. Das letzte Ziel war es, die aktuellen und potenziellen zukünftigen politischen Interventionen im Rahmen des Untersuchungsgebietes zu überprüfen.

Anhand eines Fallstudienentwurfs untersuchte diese eingehende Studie die Rolle aller Beteiligten (Verwaltungsabteilungen, Einzelpersonen, Industrielle, Abwasserbewässerer usw.) im Zusammenhang mit der Abwasserwirtschaft. Für die eingehende Untersuchung wurde ein mehrstufiger Datenerfassungsansatz mit gemischten Methoden verwendet. Es wurde ein Rahmen entwickelt, der es dem Forscher ermöglicht, den aktuellen Stand der Abwasserbewirtschaftung zu bewerten und die Lücken für eine nachhaltige Abwasserbewirtschaftung zu identifizieren. Die

erste Phase der Datenerhebung umfasste eine Haushaltserhebung und eine chemische Analyse von Boden, Bewässerungswasser und Grundwasser über drei Kategorien von verschiedenen Quellen von Bewässerungswasser: Industrieabwasser, Haushaltsabwasser und Kanalwasser. Die Daten wurden in den Randgebieten von Faisalabad erhoben. Die Daten der Haushaltsumfrage wurden mit Hilfe von deskriptiver Analyse, statistisch vergleichender Analyse und ökonometrischer Analysetechnik analysiert. Für die Überprüfung des aktuellen Rechtsrahmens wurde Desk Research mit dem Ziel durchgeführt, Vorschriften auf der Grundlage von Sekundärquellen kritisch zu analysieren. Die zweite Phase der Datenerhebung beinhaltete qualitative Datenerfassungsinstrumente, insbesondere Tiefeninterviews, Fokusgruppen-Diskussionen und ein partizipatives Mapping-Tool namens Net-Mapping. Diese Daten, die von verschiedenen Interessengruppen gesammelt wurden, wurden mit Hilfe eines Inhaltsanalyseansatzes ausgewertet, um die Herausforderungen in der Abwasserwirtschaft zu erforschen und zu identifizieren. Die institutionelle Analyse basierte auf einem konzeptionellen Rahmen, der aus dem Institutional Analysis and Development (IAD) Framework abgeleitet wurde. Neben der institutionellen Analyse wurden auch historische Entwicklungen von Institutionen (historischer Institutionalismusansatz) und deren Governance-Fehler (Diskursanalyse von Zeitungsartikeln) analysiert. Schließlich wurden auf dieser Grundlage mögliche Maßnahmen zur Verbesserung der aktuellen Situation der Abwasserwirtschaft in Faisalabad abgeleitet.

Die Überprüfung der Sekundärdaten der Abwasserwirtschaft in Faisalabad ergab, dass nur 20 Prozent des in Faisalabad anfallenden Abwassers behandelt wurden. Eine einzige Kläranlage behandelte nur häusliches Abwasser. Die Studie zeigte, dass die meisten Landwirte es vorzogen, unbehandeltes häusliches Abwasser einzusetzen, da das behandelte Abwasser salzhaltiger und organischer als unbehandeltes häusliches Abwasser war. In den letzten zehn Jahren hat sich die Menge des anfallenden Abwassers ohne drastischen demographischen und industriellen Wandel in Faisalabad verdoppelt. Die meisten Industrieanlagen verdünnen ihre Abwässer, indem sie salzhaltiges Grundwasser zu ihren Abwässern hinzufügen, bevor sie es in die Kanalisation gelangen lassen. Es zeigte sich, dass die Wiederverwendung von Abwasser und die Einleitung von unbehandeltem Abwasser in Faisalabad zunahmen. Die Belege deuten darauf hin, dass sich die Abwasserbewirtschaftung (Erzeugung, Sammlung, Behandlung und Wiederverwendung) in Faisalabad trotz aller Bemühungen zur Lösung des Problems in den letzten Jahren verschlechtert hat.

Die Ergebnisse der Haushaltsumfrage über drei Wasserkategorien (Industrieabwässer, Haushaltsabwässer und Kanalwasser) in Faisalabad bestätigten die problematische Verwendung von unbehandeltem Abwasser zur Bewässerung und seine Auswirkungen auf die menschliche Gesundheit und die Umwelt. Die Bewässerung mit häuslichem Abwasser war mit einem höheren Einkommen verbunden und trug somit zur Ernährungssicherheit bei, was die Präferenz der Bauern für diese Art von Wasser unterstreicht. Im Gegenteil, Industrieabwässer belasteten die landwirtschaftlichen Haushalte. So zeigten die Ergebnisse, dass es einen Bedarf an Wiederverwendung von Abwasser in der Landwirtschaft gibt, die ein angemessenes Management benötigt, um die damit verbundenen Risiken zu reduzieren. Es wurde der Schluss gezogen, dass die für jeden Standort erforderlichen Maßnahmen je nach Qualität des Abwassers und den örtlichen Gegebenheiten der Standorte unterschiedlich sein werden. Kein einziges Modell ist für alle Bedingungen geeignet.

Die Überprüfung der aktuellen Gesetzgebung führte zur Identifizierung mehrerer Lücken, die Verletzer oder Regeln und Verursacher begünstigten. Obwohl eine nachhaltige

Abwasserentsorgung durch verstreute Klauseln in verschiedenen formalen Gesetzen angesprochen wurde, wurden die Vorschriften nicht umfassend gesetzlich geregelt oder durchgesetzt. Die Studie zeigte, dass die Schwierigkeit, das entsorgte Abwasser rechtzeitig zu testen, und das langwierige Rechtsverfahren eine ordnungsgemäße Strafverfolgung praktisch unmöglich machten. Daher nutzten Verletzer diese Umsetzungslücken, um Bußgelder und Strafen zu vermeiden. Das lokale Bewusstsein und die Präsenz einer lokalen Interessengruppe zum Zeitpunkt der Gesetzgebung hätten Lücken in der Gesetzgebung und in der Strafverfolgung schließen können.

Anhand von Governance- und Bewertungskriterien (abgeleitet aus dem IAD-Rahmen) wurden soziale und Governance-Herausforderungen in Bezug auf die Abwasserbewirtschaftung in Faisalabad umfassend bewertet. Darüber hinaus trug der Ansatz des historischen Institutionalismus dazu bei, die eingebauten Herausforderungen der Verwaltungseinrichtungen zu identifizieren. Die wichtigste Herausforderung, die in der Studie identifiziert wurde, war die geringe Kapazität der Durchführungseinrichtungen aufgrund menschlicher, technischer und finanzieller Einschränkungen. Darüber hinaus scheiterte die Stadtplanung von Faisalabad in den vergangenen Jahrzehnten völlig, was zu verstreuten Industrieclustern in den Wohngebieten führte. Eine solche schlechte Planung schränkte die ordnungsgemäße Verwaltung, Behandlung und Wiederverwendung von Abwässern ein. Darüber hinaus zeigte die institutionelle Analyse, dass die öffentlichen Organisationen und Agenturen schwache administrative Verflechtungen untereinander aufweisen. Die Studie zeigte auch, dass ein problematisches institutionelles Umfeld, einschließlich Vetternwirtschaft und Einmischung in Büroangelegenheiten, die Funktionsweise der öffentlichen Organisationen beeinflusst.

Es wurde festgestellt, dass eine umfassende Strategie für eine verbesserte Abwasserentsorgung erforderlich ist, die gleichzeitig Fragen der institutionellen und technischen Durchführbarkeit, der Ökonomie, der sozialen Akzeptanz und der ökologischen Nachhaltigkeit angehen muss. Zukünftige Studien könnten solche umfassenden Strategien im Kontext der Entwicklungsländer weiter untersuchen.

1 INTRODUCTION

1.1 Background

While the industrial revolution and the increase in urbanization lead to a better quality of life. But at the same time,we are living in a situation that has detrimental impacts on the environment and ethical standards as is the case of Pakistan.Globally, industrialization and urbanization, the two main structural changes to societies during the last century are directing us towards the need for sustainable development as a policy goal (Langeweg, Hilderink, & Maas, 2000). More than half of the world population (54%) has already settled in urban areas and a rise to around 60% by 2030 is predicted (United Nations, Department of Economic and Social Affairs, Population Division, 2015). Such rapid urbanization growth trends are influenced by industrialization in urban areas. Availability of employment opportunities and better life facilities (education and basic health) has triggered urban migration. As a result, big cities (populations over 2 million) came to existence require appropriate management that accounts for their size. However, the situation became challenging when urbanization and industrialization could not be managed. Consequently, sustainable development has become the agenda of future policies. Sustainable development considers economic, environmental, and social-cultural developmental aspects. In this era, there is a big debate on whether natural resources should be exploited just to achieve economic benefit. Wastewater management is considered a core issue under the umbrella of sustainable development.

Metcalf and Eddy (2003) defined the term "wastewater" as *"*the liquid portion of waste and may be defined as a combination of the liquid or water-carried wastes, removed from residencies, institutions, together with such groundwater, surface water, and storm-water as may be present*"* (p.1). Wastewater or 'wasted water' is the residual effluents released after any activity or production process. It is evident that much of the water supplied is released as wastewater. Such activities and processing alter the biological and physio-chemical properties of water. The quality of wastewater depends on the point of source. Domestic discharges mainly comprise human body wastes (urine, feces), detergents, cleaners, food residues, microorganisms (pathogens, bacteria, viruses), and household chemicals. Unsafe (untreated) disposal of domestic effluents can cause the spread of water-borne diseases (epidemics) and environmental degradation (wastewater irrigation) (Ensink, 2006; Randhawa, Ahmad, Anjum, Asghar, & Sajid, 2014; Weinhold, 2002). Industrial effluents, which largely contain the residues of toxic chemicals, are used during the production process. Elements of these chemicals are extremely detrimental to human health and ecology (Amoatey & Bani, 2011; Sponza, 2000). For instance, effluents from leather and tanning industries contain a high concentration level of chromium (chromium salts are used during the tanning process). Hexavalent chromium, a well-known carcinogen, is a health risk when the residual left after processing is released in the environment (Kanpur, India and Hazaribagh Bangladesh) (Blacksmith Institute and Green Cross, 2013).

Wastewater management is one of the critical problems intertwined with industrialization and urbanization, and it is set as a target to achieve global sustainable development (Brogan, Müller, Erlmann, & Sorokovskyi, 2016; Corcoran et al., 2010). Andersson et al. (2016) explained the terms sustainable sanitation and wastewater management as follows: "Sustainable sanitation and wastewater management systems are those that minimize depletion of the resource base, protect and promote human health, minimize environmental degradation, are technically and institutionally appropriate, socially acceptable and economically viable in the long term" (p.11). Accordingly, one can conclude that sustainable wastewater management means less pollution and a more efficient system of service provision.

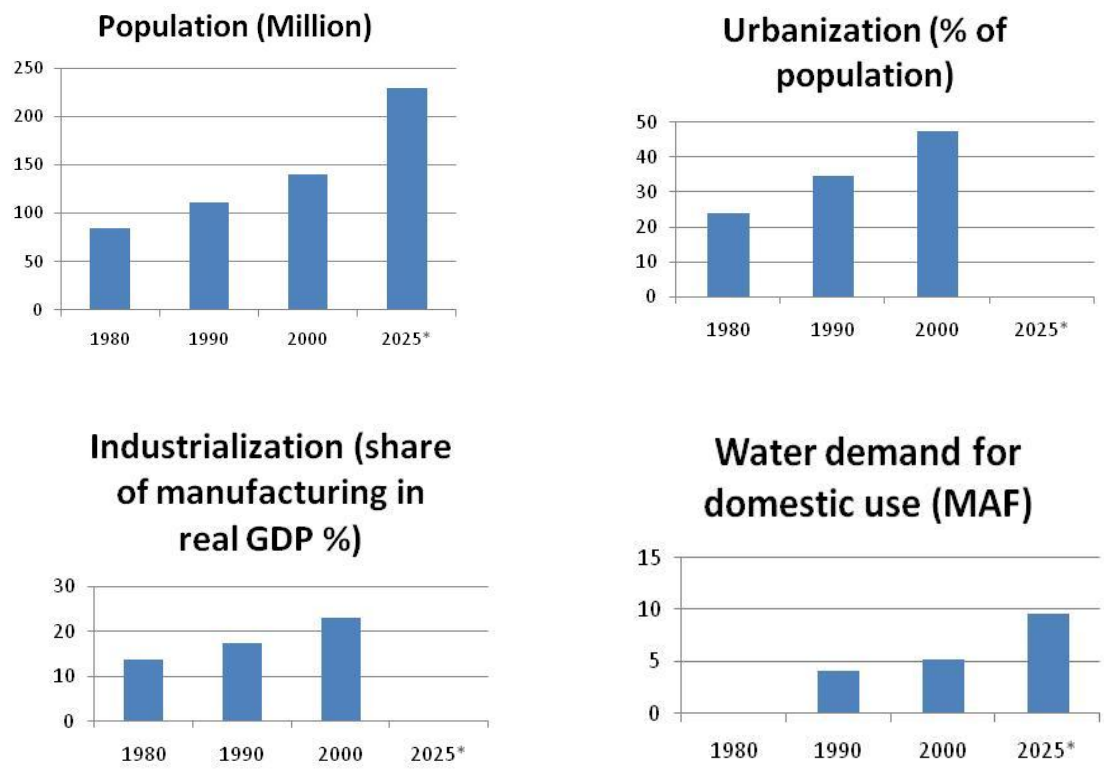
In other words, an efficient system of governance is required to achieve sustainable development (Ahmed & Basit, 2012). In most Middle Eastern countries that are facing water scarcity, integrated water management (wastewater treatment or desalinization) has been adopted to fulfill their water demands. It was well explored the importance of wastewater, asserting that wastewater supply is continuously increasing because of population growth and enhanced awareness of environmental quality (Harvey, 1997). In fact, there is a need to reconsider wastewater as a resource. UN highlighted wastewater as 'an untapped resource.' Emphasis was given to utilize this resource as soon as possible to have a positive outlook (World Water Assessment Programme[WWAP], 2017).

Most newly emerging cities during the last century are confronting innumerable complications due to the negative externalities of industrialization. Under this scenario, a real issue raised is the direct dumping of domestic and industrial effluents into drains or the environment without any treatment (Haruvy, Bachmat, Shalhevet, & Yaron, 2000; Singh, 2001). Such dumping causes problems for public health, agriculture, town planning, and environmental conservation sectors. A lack of proper planning and managing strategies has automatically made the issue more severe.

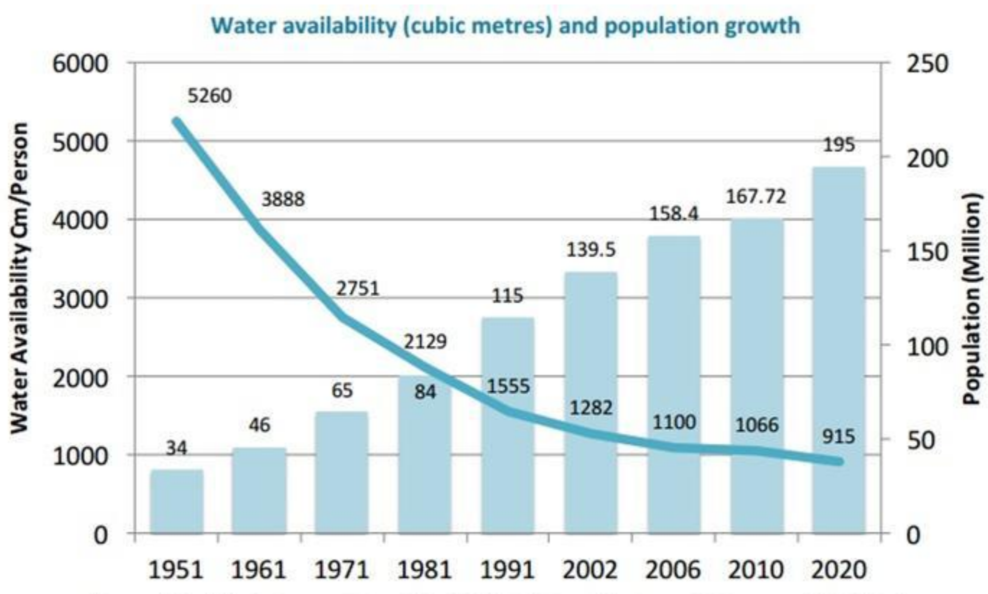
Internationally, this issue has been addressed critically through different case studies (reviewed in Chapter 2). Indeed, wastewater is somewhat debated as to consider it either a resource or an environmental issue. The circumstances in Pakistan are similar to other developing countries.

1.2 The case of Pakistan

Pakistan is a countrythat is facing economic scarcity as well as the physical scarcity of water. The only green area in Pakistan is one with irrigated agriculture from rivers (attached figure in Appendix A1). With the population growth, the stress on limited available freshwater resources increases day by day, and the situation is getting worse (Khoso, Wagan, Tunio, & Ansari, 2015).



Data sources: Population Reference Bureau (2004); Ministry of Finance & Economic Affairs (2004, 2001); Federal Bureau of Statistics (1991); Kahlown and Majeed (2002) cited in Siegmann & Shezad (2006, p.3)
Note: * Estimated



Data source: State of the environment report (draft) 2005, Ministry of Environment, Government of Pakistan
Adapted from Government of Punjab (2015d, p. 62. Figure 5)

Figure 1.1: Population, urbanization, industrialization, domestic water demand, and per capita availability of water in Pakistan

With a growing population, the per capita availability of water is declining as shown in Figure 1.1. Pakistan is facing increasing water scarcity threat, high water utilization, and deteriorating water quality (World Water Assessment Programme [WWAP], 2012).Under these circumstances, water pollution is a threat to public health and resource conservation.

Pakistan ranks among those countries whose population suffer health problems due to contaminated drinking water (microorganisms, toxic metals, and pesticides) (Azizullah, Khattak, Richter, & Häder, 2011). Wastewater management has alreadybecome a highlighted issue within all main industrial cities such as *Karachi, Lahore, Faisalabad, Multan, Hyderabad, Rawalpindi, Sheikhupura*, and *Kasur*. Only limited treatment facilities exist in a few cities. As a result, all untreated wastewater is being disposed into fields and freshwater resources (Farhat et al., 2015;Raza, 2015; Murtaza & Zia, 2011;Waseem et al., 2014).

Wastewater irrigation has become an essential feature of irrigated urban agriculture since the late 20^{th} century, especially in the cities ofPakistan. A nationwide survey was conducted in Pakistan by the International Irrigation Water Institute (IIMI) to assess the direct use of untreated wastewater in agriculture. The survey showed that about 31% of the total quantity of untreated wastewater (produced per day) was used in agriculture, 5% was directly disposed into irrigation canals, and the remaining 64% was either disposed into rivers or sea (Approximately). In the Punjab province (*Lahore, Faisalabad, Multan*, and *Gujranwala*), more untreated wastewater was used for agricultural purposes. Wastewater is the source of irrigation for 26% of the total domestic vegetable production in Pakistan. About 2% of the total 388 cities have treatment facilities(see Ensink et al., 2002;Ensink et al., 2004; Ensink, Simmons, & Van der Hoek, 2004;).

Sustainable wastewater management is not a simple task for strategists, especially when polluters are spread over a vast area and it is practically not feasible to ban wastewater generation and reuse (wastewater irrigation). The ideal situation would be establishing a unified sewer system and treatment plants to protect public health and natural resources. In addition, administrative organizations should have maximum power to regulate the system sustainably. The command and control approach, which would control the discharge into public drains, would forcibly ban the reuse of untreated wastewater and have proper surveillance on infection in risk-exposed areas. This approach requires a permanent system of supervision that is hard to work well in a country like Pakistan (due to limited financial resources and institutional capacities).

1.3 Faisalabad

Considered a unique case of rapid urbanization due to progress in the industrial sector, Faisalabad is commonly known as the ‘Manchester of Pakistan’ due to its large textile industrial sector. As the hub of industrial activities, Faisalabad is home to more than seven million inhabitants. At the same time, half of the population (approximately 52 percent) depends on agriculture for their livelihood. With the background of waterlogging and salinity (perennial canal irrigation system), groundwater is unfit for agriculture in most areas of Faisalabad. In addition, agriculture in this area is faced with limited irrigation (canal) water. The variation of water sources for irrigation has influenced urban and traditional agriculture. Farmers prefer wastewater as an alternative source of irrigation (Zafar & Akhtar, 2003). The *Chokera* village—site for domestic wastewater irrigation (either treated or not)—has been extensively studied by national and international researchers (Ensink, Mahmood, & Dalsgaard, 2007; Weckenbrock, 2010). Because treatment facilities are limited (20% of effluents are treated), untreated industrial effluents affect the environment (soil, ground water, human health, and fresh surface water resources). The extent of this impact varies from place to place depending on the quality and quantity of effluents. Consequently, wastewater management has become a troubling and notable issue.

Indeed, wastewater has proven to be somewhat controversial, either as a resource or as an environmental threat. The benefits of using wastewater, such as the continuous availability of irrigation water, recharging the supply of groundwater, and so on, are not easy to quantify. Similarly, the environmental threat and health consequences are hard to compute, especially in the absence of the necessary information. Therefore, there is a need to focus on the extent of its positive and negative impacts and to explore ways to recycle wastewater. The comparison will enable the governing bodies to make the right decision about the choice of treatment option. Forcibly banning the use of wastewater in agriculture is not the only solution to the problem.

Most studies of the study area have looked at one aspect of an issue related to the academic background of the researcher or departmental agendas. For instance, the Environment Protection Department (EPD) is concerned with the violations of National Environmental Quality Standards (NEQS) and analyses the quality of wastewater in drains, but it is not interested in drainage facilities in the city. Ultimately, environmentalists, social scientists, biologists, agricultural economists, soil scientists, and other scholars have mainly studied a particular aspect (reviewed in Chapter 2). Similar internationally, the International Water Management Institute (IWMI) launched a study but their main research centered on the *Chokera* village. Studies regarding the impact of untreated domestic wastewater irrigation on humans and the environment have been limited and the results have widely varied based on the site situation. Consequently, the impacts of irrigation with untreated industrial wastewater were also unidentified.

Laws and regulations regarding environmental conservation have made progress during the last few decades, but they could not properly address and implement standards for wastewater management (discharge and reuse). There were only a few studies accessible regarding the review of the legal framework of environmental laws in Pakistan. A critical review of the legal framework on wastewater management was missing. Identifying the legal gaps would help to highlight the reason forthe poor implementation of existing laws. The same situation prevailed in policy formulation for sustainable wastewater management. Instead of a ‘check and punishment’ approach, which has proved to be ineffective, an appropriate strategy to achieve realistic goals within a proper period would be useful.

The role of public administration in sustainable wastewater management has been evaluated but only partially. Just Water and Sanitation Agency (WASA) Faisalabad and Environment

Protection Agency (EPA) were included within the frame of investigation. However, the opinion of local representatives (stakeholders) has been poorly understood at the decision-making level. The sufferers, regulating agencies, implementing agencies, and polluters have all had difficulty cooperating to tackle the issue of sustainable wastewater management. Analyzing the challenges at the institutional level will recognize loopholes in the wastewater management sector.

Recently, development projects in wastewater management have focused on engineering-oriented solutions (collective treatment plant) for proper wastewater management. Such options require considerable investment. Currently, possible solutions to the problem have considered market-oriented approaches such as public-private partnership for the construction of treatment plants (City District Government [CDG] Faisalabad, 2012). These engineering-based solutions are not the only option for future policy formulation. A deeper look into the situation, however, may cause chaos among all involved actors and institutions. The decision-maker involved in this collective action must tackle wastewater management by strategically approaching the issue as a tragedy of the commons. By doing so, there may be possible solutions to the issue of wastewater management.

In sum, case-specific wastewater management issues and solutions are missing. This case study approach provides an opportunity to gather evidence on the existing norms of sustainable wastewater management. Furthermore, it offers a new vision and future recommendations that have not been offered in the past.

Figure 1.2:Research gaps

A multidisciplinary approach (with a focus on wastewater management) is required to develop possible strategies for sustainable agriculture and industrial development along with rapid urbanization (Figure 1.2).

Problem statement:

As one can conclude from the overview of previous discussions, the main body of literature regarding the information on generation, treatment, and disposal of wastewater for the whole city is mainly missing. In addition, the review of the legal framework focusing on wastewater management within Pakistan was not available. Likewise, governance and wastewater have never been addressed at any policy level. The perspective has mainly focusedon collective treatment plants. There is little known about policy solutions at the grass-root level. In light of this, the main target of this case study is to capture the complex enviro-socio-economic evidence across different contexts within the study area.

1.4 Objectives and specific research questions

The overall aim of the study was to look at the challenges of sustainable wastewater management in the city of Faisalabad. For this purpose, the research was divided into five segments. The needs assessment study reiterated the problem statement and helped to understand the local circumstances of sustainable wastewater management. Exploring the impact of the quality of wastewater on communities and resources specifically guidedsite-specific solutions such as the selection of treatment plants or investment in drainage infrastructure. The desired review of former and current legal frameworks explained the contextual perceptive for poor implementation of laws. The segment regarding governance challenges within the framework of institutional analysis delivered the pinpointed goals for future policies. Finally yet importantly, the review of current and future development schemes within this sector identified the gaps for the next strategies.

1. The first objective was to evaluate the impact of poor wastewater management on community and natural resourcesin Faisalabad city. For this purpose, wastewater irrigation was selected (due to direct contact with humans and the environment) to observe the influence on socio-economic conditions, health, and natural resources (soil and ground water). Specific research questions include:

i. What was the impact of wastewater irrigation on the socio-economic conditions of farmers?

ii. What was the condition of natural resources (such as soil, groundwater) in the study area?

iii. What was the health status of farm households that reside in the study area?

iv. What were the total costs and benefits in a given crop year (land tenure system, crop diversity, net crop income, and farm income)?

v. What was the financial status (income and expenditure) of farm households who apply different qualities of irrigation water?

vi. What was the impact of the quality of irrigation water on crop yield and farm income (Dose-response analysis)?

2. The second goal of the study was to evaluate the gaps in the legal framework of wastewater management in Faisalabad, Pakistan. The environmental laws to regulate the quality of irrigation water and discharged wastewater existed but they had been hard to implement. Specific research questions included:

i. What kind of legislation existed to address the issues of water pollution, untreated wastewater irrigation, public health, sanitation and drainage systems, and wastewater generation?

ii. What kind of national policies had addressed the wastewater management sector?

iii. How had the international community influenced national policy formulation?

iv. What kinds of gaps in the legal framework were responsible for the poor implementation of laws?

3. The third objective of the study was to identify the challenges in wastewater management in Faisalabad. The hierarchical orientation of institutions (stakeholders) involved in wastewater managementwasexplored using qualitative techniques (Net-mapping, stakeholder analysis). Specific research questions and targeted investigations included:

i. Was wastewater management a social/governance dilemma?

ii. What was the nature of goods and services linked to wastewater management?

iii. What were the attributes of the community in Faisalabad?

iv. How did the working rules of institutions affect the desired outcomes?

v. What was happening within the action situation of wastewater management in Faisalabad?

vi. What kind of interactions between institutions and individuals existed?

vii. What were the challenges in sustainable wastewater management in Faisalabad? (Structured conceptualization)

4. Finally, the last objective was to review current development projects and to assess a few potential approaches for future strategiesin the wastewater management sector of Faisalabad.

i. What were some internationally sponsored interventions for sustainable wastewater management, and how much have they influenced the situation?

ii. How should policiesbe reformed to address the problem? The existing data was reexamined to address new policy formulation options (Secondary analysis)

The studyaimed to evaluate the causes, influences, and consequences of poor wastewater management in Faisalabad.

1.5 Scope of study

Sustainable wastewater management, one of the global Sustainable Development Goals (SDG 6, 6.3), has fostered a debate on its complex role in sustainable development. Internationally, this issue hasbeen addressed critically with different case studies. A general criterion to adopt the precautionary measures for reducing the risk associated with poorly managed wastewater has been defined (Andersson et al., 2016;Bernhardt & Pieron, 2012;Corcoran et al., 2010; World Health Organization [WHO], 2006, Vol. 4). However, in reality, it was not possible to follow a single strategy because every situation and circumstance is different. Each case study faced different kinds of pollution sources and different management practices. Practically, ground-level information based on real facts was prerequisites to recommend a particular policy for the targeted area. Otherwise, the suggested policy based on another situation would fail to achieve its targeted goals.

The policies to design a better mechanism for wastewater management were not considered significant in Pakistan's strategic planning,as canal irrigation (freshwater resources)in Pakistan is still underpriced (Sahibzada, 2002). The question was whether sustainable wastewater management should rank as a top priority target in the near future or not. If the answer was 'yes,' then howcould one approach that target under specific circumstances? Likewise, the extent of these strategically possible solutions and approaches were hard to decide because the risks involved inwastewater mismanagement were infeasible to quantify. In the same way, unexpected benefitswere also impossible to evaluate. Therefore, learning the trade-off between overall risks and benefits involved in wastewater management would help to suggest proper solutions. In the absence of necessary reliable information, possible policy options were difficult to propose. Estimating possible benefits and incurred costs would provide the necessary information for understanding the extent of the problem and proposing plans. The decision of action and/or no action for policy-makers would only be trustworthy when they know the real facts and circumstances of the issue at ground level.

There were two aspects to advocating the selection of theabove-stated problem. First, it is necessary to explore how sustainable wastewater management affectspeople and the environment. Therefore, it was essential to know the exact nature, background, extent, and consequence of the issue to formulatean appropriate policy. That was the reasonwhy an exploratory kind of research was necessary. Secondly, the study was essential to restructure the related administrative departments such as the EPA, the Urban Unit, and WASA to adopt corrective measures. This research identifies the administrative inefficiency and points out ways to overcome it.

The scope of this study was to try to find the potential for integrated wastewater management in Faisalabad.The study assessed the impact of untreated wastewater irrigation;the legal framework and the institutional setup onlaw enforcementare critically reviewed;and after involving all stakeholders who provided baseline data for future planning aimed at sustainable wastewater management, the challenges for appropriate policy formulation are evaluated.

The significant areas of concern were reviewing the legal and institutional framework, assessingthe impact of wastewater on farm household's socio-economicconditions, farm income and health status, soil and groundwater resources, and discussing the management of common-pool resources and policy formulation.

1.6 Structure of dissertation

The manuscript of the monograph is organized as follows: first, itintroduces the background, the conceptual framework, and the methodology adopted. Then, the needs assessment study is presented. Afterward, wastewater irrigation in Faisalabad is detailed; the legislative and institutional framework is reviewed and governance challenges are identified, and current and future policy interventions are detailed. Finally, recommendations provide a comprehensive awareness ofthe challenges in sustainable wastewater management in Faisalabad.

Chapter 1, *Introduction*, illustrates the problem and describes the research objectives.

Chapter 2, *Literature review*, is structured with the literature elucidating all concepts and theories to describe the background, methodological work, andthe scope of the study. To highlight the challenges in the sustainable management of wastewater, Faisalabad iscompared to other countries in the developing world.

Chapter 3, *An introduction to research methodologies*, discusses the applied methodological approaches and techniques to accomplish the objectives.

Chapter 4, *Study area and needs assessment*, explores the main characteristics of the study area and its current wastewater management situation.

Chapter 5, *Wastewater irrigation, intertwined threats, and opportunities*, addresses the quantitative analysis of the impact of untreated wastewater on communities and natural resources in wastewater-irrigated sites around Faisalabad. The research attempts to evaluate the impact of untreated wastewater on the environment and health as well.

Chapter 6, *Review of Legal framework*, looks at Pakistan's laws and regulations regarding wastewater generation, collection, treatment, and its disposal.

Chapter 7, *Challenges in wastewater management*, presents the institutional analysis of all stakeholdersinvolved with wastewater management, including public administration. The analysis identifies the main challenges in the implementation of laws for sustainable wastewater management.

Chapter 8, *Current and future policy interventions*, reviews the current development strategies in the wastewater management sector and illustrates a few possible policy interventions.

Chapter 9, *Conclusion and recommendation,* briefly states the overall conclusion of the studyand describes the planning solution for the wastewater management sector.

2. LITERATURE REVIEW

The background of this research stemmed from the growing need forfreshwater resources mainly in urban (highly populated) areas of low-income countries. Most of these areas already have been facing water scarcity (such as India, Egypt, Pakistan, China, Mexico) issues and local water supply cannot fulfill the increasing demands(Mara, 2003; Mara & Cairncross, 1989). Within such areas, natural water resources have been at risk by either mixing untreated water with freshwater resources or overexploiting limited groundwater resources(International Finance Corporation, 2007; Turner et al., 2004).The real issue was raised with the direct dumping of industrial effluents into municipal drains without any treatment (Ensink & Van der Hoek, 2009; Wu, Maurer, Wang, Xue, & Davis, 1999). UN research showedthat freshwater resources of the worldare being contaminated at the rate of a minimum of two million tons of domestic and industrial effluentsdaily(World Water Assessment Programme[WWAP], 2003).In developing countries,approximately seventy percent of untreated industrial discharge has been released to global freshwater resources (United Nation Water [UN-Water], 2015).

Likewise, hygiene and sanitation studies claimed that overall wastewater management is extremely inadequate in many parts of the world(Brogan et al., 2017). Wastewater reuse is too common with increasing trends;in some cases, wastewater reuse is unofficial or unorganized and it often has lacked treatment. The rationale for reusing untreated wastewater has been that untreated wastewater has been extremely beneficial for new economies; however, it could pose risks to human and environmental health. Thus, the problem is how to manage wastewater in such a way that it reduces the associated risks while meeting water demands with a limited budget.Wastewater management cannot be ignored, avoided, and delayed anymore.As it is an essential feature in efforts to promote water supply for human, food security, industrial, and recreational water usage. There is a need to manage this increasing water resource effectively and efficiently. In some parts of the world, sustainable wastewater management has been successful through proper planning and management practices.

This chapter lays the foundation to construct the conceptual and theoretical framework for sustainable wastewater management and to address why it is necessary to manage wastewater resources sustainably. Sustainable wastewater management helps to cover increasing water demands, protect valuable freshwater resources, and ensure healthy and eco-friendly activities, especially in low-income countries. Therefore, the literature review has primarily traced, unpacked, and analyzed the processes (sanitation and hygiene, public health, wastewater irrigation, governance challenges in the public sector, and resource protection) leading up to sustainable wastewater management and all concerned aspects.This chapter aims to explore a gap in the literature related to policy-oriented research targeting wastewater management, particularly in the Pakistan context.

The KIM database (HohSearch) of Hohenheim University was used to review the literature. Catalog Plus, Google Scholar, ScienceDirect, and Valley Online Library were used to select the literature regarding "Wastewater management". The keywords used for searchingwere "wastewater irrigation", "sustainable wastewater management",and "wastewater and institutions".In some cases, results were limited. For example, "wastewater and institutional analysis" had limited results, so simpler terms such as "institutional analysis" or "public administration" were also searched to expand the field. After identifying the keywords, the literature during the last 20 years was filtered. For information regarding Pakistan, an attempt to collect all available informationwas made regardless of when the literature was available.

This chapter is structured as follows: Section 2.1 highlights the aspects of wastewater generation, reuse, and wastewater's impact on health and the environment. Section 2.2 justifies the goals forwater and sanitation as global sustainable development goals. The next section exemplifiessuccessfulcases ofsustainable wastewater management (circular water economy). Afterward, Section 2.4 explores the theories/concepts to achieve the goal of sustainable wastewater management. The last section details the situation in the study area regarding wastewater management.

2.1 Wastewater

This section includes five subsections addressing the different aspects of the water cycle. The first subsection briefly explains the sources of wastewater generation. Then, options for wastewater reuse are summarized. The third subsection discusses the links between wastewater management and public health. Afterward, socio-economic and environmental aspects related to wastewater are described. The last subsection concisely summarizes all interlinked features of the water cycle.

The term 'waste' is hard to be defined exactly. Pongrácz, Phillips, and Keiski (2004) determined four attributes: "Purpose, Structure, State, and Performance" (p. 62). Wastewater can be categorized under Class 3 of wastes as "Things with well-defined purpose, but their performance ceased being acceptable due to a flaw in their Structure or State" (Pongrácz et al., 2004). 'Wastewater' generally refers to the surplus of water after any production or human activity that may be altered (in terms of quality). Such alteration affects wastewater's reuse options. Therefore, wastewater can be recognized as 'wasted-water' or as a missed opportunity. Metcalf and Eddy (2003) stated that"wastewater is the liquid portion of waste and may be defined as a combination of the liquid or water-carried wastes, removed from residences, institutions, together with such groundwater, surface water, and storm-water as may be present"(p.1). Also, Raschid-Sally and Jayakody (2008) stated that "wastewater is usually a combination of one or more of the following: domestic effluent consisting of grey water (excreta, urine, and associated sludge) and black water (kitchen and bathroom wastewater), water from commercial establishments and institutions, including hospitals, Industrial effluent were present, stormwater and other urban runoff"(p.1). The above-mentioned definitions classify wastewater based on the point of generation such as domestic discharge (sewerage), industrial effluents,and rainwater runoff (stormwater).

Another term untreated wastewater's qualityis referred toas 'marginal quality of water'. It informs about the quality of water that poses a risk for human health and sustainable agriculture but can be used for irrigation purposes under precautionary measurements (Ayers & Westcot, 1989).

The composition of wastewater mainly depends upon the source of generation. Generally, 96-99.9% of wastewater consists of water. The reaming solid part contains dissolved solids (TDS), suspended solids (SS), and settling solids (girt, sand, etc.). It may contain organic matter (protein, carbohydrates, fats, oil, and trace elements), nutrients (nitrogen, phosphorus, and potassium), dissolved chemicals (carbonate (CO3), bicarbonate (HCO3), sodium (Na), potassium (K), magnesium (Mg), calcium (Ca), sulphate (SO4), chloride (Cl)), trace heavy metals (Cd, As, Pb, Cu, Hg, Cr, Zn, Fe, Ni, Mn, As, and so on), and microorganisms (virus, bacteria, and pathogens). Organic matter released from humans, plants, and animals is biodegradable by bacteria and protozoa. Such a process requires oxygen, which is measured as biological oxygen demand (BOD). Chemical oxygen demand (COD) expresses the required oxygen to oxidize all inorganic and organic matter. BOD and COD refer to the amount of organic and inorganic matter in the wastewater (see; Azizullah, Khattak, Richter, & Häder, 2011;Li et al., 2018; Kahlown, Ashraf, Hussain, Salam, & Zeeshan, 2006; Raja, 2014).

2.1.1 Wastewater generation

Waterhas been used as the primary resource for mostindustrial activities along with human, plant, and animal needs (Nygård, 2008). After its usage, water has been directly released to the environment without proper treatment.This trend is quite common in low-income countries. In 1995, the volume of wastewater globally was about 1500m^3(WWAP, 2003). Such a growing trend of wastewater generation has continued in the 21st century. The core aspects of transitional development structures (from agriculture to industrial) in newly developing countries are industrialization and urbanization. As a result of industrialization in urban areas, the rural population has migrated to cities for better employment opportunities. Based on the UNforecast, fifty percent of the world's population would shift to urban cities by2050(United Nations, Department of Economic and Social Affairs, Population Division, 2015).Therefore, water demands in urban areas are also increasing. Such rapid urbanization has caused problems for the environment, agriculture, and town planning sectors in urban areas (Biswas, 2006; WWAP, 2012)the situation is worse in urban slums. Mostly, small and medium-size industries are established within urban areas without proper planning for drainage.The phrase "wastewater everywhere" can explain the sanitation condition of most urban dwellings in developing countries (Saravanan, Mollinga, & Bogardi, 2011).

2.1.1.1 Domestic discharges

The role of water as a fundamental natural resource and necessity is obvious. The amount of sewage produced is directly linked to the population. It is worth noting here that a bare minimum of 20 liters per capita per day (Lpcpd) of water is a human right (United Nations Development

Ptogramme [UNDP], 2006). However, the water consumption rate is 400-500 liters per capita per day in water-abundant areas or developed countries (United Nations System in Pakistan, 2003). At least, 100-180 Lpcpd can be considered as the average human water consumption excluding water-stress areas (Saira et al., 2018).

Most of the water used in a domestic setting is released after personal use (washing, cooking, gardening, and flushing). Such releases are recognized as domestic discharges. Domestic (sewage) wastewater from communities (residences) mainly contains human wastes (urine, excreta), food residuals (from the kitchen), detergents (from washing and cleaning), and some other particles. Whereas, according to another classification 'Blackwater' refers to human discharge from toilets including feces and urine whereas 'Greywater' is generated by other human activities (excluding human wastes)(Raja, 2014).

Pathogenic organisms including bacteria, parasitic protozoa, helminths, and enteric viruses present in domestic sewage are associated with disease transmission through contact.Somefactors influence the prevalence of microbial pathogens andthey are identified in many epidemiological studies(Labite et al., 2010; Raja, 2014; Sridhara Chary, Kamala, & Samuel Suman Raj, 2008). Focus on sanitation is required to avoid any water contamination in rivers and to maintain ecological balance for the environment.

2.1.1.2 Industrial effluents

Asthe"universal solvent", water is also a key element for most industrialactivities (for example, processing, washing, boiling, drying, and cleaning) to produce goods using raw materials. Such 'used water' after any industrial activity has been released to the environment without any proper treatment. Mainly, industrial effluents carry chemicals and traces of heavy metal used during processing, which have polluted global water resources. With industrialization in urban areas, the composition of sewage discharge changed from human wastes (organic matter) to toxic chemicals and heavy metals(Mapanda, Mangwayana, Nyamangara, & Giller, 2005; Qureshi, Hussain, Ismail, & Khan, 2016).

2.1.2 Wastewater reuse options

With the forecast of the world population reaching nine billion by 2050, the future water supply is under stress. Throughout the world, population growth and increasing demand for water usage are pressuring the global supply of freshwater. This pressure is considered a major motive for reusing untreated wastewater (Raschid-Sally & Jayakody, 2008; WHO, 2006, vol. 1).

2.1.2.1 Reuse of wastewater in agriculture

Conventionally, municipal wastewaters (domestic and commercial effluents) have beenutilized as irrigation water for centuries. There is a substantial level of consensus in the literaturethat irrigation with domestic wastewater supplies nutrients and organic matters.Shuval, Adin, Fal, Rawitz, and Yekutiel (1990) reported that the concept of using domestic wastewater for irrigation has existed since ancient times in some parts of Asia and China. This practice was documented in

Europe, first in Germany during the 15th century and secondly in Scotland in 1650. Its application increased in Europe after the Royal Commission submitted a report on sewage disposal in England. In this report, irrigation with domestic discharges was declared as the right way of disposal to avoid river pollutions. In the U.S., wastewater irrigation was first documented in the late 1870s and the risk of diseases was found later on(Shuval et al., 1990).

There is overwhelming evidence corroborating the beneficial aspects of municipal wastewater irrigation. One of the arguments is that municipal sewage contains nutrients and organic matter for agricultural production. Domestic wastewater irrigation reduces organic fertilizer costs. It also reduces the farmer's dependence on inorganic fertilizer. The continuous supply of domestic wastewater allows multiple cropping throughout the year. For that reason, domestic wastewater irrigation ultimately lowers the cost of production and enhances the farmer's net returns. Additionally, wastewater irrigation is predominantly related to urban or peri-urban agriculture. Intensive agricultural practices with wastewater reuse provide the possibility of continuous supply of food products in the urban area (Drechsel, Giordano, & Gyiele, 2004; Drechsel, Graefe, & Fink, 2007; Drechsel & Scott, 2010; Scott, Faruqui, & Raschid-Sally, 2004). Moreover, irrigating with wastewater helps recharge underground water, which would ultimately increase crop yield and net returns for farm households (Hanjra, Blackwell, Carr, Zhang, & Jackson, 2012). In addition, the usage of wastewater in agriculture is also a low-cost alternative for municipalities where treatment technologies are expensive and land-based disposal is limited in space(Haruvy, 1997). Countriessuch as India, Israel, Jordan, Ethiopia, Peru, and Pakistan facing physical water scarcity have promotedwastewater reuse in agriculture (Biswas, 1993).

The adverse impacts of domestic wastewater irrigation, such as health hazards due to the presence of microorganisms and pathogens in wastewater and alteration of soil properties, especially after prolonged application for about a decade or two, have been documented. Primary and secondary treatment of wastewater has been highly recommended for safe wastewater use for agriculture (WHO, 2006,vol. 2).However, developing countries cannot adopt this recommendation and mostly untreated sewage is used for agriculture. As mentioned in the research, untreated or partially (treated/diluted) wastewater irrigates approximately20 million hectares of agricultural areas in 50 developing countries. This area covers ten percent of the irrigated land area in developing countries (WWAP, 2003).

Sridhara, Kamala, and Samuel (2008) mentioned that about 2.6 billion m^3 wastewater has been generated from 200 cities in India annually and its use in urban agriculture continued to increase. Likewise, pressure on urbanization in Kenya (Nairobi) and Kumasi (Ghana) also showed the adoption of wastewater irrigation (Raschid-Sally, Carr, & Buechler, 2005). Bahri (2009) detailed the associated potentials and risks of wastewater irrigation. Cross-sectional and longitudinal studies identified the socioeconomic, environmental, and health effects of untreated and unplanned wastewater irrigation worldwide. Several countries like India, China, Mexico, Ethiopia, Vietnam, and Pakistan have directly irrigated agricultural fields with untreated wastewater (liquid) and night soil (solid waste). Limited treatment facilities are available for effluents in developing countries (Mara, 2003).

2.1.2.2 Pollutingthe freshwater resources

Environmentally, it is desirable to treat wastewater immediately after its generation from its source. However, adding treatment costs to the manufacturing cost of industrial products may ultimately increase the prices. As a result, industrialists may lose their markets;therefore, such contaminated wastewaters are discharged into agricultural fields or freshwater reservoirs without any proper treatment.

Mostly, small and medium-size industries are established within urban areas without proper planning for drainage.Based on studies, the real issue of water pollution was regarding direct dumping of industrial effluents into municipal drains without any treatment in most developing/low-income countries (Ensink, 2009; Esink et al., 2004; Wu, Maurer, Wang, Xue, & Davis, 1999). As reported, approximately seventy percent of untreated industrial discharge has been released to world water resources in developing countries (UN-Water, 2009).

The chemicals and heavy metals used for processing directly affect water quality. Theyrequirea specific, advanced treatment facility to filter pollutant particles. A minimum of two million tons of domestic and industrial effluentsare mixing with freshwater resources daily on a global scale(WWAP, 2003).

2.1.3 Wastewater and public health

No doubt, there is a direct relationship between the health of the urban poor and local wastewater management (Black, 1998).Research showed that global health indicators are directly linked with "safe drinking water, sanitation, and hygiene"(WHO/UNICEF, 2015; WHO/UNICEF Joint Monitoring Programme, 2015).Evidence of disease transmission through contact with wastewater has been evaluated in many epidemiological studies (Nygård, 2008).Such epidemics not only result in economic loss from productivity loss or treatment cost but also severely impact local industriessuch as tourism or the food industry.The health risks are mainly based on the type and extent of the contamination. Broadly, they can be divided into microbial and chemical health hazards.

2.1.3.1 Microbial and pathogenic health hazard

The most crucial and highlighted facet of wastewater management is associated with the microbial pollution of water. Rapid urbanization has triggered this issue. Highly populated areas with limited water and sanitation facilities put slums or towns at risk from water-borne diseases. In 2015, it was estimated that around 60 percent of the global population lack safe sanitation facilities(Bain et al., 2018).Human excreta have been implicated in the transmission of many infectious diseases including cholera, typhoid, infectious hepatitis, polio, cryptosporidiosis, and ascariasis(Carr, 2001).Water-borne diseases are considered silent crises. World Health Organization (2004) estimated that '5 billion people diagnosed with diarrhea per year in developing countries and about 1.8 million people die annually from diarrheal diseases where 90% are children under five, mostly in developing countries'(United Nations Development Programme[UNDP], 2006).In 1991, a cholera outbreakin Peru was reported due to inadequate wastewater management. Clean drinking water and proper waste management facilities were nonexistent in densely populated urban slums around the coastal areas. Such areasare breeding groundsfor a cholera outbreak. Consequently, Peru suffered about one billion US dollars due to reduced seafood export and fewer tourist visits only within a few weeks. This loss was three-fold higher than the total investment in the water supply and sanitation sector during the last decade in that region(Wright, 1997).

Wastewater is also linked to public health when untreated wastewater is used for irrigation purposes. Untreated municipal effluents, including domestic and industrial discharge,are utilized for urban agriculture, andthe urban population directly consumesthe grown produce. This pathway also causes the outbreak of pathogenic diseases. It was evident from typhoid (fever) epidemic in Santiago during 1978-80. The infection rate was so high, about 200 incidences out of 100,000 inhabitants. Shuval, Wax, Yekutiel, and Fattal (1989) investigated the causes of this epidemic and found that untreated wastewater irrigation was applied over a vast area (13,500 ha). The vegetables (tomatoes, celery, cauliflower, lettuce, cabbage) mostly cultivated therewereconsumed raw. This pathway was responsible for disease transmission on such a vast scale. Shuval et al. (1986)indicatedthat partially treated/untreated wastewater use in agriculture has been taking place for decades, even centuries, in countries like Mexico, Vietnam, and China. Also, communities applying untreated domestic wastewater faced a higher risk of communicable diseases as compared to non-wastewater-irrigating communities(Katzenelson, Buiun, and Shuval, 1976).

2.1.3.2 Toxicity due to heavy metal concentration

As discussed in the earlier section, the risk of epidemics is directly allied with wastewater management practices.It was also evident that untreated industrial wastewater is harmful to public health due to exposure to chemicals. Thus, crops (e.g. root and leafy vegetables) sensitive to heavy metals should only be irrigated with untreated wastewater (Lucho-Constantino, Álvarez-Suárez, Beltrán-Hernández, Prieto-García, & Poggi-Varaldo, 2005).

Chemical and other hazardous materials in industrial effluents also enter the food chain, which can cause fatal diseases such as the Minimata disease (illness due to an excess of Mercury)(Kirbyet al., 2013; Khwaja, 2013). Blumenthal, Mara, Peasey, & Stott (2001) also found the same threat in León.Another example is the spread of cancer among leather factory workers. Effluents from leather and tanning industries contain a high concentration level of chromium. Hexavalent chromium is a well-known carcinogen, andchromium salts areused during the tanning process. The residual left after processing is released, which canput exposed people at severe health risks.These findings are based on two case studies, *Kanpur* in India and *Hazaribagh* in Bangladesh (Blacksmith and Green Cross, 2013; Singh, 2001).

These few case studies cannot exactly elucidate the threats caused by untreated industrial effluents discharge globally. Although these studies can only indicate theharmful effects. Nevertheless, thescope and scale of these effects are too wide and varied,and cannot be fully described in the scope of this study.

2.1.4 Socio-economic and environmental impacts

Although the health risks associatedwith wastewater irrigation have been reported, it is generally argued that not every microorganism (health hazard) in wastewater, soil, crops grown with wastewater irrigation can cause infection(Shuval et al., 1986).Accordingly, the wastewater irrigators also outweigh the benefits over the risks on a short-term basis.They just considered the short-term economic benefit of having a continuous supply of irrigation water(Haruvy, Offer, Hadas, & Ravina, 1999). Another strong argument in the favor of wastewater irrigation is its impact on food security. Throughout the year, itsavailability ensuresthe growthof a variety of crops and provides fodder for livestock.Consequently, it improves nutrition in urban areas by supplying markets with perishable but nutritious commodities (vegetables) (Drechsel, Graefe, & Fink, 2007; Drechsel & Scott, 2010).Certainly, the social cost of ill health and alteration of resource quality was excluded from such evaluation.

No doubt that the chemical and biological composition of wastewater affects the physical (soil structure, soil texture, field capacity), chemical (pH, organic matter, N:P:K ratio, ion concentration, minerals, trace elements, and pollutants), and biological (microbial and enzymes) composition of the soil and groundwater (Li et al., 2018).Gallegos et al.(1999)as well evaluated the harmful effects of untreated wastewater irrigation on groundwater quality. Correspondingly, Lucho-Constantino et al.(2005) investigated the impact of raw wastewater application (over 20 years) and found a linear relationship between metal concentration (B, Cd, Cr, Hg, Pb, Ar,) in soil and period (years) of wastewater irrigation.One of the arguments in favor of wastewater irrigation application is that recharges groundwater. It recharges the groundwater, but at the same time, the quality of wastewater also affects the quality of groundwater.

Precisely, it is a hard task to calculate or even visualize the comprehensive image of wastewater reuse. It is like a several-branched hedge plant, which requires permanent pruning for each branch keeping in focus the objective of sustainable use of resources. The purpose to discuss all these aspects associated with wastewater was not just to run a debate. Its main theme was to explain comprehensive background knowledge before exploring the new facet in my scope of the study.

2.1.5 Summary

Concluding to the proceeding,several empirical, conceptual, and policy-based researches highlighted the direct and indirect impacts of wastewater on environmental degradation and the public health and economic conditions of those exposed to wastewater. Irrigation with untreated wastewater posed health risks to producers and consumers,changed the soil structure, andaltered groundwater and crop quality(Hussain, Raschid, Hanjra, Marikar, & Hoek, 2002; Clemett & Ensink, 2006; World Health Organization, 2006: Vol. 4; Raschid-sally & Jayakody, 2008). Even the nature and extent of these impacts vary case by case.Most of thesestudies focused on the harmful impacts on health and the environment as compared to optimisticeffects(World Health Organization, 2006, Vol. 1). Impartially,the harmful impacts outweigh the limited socio-economic impacts. Asdischarging untreated wastewater in eco-system insertsa substantial externality that would be paid by the society.

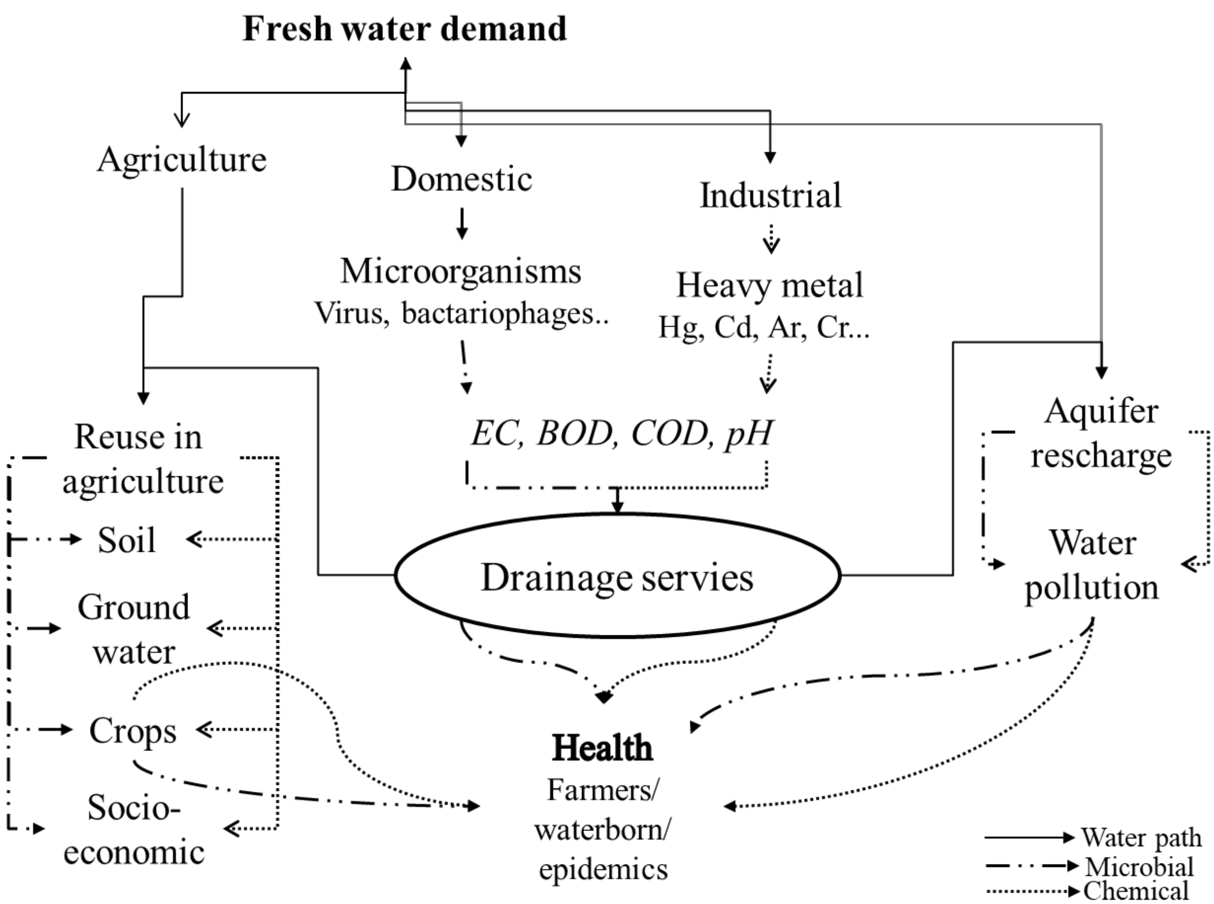


Figure 2.1:Links between wastewater generation, reuse, pollution, and health
Source: Author

Figure 2.1 portrays the general unsustainable water cycle in economically developing nations. The arrows represent the interaction between the processes involved in the water cycle. Such kind of interaction (impacts) may be beneficial or harmful. Here, only harmful interactions have been presented for simplificationrationale. Conclusively, wastewater has been managed unsustainably. However, it is hard to suggest a single criterion for global sustainable wastewater management. There are critical gaps regarding the impacts of poor wastewater management and how to mitigate the concerns(Ardakanian, Sewilam, and Leibe, 2012). There is a need to study them specifically (case-oriented solutions) and objectively (targeting global sustainability).

The next section explains the importance of sustainable wastewater management to achieve global development goals.

2.2 Global sustainable development goals

In this section, the focusis to briefly elaborate on the global scenario addressing sustainable wastewater management. Globally, this targethas been monitored through manyindicators (including health, water &sanitation, and economic resources). The topic 'access to safe water, sanitation, and hygiene' covers almost all aspects associated with wastewater management and health. Increasing resilience against any water-related diseases is also a motive to create a water-secure world.For instance, infant (under five-year-old) mortality and health risks due to diarrhea can be reduced with improved "drinking water, sanitation and hygiene"(WHO/UNICEF, 2015; WHO/UNICEF Joint Monitoring Programme, 2015).The saying "human right to water and sanitation" has been discussed and narrated by the WHO. Furthermore, the human right to frame policies on the topic of 'water and sanitation'has also beenaddressed. They are also concerned withenlisting measures in case someone was not given this right before and how it should be rectified in the future (WHO, 2003). Next, a concise sequential (1990-2017) discussion about a sustainable world concerning water management has been elaborated.

2.2.1 Millennium Development Goals

Development goals, as aninternational policy framework to reduce poverty and attain sustainable development, have received attention at the end of the 20th century. The targets for 'water, sanitation and hygiene' directly connected with human health, education, and livelihoodsare concisely set under the objectives of the global developmental strategy. The first step to address these objectives on a global scale took place when the eight Millennium Development Goals (MDGs) were recognized in 1990.

Mainly, MDGs were established addressingthe areas lacking basic human necessities. In the wastewater management sector, it looks at them safe drinking water, open defecation, and unhygienic conditions.MDG 7 - to ensure environmental sustainability, exactly investigate the above mention objective. To achieve this goal the target nine, ten, and eleven were put forward. Target ninereferred to integrating sustainable development inpolicyand strategy formulation. Target 10 was set for reducing the proportion of the populationwithout "safe drinking water and sanitation" facilities by 2015.And, the goal of improvingthe lives of urban slum dwellers until 2020 wasset in target 11.The term 'sanitation' here is addressed in a very broad spectrum.

World Health Organization(2004) defined the term 'sanitation' as follows: "*Safe collection, storage, treatment, and disposal/reuse/recycling of human excreta (feces and urine);* Management/re m use/recycling of solid wastes (trash or rubbish); *Drainage and disposal/reuse/recycling of household wastewater (often referred to as sullage or grey water); Drainage of stormwater treatment and disposal/reuse/recycling of sewage effluents; Collection and management of industrial waste products;* and management of hazardous wastes (including hospital wastes, and chemical/ radioactive and other dangerous substances)”[1](Annex-A, p.9).The aspectsof sanitation presented in italic have integrated within the scope of wastewater management of this study.Later, the goals and targets set in MDGs were outlined as “reuse of wastewater” in the WHO health guidelines (2006).

Huge efforts and investmentswere carried out to accomplishthe targets in drinking water, sanitation,and hygiene, particularly in developing countries. However, many obstacles werefaced in achieving these targets. Despite allthese obstacles, a partialaccomplishment regarding MDGs targeting water and sanitation was achieved. Statistical output from 1990 to 2015 showed that the targettosupply safe drinking water was already achievedby 2010 before the target period. Conversely, sanitary targets could not be fully accomplisheddue to diverse conditions all over the world. Unfortunately, there was no target (in MDGs) set concerning hygiene conditions(WHO/UNICEF, 2015; WHO/UNICEF Joint Monitoring Programme, 2015).

Resultantly, it was decided to expand MDGs as Sustainable Development Goals (SDGs)during the 2012 UN Conference in Rio. Allnations agreed on achieving MDGs, but they also wanted to develop a new set of sustainablegoals.Specifically, the Budapest Water Summitwas held in 2013 to reinforce the global water and sanitation goals in the SDGs. Five sessions for monitoring water and sanitation goals were arranged including universal access to water and sanitation, integrated water resource management, good water governance, the green economy for blue water, and overall matters regarding investment and financing of projects.

2.2.2 Sustainable Development Goals

Lastly, SDGswere proposed with further specifications and modifications from the MDGs. Seventeen goals and 169 targets were set for sustainable development and these objectives were recommended to be achieved by 2030. The “2030 Agenda for Sustainable Development” included a comprehensive goal for water and sanitation as described in SDG 6(United Nations, 2015). SDG 6deals with equitable and affordable access to water, sanitation, and hygiene. Additionally, improving the quality of water hasbeen proposedby reducing the quantityof untreated wastewater, and safely and sustainably increasing water recycling.

Table 2.1:Goals, targets, and indicators of wastewater management in SDGs

SDG 6: “Ensure availability and sustainable management of water and sanitation for all”	
Target	**Indicator**

[1].

6.3. By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing the release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	6.3.1. Proportion of wastewater safely treated 6.3.2. Proportion of bodies of water with good ambient water quality
6.4. By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	6.4.1 Change in water-use efficiency over time 6.4.2. Level of water stress: freshwater withdrawal as a proportion of available freshwater resources
6.5. By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate	6.5.1. Degree of integrated water resources management implementation (0–100)
6.a. By 2030, expand international cooperation and capacity-building support to developing countries in water and sanitation related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling, and reuse technologies	6.a.1. Amount of water- and sanitation-related official development assistance that is part of a government-coordinated spending plan
6.b. Support and strengthen the participation of local communities in improving water and sanitation management	6.b.1. Proportion of local administrative units with established and operational policies and procedures for the participation of local communities in water and sanitation management
Source:UN General Assembly(2014); UN-Water, (2017); UN-water, (2018, p.27)	

Table 2.1 elaborates the targets 6.3, 6.4, 6.5, 6.a, and 6.b and further related indicators.

SDG6 advocates that "access to safe water for drinking and sanitation" is a right for all, along with a right to life and standard of living. Furthermore, these proposals aim to prevent any water crisesto avoid overexploitation and to ensure that water would be available for future generations. Specific targets were set to improve water access, strengthen government accountability, reduce untreated wastewater, and likewise decrease water pollution and human mortality due towater-related hazards by 2030 (UN-Water, 2014, 2017).

A move from MDGs to the 'water and sanitation' section of the SDGsis a shift of "access to water, sanitation,and hygiene" to a full emphasis on sustainable management of the 'whole water cycle'. MDGs contain only three indicators for water, sanitation, and hygiene whereas SDGs target 11 indicators. For instance, the improved quality of water, reduced water pollution, and water treatment/recycling hadbeen included in the SDGs.MDG indicators were primarily monitored by domestic surveys.Whereas,to survey and monitor SDGs, national and international officialswould have to cooperate. So,the targets should be monitored to get political support to strengthen national capabilities and resources(UN-Water, 2017).After the introduction of SDGs, sustainable wastewater management had been buzzing in the policy arena (Ferguson, Dakers, & Gunn, 2003a). Therefore, there is a threshold notion for the shift of the global water management sector from linear to circular water economy, which would be sustainable.

2.3 Linear to circular wastewater management

This subsection is further broken down into three parts. The first segment contains general information regarding public administration in the wastewater management sector. The second part exemplifies regions that are practicing a circular water economy. The last part debates the concept of sustainable wastewater management.

Recently, the policies and strategies have aimed to move toward a more circular water economy. The transitional (linear to circular) wastewater management context refers to a combination of methods for optimizing system sustainability (Taelman, Tonini, Wandl, & Dewulf, 2018). Suchpolicy framework primarily would help to assess the linear wastewater management economy, which is the “Take-make-dispose” approach. Latterly, it would guide towards a circular economy including wastewater recycling and treatment. No doubt, a closed-end wastewater management is sustainable(for detailed study see, Casiano Flores, Bressers, Gutierrez, & de Boer, 2018; Hoppe, Arentsen, Mikklia, & Linnanen, 2012; Nayono, 2014; Taelman et al., 2018).

Concisely, one can say that a circular water economy synonymously would refer to as sustainable wastewater managed sector. Therefore, a few tools and approaches to achieve a circular water economy with the reference of previous research are briefed in the subsequent segments. The literature was reviewed keeping the focus on the aim of the study (i.e. governance challenges).After deciding the public regime, the risk reduction practices (technical and financial aspects) can be decided such as innovation for the processing of wastewater, increased knowledge, research, and capacity development of people (Bernhardt & Pieron 2012). (Technical, biological, chemical, and financial estimation were excluded).

2.3.1 Public administration and wastewater management

The focus of this study was to identify the lacking factors in the sustainable wastewater management sector within the scenario of developing countries. Therefore, within this section,the role of public administration to achieve a sustainably managed (circular) water economyhas been overviewed. The following first subsectionelucidates the public investment and economic conditions at the regional level as a tool for improving the management level. Secondly, the alternative options for best administrative decision-making are addressed. And the last subsection briefs the possible treatment and reuse options (success stories).

2.3.1.1 Public investment and economic condition

Objectively, each public administration is centered on two main questions that are, where to invest and how to invest. As public goods, wastewater infrastructure and management services require public investment for the public welfare. In addition, if direct investments are properly financed, it might lead to long-term benefits in the future for society. A rapid response assessmenthas shed light on the direct and indirect effects of wastewater. It may increase the cost of healthcare at first.Nevertheless,if not, it would restrict the rapid development of a community. Eventually, high healthcare costs enhance labor productivity (Corcoran et al., 2010).

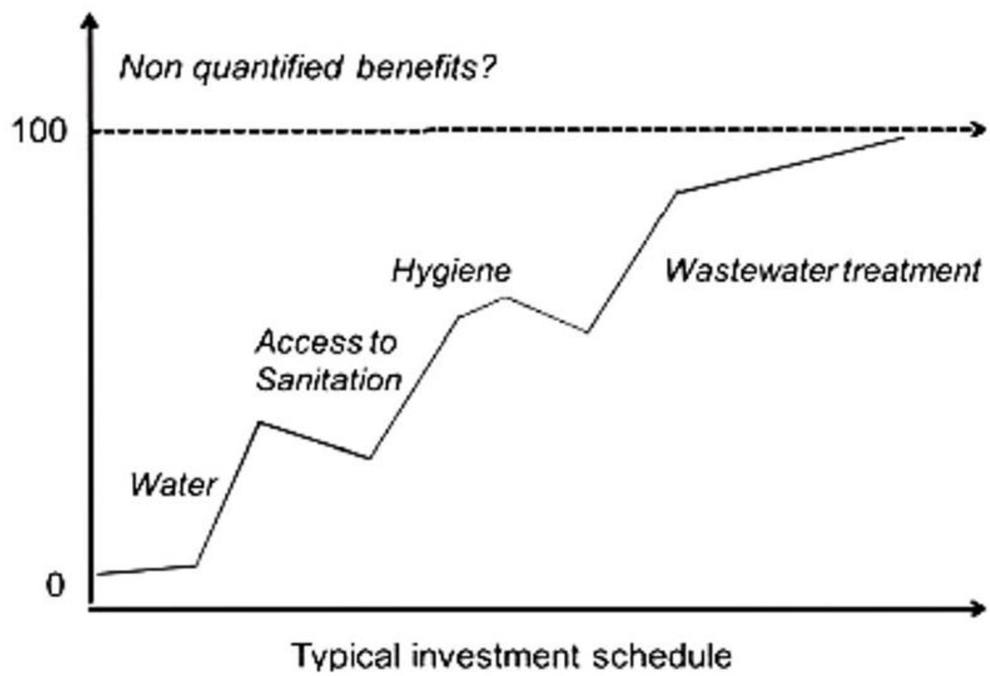


Figure 2.2: The water and sanitation benefits curve

Source: Adapted from OECD (2011,p.15)

Figure 2.2 illustrates the benefit to investment curve for water and sanitation services. Sanctury and Tropp (2007) estimated that the ratio of benefit to cost within this sector would be$3-34/$1 depending on the infrastructure status.Globally, an estimated 66 billion dollars were gained by reducing productivity loss (after achieving the MDG targets for sanitation). In addition, it was estimated that a 10-year increase in average expected life would increase 0.3-0.4 percent economic growth annually (ADB, 2006). Such estimates have been based on comparing the “cost of action” to the “cost of no action”. At this notion, the costs (social and environmental) include health costs, natural resources reclamation costs, dumping, and transportation costs. Such estimated costs represent the “cost of no action.” Alternatively, the “cost of action” includes the installation costs, operational costs, costs of using recycled water, and transportation costs of the treatment plant. However, quantifyingthese costs and benefitsis another convoluted task in the absence of real markets (resource markets). These cost and benefits estimates using shadow prices are sometimes extraordinary and are considered difficult to accept(Hernández-Sancho, Lamizana-Diallo, Mateo-Sagasta, & Qadir, 2015).

Environmental degradation is linked with the economic conditions of the region.The following Figure 2.3 closely explains this concept of how an increase in national wealth affects local, regional, and global environmental burdens (pollution). It elaborates that investment decisions are generally based on the economic state. Emerging economies compromise at the higher economic benefit over a little share in the global environmental degradation. Such low-income countries possess the highest level of local pollution burdens that directly affect the local society. Alternatively, the local pollution burden in high-income counties is low but global pollution is high (due to a high level of economic activity).

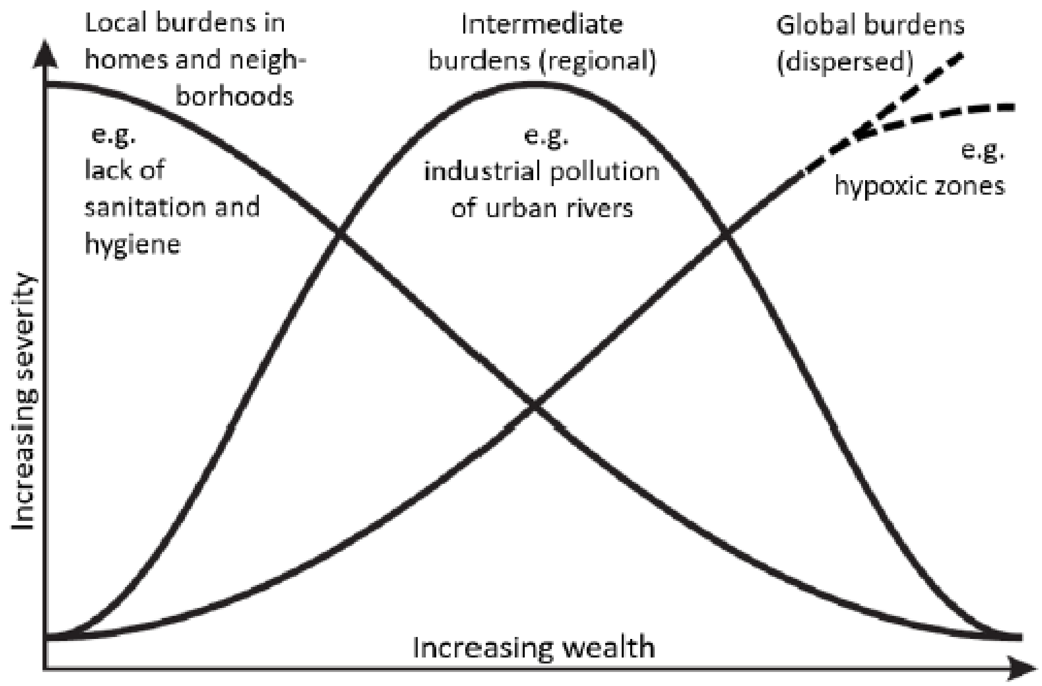


Figure 2.3:Relationship between the economic conditions and environmental transition
Source: McGranahan et al. (2001) as cited byMcGranahan & Marcotullio (2005, p.807) andKjellén (2018, p.225)

It emphasizes that developed nations should invest higher as compared to developing countries. For instance, the US environment protection agency (EPA) constructed a comprehensive schematic framework for the discharge and reuse of wastewater in agriculture at the national level.Even, USEPA national wastewater quality standards are stricter as compared to WHO (global) standards. Such strict restrictions result inextremely low values of quality parameters of discharge. Even, such low limits had no medical grounds but a lot of effort was spent on monitoring and enforcing these standards (Kramer, Post, & Reseach, 2001).

International investment in sanitation and health sectors will result in economic profits and social benefits. As mentioned earlier, a benefit of 66 billion dollars estimated by reducing productivity loss (after achieving MDGs). Whereas, the funding of 42 million dollars for waterand 142 million dollars for sanitation was invested in developing countries(ADB, 2006). Later on, 322 million dollars and216 million dollarsrespectivelywere approved for the maintenance of already existing services. It shows a growing trend of international investment for the provision of "water and sanitation services" globally(Hutton & Bartram, 2008). Standards were set globally, but their implication and application can only possible within a viable local scenario.Global tendencies for wastewater management have indicated the pattern of 'Local, global, and back.'

2.3.1.2 Administrative decisions

Local resistance or resilience may prove any sound policy either thrivingor failing. Local or regional administrative decisions play a vital role and their role varies from region to region. Different models of public administration, such as centralized or decentralizedpublic regimes, privatizations, and public-private partnerships, have been frequently discussed. The same situation also exists for the wastewater management sector even if there have been only a few studies were found with this regard. Recently, a decentralized on-site treatment has been highly recommended for achieving sustainable wastewater management(Boguniewicz-zablocka & Capodaglio, 2018: Ferguson, Dakers, & Gunn, 2003).

Whereas, developing economies with a centralized management system may face challenges operating long-term, large treatment plants.Halpern, Kenny, Dickson, Oliver, & Ehrhart (2008) found the incidence of corruption within such infrastructure. However, the option of centralized or decentralized wastewater management depends on local circumstances. And to minimize corruption,there should be a focus on improving governance incentralized public administration.

Another critical obstacle for developing economies is limited financial resources for public development investment. In such cases, private investment should not be a permanent solution to solve the problem. It is evident from a study that focused on the privatization of the water and sanitation sector in three cities of Turkey(Cinar, 2009). A public-private partnership may be another option for the improvement of public infrastructure (reformed administration). Birner & Wittmer(2006)preferred the public-private partnership in such situations. Moreover, it can minimize the political capture of natural resources.Another possible option is participatory wastewater management, which has been recently considered as a solution for the sustainable use of water resources. No doubt, this approach can reduce local resistance and would be the least costly to conserve the environment(Mburu, Birner, & Zeller, 2003).

2.3.1.3 Treatment options and reuse schemes

The subsection does not go into detail for each type of treatment and reuse option. Instead, the focus of this review is to explain the basic criteria or principles for exploring treatment and reuse schemes from the administration point of view. Governing authority can decide the level of treatment after analyzing the local circumstances, financial outlay, level of pollution, and the administrative capability of organizations.It is always advisable to investigate a preliminary study exploring possible outcomes, sustainable long-term operational life, and reuse options for treated wastewater before suggesting a treatment project/scheme. The economics of wastewater and its treatment options were also evaluated in different case studies (Roxendal, 2012; Turner et al., 2004; Winpenny, Heinz, & Koo-Oshima, 2010).

Subjectively, the knowledge of typology of discharged wastewater (as mention in section 2.1)directs toward the required level of treatment.Traditionally, storage ponds have been practiced as a natural treatment solution for centuries. Through this process, the wastewater quality usually has improved and can be utilized for irrigation purposes. Therefore, the waste stabilization pond (WSP) technique is a low-cost conventional treatmentfor domestic wastewaterto reuse it safely for irrigation purpose in developing countries. But still, there is a need to treat wastewater in such a way that ensuresthe minimal health risks ofexcreta-related diseases (Mara, 2003). To ensure this purpose,Mara & Cairncross (1989) comprehended different measures for governing the wastewater discharge and reduces its negative impacts.Mara (2003)also favored the WSP as the most suitable and cheap treatment option as compared to other techniques. Another effective technique for microbial treatment, Effective microorganism (EM) was introduced to purify domestic wastewater after the microbial breakdown of organic matter (Okuda & Higa, 1999). Furthermore, the reduction of BOD, COD, and SS parameters would make the wastewater more feasible for advanced tertiary treatment. Then, tertiary treatment to remove microorganisms (virus and bacteria) continued by applying free chlorine (Apau, 2017). Obviously, urban sewage must be treated rather in any case before discharging into the environment.

The treatment is so complicated for industrial effluents. Therefore, industrial treatment plants are suggested after inspecting the composition of discharges. Mostly, they require specific and authenticated technology that makes it so expensive. Oliveira &Sperling (2011) demonstrated how various treatment plants performed and what treatment options are available.

Another type of water treatment plant isthe Desalinization plant. Many industrial units installed these plants to fulfill their water requirement. Such plants utilize the reverse osmosis processand to make each drop of good quality water, gallons of highly saline water is produced. Even such treatment plants also use nuclear energy in many developed countries. Ultimately, each drop of water is cleaned at the cost of nuclear pollution.Mateo-Sagasta et al., (2013) reported a general criterion for wastewater management. The foremost aspect of this study was to estimate the economic aspect of recycling and reuse strategies. The next main component was regarding the reuse-oriented strategies.

It is necessary to reconsider the reasons for using untreated wastewater in agriculture. In most cases, it is due to the lack of irrigation water in those areas (water scarcity). From the municipalities' perspective,another reason is that dumping untreated wastewater is a cheap option for wastewater disposal.The controversial role of wastewater irrigation followed a line of investigation to explore safe use in agriculture with minimum risks. Urban wastewater must be treated rather than using untreated or dumping into freshwater resources. Irrigation with such treated water may affect the physiochemical characteristic of soil and groundwater. Even, the concentration level of the parameters remains within the permissible level. Such treated water is suggested to be utilized for irrigating plants such as fuelwood, turf grass, and green belts (Pereira, He, Stoffella, & Melfi, 2011; Babayan, Javaheri, Tavassoli, & Esmaeilian, 2012). Whereas in the case of food crops such as salad and other vegetables, further protective measuresshould be engaged to ensure minimal health risks (Shuval et al., 1986).

The preceding brief review about the role of administrative decisions and their capacitates clearly outlined the obstacles to achieve the goal of sustainably managedthe wastewater. The strategies to overcomesuch governance challenges can be proposed.However, these strategies and recommendations can be suggested while keeping in mind that one single solution could not solve the problem everywhere. Historically, the 'one size fits for all' approach for suggesting possible solutions showed to be unsuccessful in achieving policy objectives. There is a need to explore context-specific strategies for overcoming the governance challenges (Birner et al., 2009). A context-specific strategy can guideselecting a specific solution suitable for local circumstances. It considers sustainability, discussing the need to take measures to ensure sustainable water resources for all. Consequently, all experts and decision-makers should adopt a participatory approach and include all stakeholders (Turner et al., 2004).

One can conclude from the previous discussion in this chapter (section 2.1) that untreated wastewater is adverseto public health, environmental conservation, and natural resources.If managed/treated/recycled properly and adequately, wastewater would serve as an alternative water source(section 2.3). Many high-income industrial countries have already achieved this purpose.The following section briefly describes how realistic perspectives on proper wastewater management could help in this regard.

2.3.2 Wastewater as an alternative water resource (circular economy)

There is rapidly growing literature on water-conservingwaysto "save each drop before its dips." Here, it is not the question that either water is a natural, renewable resource or non-renewable. As further recognition to this debate, Andersson et al. (2016) convincingly argued water is a scarce environmental resource. To secure this scarce resource, a working definition of water security has been constructed in an analytical brief by UN-Water (2013). Water security is considered an interconnected challenge, with a central goal of achieving security, sustainability, development, and human well-being. Additionally, transboundary water security can be a solution for cooperation among different regions. Communally, water should be managed across sectors and decisions should be made taking all stakeholders and users into account (UNDP, 2006).

Regions facing water scarcity such as Small Pacific Island Developing States (SIDS) have also faced challenges to manage and conserve their limited freshwater resources. In Singapore, water purification and recycling schemes have been successfully implemented with NEWater technology (Singapore's National Water Agency, n.p.). Recently, Singapore is fulfilling 40% of its water requirement through this technology. Through awareness-raising and educational campaigns regarding NEWater treatment plants, the message (sustainably managed water resources) was made accessible to all world (WWAP, 2015a).

A similar situation has also prevailed in the Gulf States/Middle East countries. Facing freshwater water scarcity, they are fulfilling their water demands through Integrated Water Management (wastewater treatment or desalinization) with the continuous increase in wastewater generation. Likewise, Saudi Arabia and the UAE are treating saline seawater to meet their domestic water demands. However, these countries are not agricultural counties. Other agricultural countries of this region are using wastewater for irrigation proposes considering the wastewater as a cheap alternative water source.

Israel is one of the prominent countries thathave satisfied its agricultural sector's water by treating the wastewater (Haruvy, 1997). In Israel, treatment of urban wastewater is cheaper than other alternatives (desalination). Haruvy et al., (1999) also preferred the reuse of such treated water for irrigation purposes, as an alternative source of water. Currently, Israel has been fulfilling 63 percent of its agricultural water demand through treated wastewater (Haruvy et al., 2000). According to Israel water commission report, 70 percent of the irrigation water demand in Israel would be satisfied with treated sewage effluent by 2040 with a water supply of 1 billion m^3 (Haruvy et al., 1999).

In the same way, treated wastewater is mostly utilized for irrigation purposes after fulfilling the environmental standards in several high-income economies. These treated effluents also satisfy the demands of the industrial and construction sector, wildlife and aquaculture, and landscape requirements. The largest wastewater treatment system—enhanced lagoon system—is situated in Melbourne, Australia. This system has met the environmental quality standards of the 21st century. First, it was established on a wastewater-irrigated farm in 1897. Later, the WSP system was introduced in 1937. Recently, WAP received wastewater from 1.6 million people of the city and industries. In 2001, the '55 East Lagoon system' was further launched. Another successful example is the U.S., where treated effluents have been commonly used to irrigate golf courses with secondary municipal sewage (Melbourne Water, n.p.)

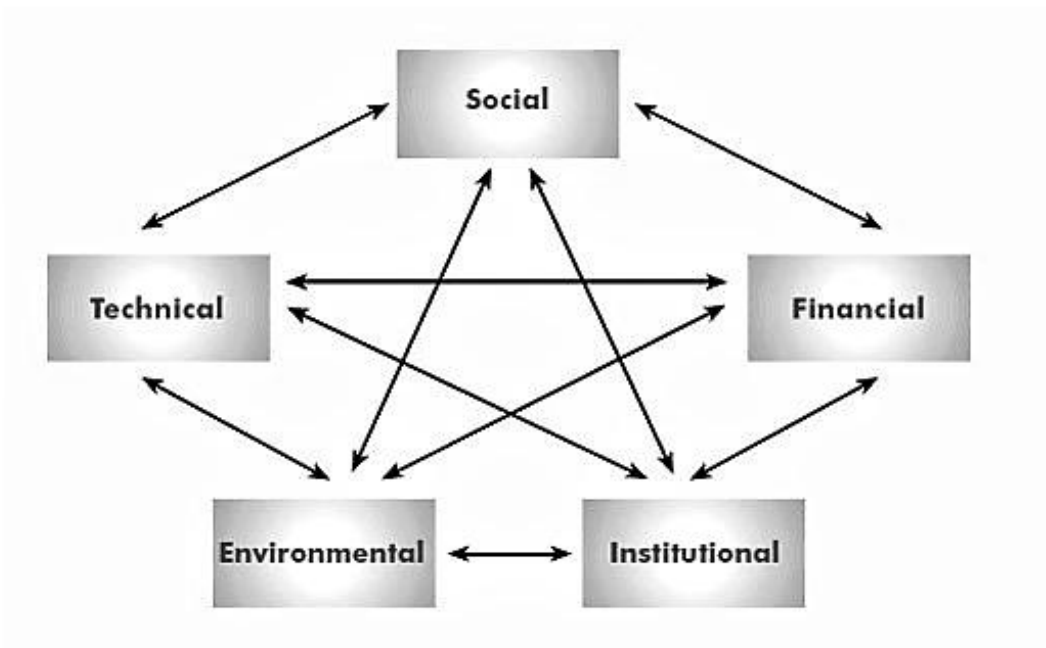
In short, the rapid increase in the world (urban) population along with industrial development has depleted alreadylimited natural resources. Water is one of them. Within the global scenario, the United Nations stated wastewater as 'an untapped resource' and an emphasis has been made to utilize this resource as soon as possible to have an affirmative view. Instead of draining freshwater resources, wastewater can be considered as an alternative water source, which can be achieved with proper management and planning (WWAP, 2017).

2.3.3 Sustainable wastewater management

The term 'sustainability' has quite a wide spectrum of facets. WWAP (2012) highlighted sustainability through three main dimensions, which are poverty and social equality (1), economic development (2), and environmental protection and ecosystem services (3). These all dimensions are also widely or partially interconnected. In the obvious phrase, sustainable development means that zero or minimal level of adverse external effects on the environment, humanity, and wellbeing is associated with any economic activity. Undoubtedly, water being a scarce environmental resource appears under the umbrella of sustainable development. Without sustainably managed this resource, the global sustainable development goals cannot be achieved. Precisely, sustainable sanitation and wastewater management is one of the ways to achieve sustainable development. Andersson et al. (2016) explained the term sustainable sanitation and wastewater management systems such as follows:

"Sustainable sanitation and wastewater management systems are those that minimize depletion of the resource base, protect and promote human health, minimize environmental degradation, are technically and institutionally appropriate, socially acceptable and economically viable in the long term." (p.11)

It is evident that sustainable management of water and sanitation is extremely complicated due to its multifaceted contexts. Mostly, many contextual targets have to be addressed simultaneously to achieve a single policy target.



"Sustainability = Continuous, satisfactory functioning and effective use of WSS services. (Effective use by the majority in a health-promoting and environmentally sound manner)."

"Equity = Everyone (e.g., women and men, rich and poor, social minorities, and majority groups) has equal voice and choice in decision making, equal access to information/external inputs/benefits from projects, and shares burdens and responsibilities fairly."

Figure 2.4:Five aspects of sustainability in water and sanitation services

Source: Adapted and modified from Mukherjee ad Wijk, 2003: p. 3

Figure 2.4 explains the five interconnected features required to maintain sustainability in the water and sanitation sector. Mukherjee and Wijk (2003) elaborated these five interconnected features that are social, financial, institutional, environmental, and technical. Within the scope of this study, the focus is to investigate and analyze the information around these pillars to get insight into reasoning for unsustainability in the system. From the management or administration point of view, all these features are crucial. Bearing responsibility to run the system for betterment, administrative bodies have to either take decisions short term or long term basis. Decisions were made based on the existing financial and physical resources keeping in view the strategic targets. These decisions initiate actions through institutions, which are monitored by existing laws within that region. The institutional framework implements the new or decided plans for humans and environment. Even then, technicalities of the all predefined actions may affect the scenario. Therefore, with such complex perspective, policymakers should be clear about the interactions among the problems, policy's targets, legislation, institutions, and organizations/agents. Mayda (1985) explored the essential component of the national/regional ecomanagement system with this simple diagram (Figure 2.5).

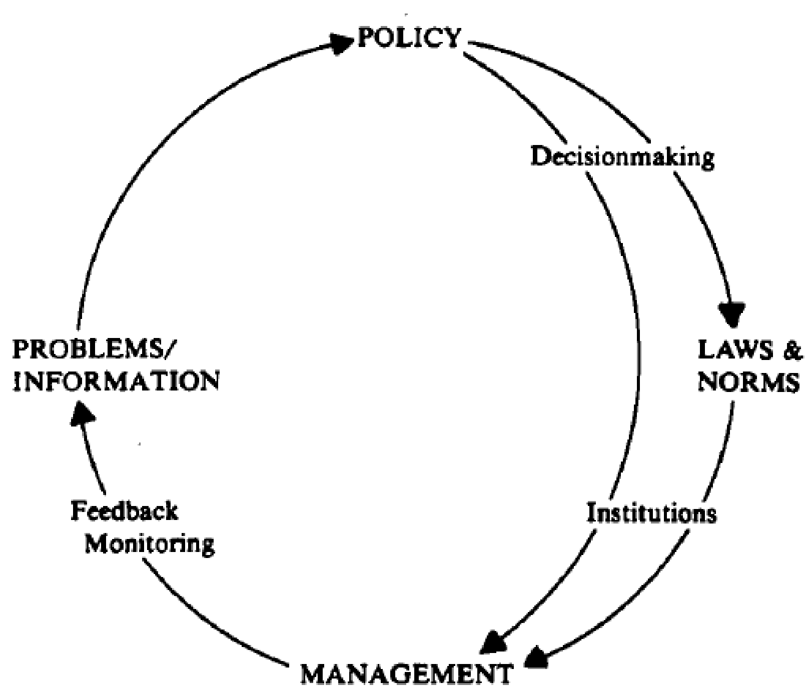
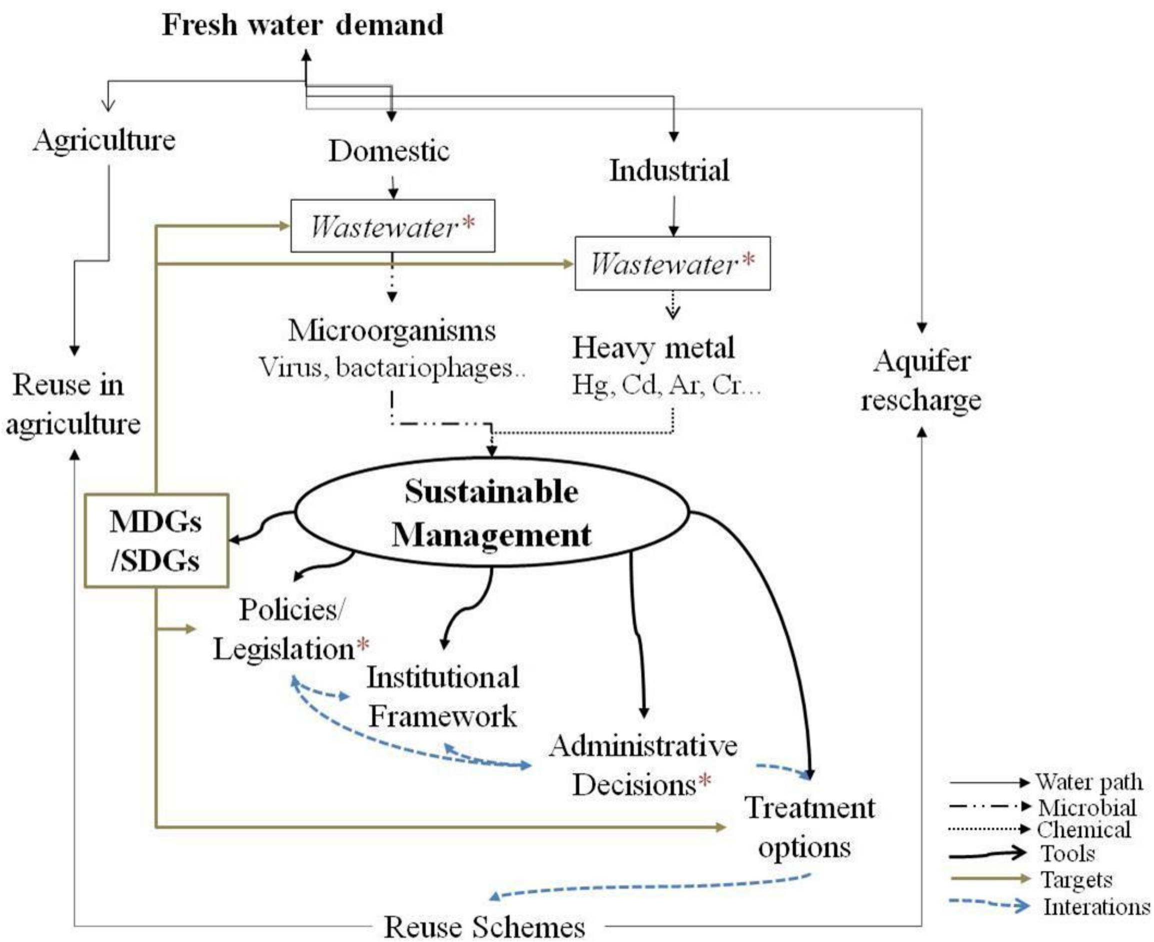


Figure 2.5:Interactions among problem, policy and management
Source: Adapted from Mayda (1985, p.1001)

The steps and their interactions in Figure 2.5 elaborated as "problems/information—policy—management". This model explained generally that legislation and management are tools to achieve policy objectives of ecomanagement through institutions. The laws and norms would internalize through institutions. Each component on its own, even if 'best,' could not achieve the prescribed goals alone. This model helped to image a conceptual map for analyzing the problem, legal background, role of institutions, and the management challenges. In line with such conceptual background, the increasing trends of the continuous discharge of wastewater require such management, which would sustain the world's limited natural resources.Consequently, the only option to achieve this target is sustainable wastewater management (socio-economic, environmental, and institutional).

The challenge for under developed and emerging economies to achieve sustainable wastewater management with a limited development budget is a hard task. Sustainable wastewater management has been a top-ranked policy objective in developing economies (SDG targets). The indication of a sustainability targets is crucial step for further implementations (Opoku, 2016). Focusing on wastewater management, treatment, and reuse schemes, Pescod (1992) also emphasized five main yardsticks. These include the monitoring of wastewater discharge, target setting to water and sanitation conditions, access to water and sanitation facilities, safety training of users (farmers and/or others), and multi-objective interdisciplinary planning. Wastewater, either domestic discharges (both grey and black), industrial effluents, or storm water should be managed/treated/recycled in a sustainable way so that it would not have any negative impacts on either the environment or our generations (recent and future).



* Standards on quantity and quality of discharges and monitoring the regulations through institutions

Figure 2.6:Conceptual framework for sustainable wastewater management
Source: Author

The wastewater and freshwater cycle are interconnected and the associated benefits and risks have already been briefly mentioned (Section 2.1). The Figure 2.6 nearly explains the term ‘sustainable wastewater management’ used with the reference of this study.

As, sustainable wastewater management just cannot be attained just through treatment and reuse schemes. A sustainable wastewater management system, theoretically such system, which ensures zero or minimal harmful externality to environment and human on long term basis. Such system requires efficient legislative bodies focusing the sustainable goals, effective legal framework for monitoring and enforcing laws, strong implementing institutions, advanced technical and scientific assistance for cheap solutions, and good governance.

As mentioned earlier, sustainable wastewater management is a multifaceted approach. It requires multidisciplinary steps simultaneously at each level. Moreover, pollution is no more a local or regional threat. Yet, it is global even spreads out over the future generations. Within the scope of study,focus is towards exploring the reasons of mismanagement of wastewater in the developing countries scenario. Before going in depth with administrative and management system of any particular region, there is necessitate to first comprehend the existing knowledge on the subject ofintuitions, institutional behavior, institutional economics, institutional analysis. Next, a concise review of excising literature was briefed keeping with the focus of the aim of study (challenges within the institutions responsible for wastewater management).

2.4 Institutional analysis

This section overviews the institutional arrangements for sustainable management of wastewater.At first, literature regarding constitutional and legislative framework to control water pollution and safe reuse in agriculture is reviewed. Next, theories and concepts for analyzing an institutional setup are presented and the indicators for institutional challenges are indentified.

A brief review of the literature on transitional (linear to circular) wastewater management has discussed earlier (Section 2.3). Taelman et al., (2018) studied a combination of methods for improving system sustainability. Such sustainability framework referred to a number of analytical approaches such as ‘life cycle assessment’, ‘risk assessment’, ‘material and energy flow analysis’, ‘multi-criteria optimization’, ‘stakeholder analysis’, and so on. Theoretically, such certified techniques/methods are capable to recognize the scenario analysis and impact assessment. These methods are so authentic but require specified data and information. Whereas, the situation is convoluted in low and middle-income countries; the absence of required data for these analytic methods makes the situation chaotic for policymakers and administrators.Under such circumstances policies and strategies, which proved successful in some other region, are applied without knowing the real issues in that specific region.

Hence, the basic concepts of institutional theory were reviewed for understanding the theme of institutional analysis. The objective was to analyze the institutional framework of wastewater management within a specific context. Here, the consideration of water/wastewater as a common pool resource also push first to understand the institutional arrangement, their interactions with actor (stakeholder), and existing rules and regulations.

Explicitly, institutions are instructions—utilized by humans—to govern or organize repeated interactions with one another (family member, friends, markets, and government officials).The institutional framework is a composite of rule, informal constraints (norms of behavior and conventions) and its enforcement characteristics (Milgrom, North, & Weingast, 1990; North, 1991).

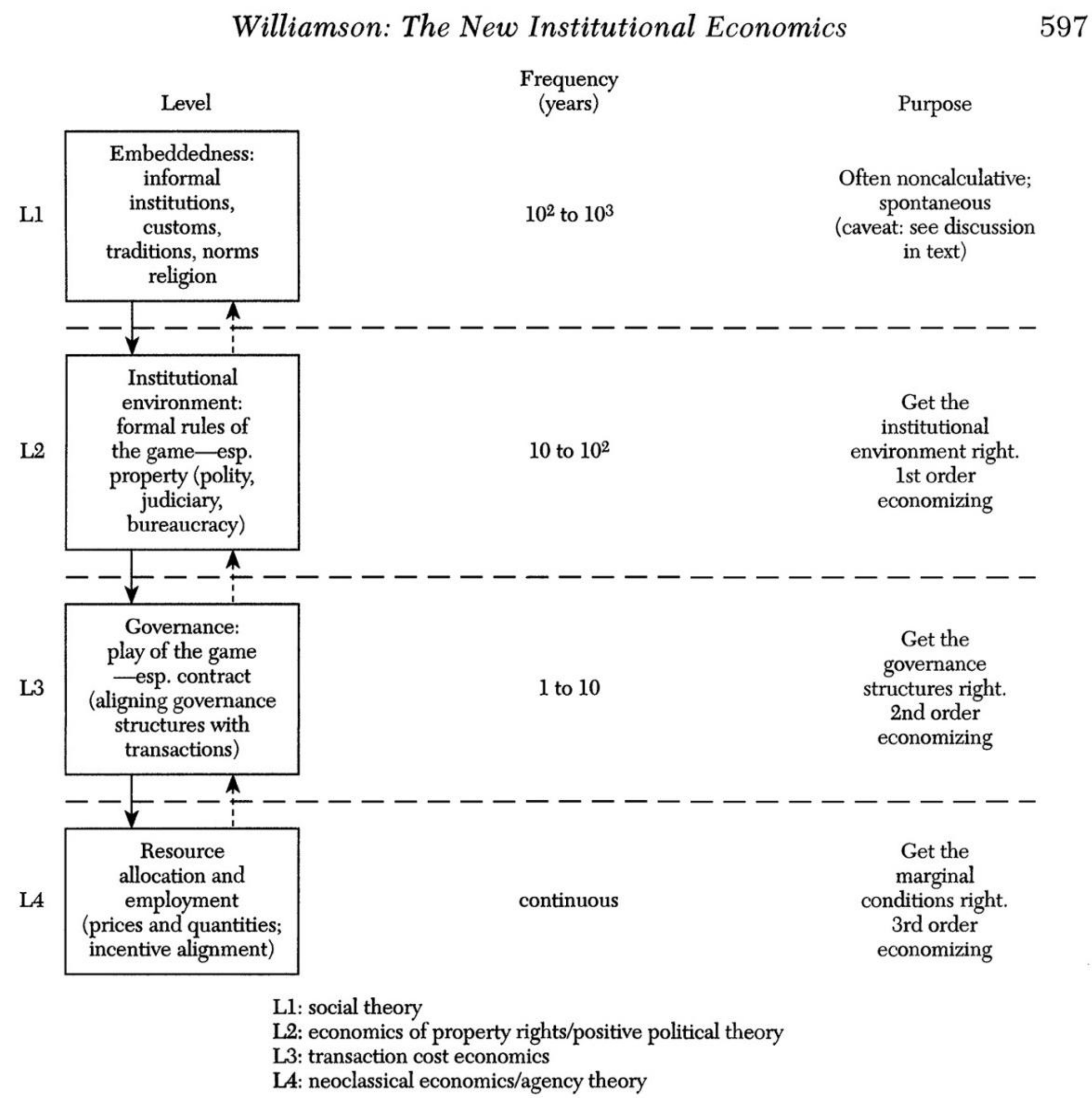


Figure 2.7:Levels of institutions and their time horizon

Source: Adapted from Williamson (2000, p.597)

Figure 2.7 explains the time horizon for development/modification of laws, the establishment of institutions, and decisions about resource utilization (firm theory). He argued that any policy objective with social interactions normally takes decades to achieve. This layout helped to understand the different level of institutions for this research.

The institutional theory has been mainly used in the fields of economics ((North, 1991); Williamson, 2000; Ostrom, 2005) as rational choice institutionalism. Economists have often used the rational choice theory to input available institutional and socio-economic information to evaluate generalized models. The process of knowledge creation would be valid when case studies based on randomly selected objects having less 'degree of freedom'. The choice of the dependent variable – selection a 'phenomenon of interest' where it occurs and ignoring where it does not occur – and other explanatory variable provide an optimal way of arguing. At the same time, some important implicit variables have been omitted from the model while supposing 'other things remain constant.' The way the current model is setup may influence the same variables to react differently (Moloney, 2013; Pierson & Skocpol, 2008; Steinmo, 2008; Thelen, 1999).

Furthermore, institutional theory has also been employed in organizational sciences (Alexander, 2010; Moulaert, 2005) as historical institutionalism (HI). Historical studies on administrative organizations have critically evaluated their objectives, establishment development, hierarchy, and resources (Moloney, 2013; Thelen, 1999).

Moreover, institutional theory has also been engaged with political science (Ostrom, 2005a) and sociology (Geels, 2004) as sociological institutionalism. Steinmo (2008) described the institutional analysis in social and political sciences in details.

A comprehensive framework involves two steps introduced in the ecomanagement system (see Figure 2.5). First, policies that aim to promote minimum pollution and maximum resource recovery after the water withdrawal and usage are explored. The legislative branch at regional or national levels would be recommended to take on this task. Then, the second step is to properly implement and monitor regulations through institutions. The following subsections flow this inclination.

2.4.1 Legal framework

The following segment describes the literature addressing possible strategies and policies for sustainably managed wastewater.

The behavioral studies of formal rules and stakeholders can actually help to understand the reason behind accepting or rejecting new ideas or changes within society. Within the traditional concept of institutionalism, institutions are established, functioning, and modified based on the basic principles of economics. These institutions are established to structure the basic needs and interests of the society. In contrast, the new institutionalism approach advocates the establishment of institutions based on formal rules derived by individuals. It would improve the institutional capacity of society in two ways. First, it can reduce uncertainty/fear of stakeholder against any new idea/change. Secondly, existing rules can be well understood and adopted by the actors(Klein, 2000; Nhundu, 2013).

2.4.1.1 Guidelines and standards

The UN contributed a lot in terms of setting guidelines and standards for wastewater management. International standards were set regarding wastewater dumping, health guidelines for reuse of wastewater, and parameters for irrigation water (International Finance Corporation, 2007). World Health Organization also gradually revised health guidelines of wastewater irrigation, in 1985, 1989 and 2006 (Mara & Cairncross, 1989; WHO, 1989, 2006). Gradually, these standards became accurate and precise. The aforementioned framework introduced an acceptable range for microbial contamination and other chemical substances in wastewater (WHO, 2006). In addition, the Food and Agriculture Organization (FAO) recommended the parameters for the quality of irrigation water. The goal was to develop a frameworkthat would reduce risksof wastewater irrigation.Three objectives set by policymakers were public health, environmental protection and food security.With reference to sampling procedures, evaluation, and reporting the quality of wastewater, the International Organization of Standardization (ISO) has set the standards. Such international guidelines can help national or regional government while setting their own national or regional standards by reducing the evaluation cost or by following the procedure and/or standards(WHO, 2006, Vol. 1).

However, setting up standards and periodic revisionsare not enough. Without proper implementationand monitoring, it is difficult to regulate(Gomes, 2009). Thus, it depends onthe local administration of each region/country to which level they follow these international standards while setting their national environmental quality standards (NEQS). After conducting an empirical study using available global survey data about pit latrine coverage,Graham & Polizzotto (2013) concluded that domestic effluents guidelines vary widely from country to country.

2.4.1.2 Policies, rules, and regulations

The institutions provide frameworks and perspectives to allow or hinder work for changes in society (Bandaragoda, 2000; Ostrom, 1992; Pierson & Skocpol, 2008). The traditional theory of institutionalism incorporates the concepts of "formal rules," "rules and regulations," "governance systems," and "informal norms." Informal rules or "rule-in-use" are codes of conduct among society members, which influence behaviors such as culture and recognition (Bandaragoda, 1993, 1999; Devi & Samad, 2006; North, 1991; Polski & Ostrom, 1999).

Type of Rule	Function of rule
Poistion rules	Create positions (e.g., member, judge, voter, representative) that actors may hold.
Boundary rules	Define (1) who is eligible to hole a certain position, (2) the process by which positions are assigned to actors (including rules of succession), and (3) how positions may be excited.
Choice rules	Prescribed actions are actors in positions must, must not, or may take in various circumstances
Aggregation rules	Determine how many, and which, players must participate in a given collective or operational-choice decision.
Information rules	Authorize channels of information flows available to participants, including assignation of obligations, permissions, or prohibitions on communication.
Payoff rules	Assign rewards or sanctions to particular actions that have been taken or based on outcomes.
Scope rues	Delimit the range of possible outcomes. In the absence of a scope rule, actors can affect any physically possible outcomes.

Figure 2.8:Types of rules followed by IAD framework
Source: Adapted from Cole (2014, p.16)

Constitutional rules and regulation determine the operational choice by the institutions (Figure 2.8). These rules affect the outcomes and interactions between institutions and individuals (Ostrom, 1998).Constitutions, laws, rules, and regulations are formally written instructions to establish institutions and interactions among players/agents. Such formal rules are written on paper and are designed to control the players' behavior long term. Administrative orders, legal notices, penalties, contracts, and sanctions are examples of formal rules which give directions under specific policy intents (Milgrom, North, & Weingast, 1990).

The legal framework for controlling water pollution or health impacts has multifacetedaspects at various administrative levels.Laws regarding freshwater pollution, wastewater treatment, untreated wastewater irrigation, and industrial toxicology promulgated until the end of the twentieth century in most developing countries (Slater, 1999).Traditionally,most regions adopted a command-and-control approach, which proved ineffective due to limited available resources, both human and financial (Malik & Datta, 2005).

Unfortunately, weaklaw enforcement in developing countrieshas not helped improve their performance in the wastewater management sector. The situationhas becomeinferiortobefore. Public infrastructure for wastewater management has also suffered fromweak governance and mismanagement. The empirical studies proved that responsible authorities of these regulations could not control the situation in most casesindeveloping countries(Blackman, Lahiri, Pizer, Rivera Planter, & Muñoz Piña, 2010; Sjöberg, 2016).

2.4.2 Institutional and administrative analysis

Daily, laws are not made, but implemented. The next consideration is about regulations and law enforcement through institutions.Administrative and organizational networks are responsible for effectively enforcing legislation to achieve the targets of environment protection and human welfare. Institutions are made under the law to take management decisions.

Later in the 21st century, the notion of 'new or neo-institutionalism' appeared. It emphasized the relationships between institutions and behavioral actions of agents (North, 1991). The interactions between rules and actors or stakeholders were the focus of new institutionalism. Such adaptation was a result of the theory of institutions predicting and analyzing the behavior of agents over formal rules, which established through rational choice theory without considering the norms of society such as culture, personal preferences, and perceptions (Coase, 1998; Klein, 2000; Ménard & Shirley, 2014; North, 1993).

The following segments briefly discuss historical institutionalism, institutional analysis and development framework, and evaluation indicators for institutional frameworks.

2.4.2.1 Historical institutionalism

As above-mentioned (Section 2.4)schools of thoughts—historical institutionalism, sociological institutionalism, and rational choice institutionalism—appeared under the umbrella of 'new/neo-institutionalism.' All these approaches have focused onexploring the interactions among institutions and social behavior. Simply, these approaches have aimed to look at the role of institutions within diverse social and political scenarios (Hall & Taylor, 1996; Thelen, 1999).

Historical institutionalism (HI) is neither a specific theory nor a particular method, but an approach analyzing the combined effects of institutions and progressions over time rather than just examining one institution or procedures at a time like in behavioral studies (sociological studies) (Steinmo, 2008, p.1). Historical institutionalism can be defined as:

"Taken together, these three features --substantive agendas; temporal arguments; and attention to contexts and configurations -- add up to a recognizable historical institutional approach that makes powerful contributions to our discipline's understandings of government, politics, and public policies" (Pierson & Skocpol, 2008, p.3). In short, HI has an aim to get across the historical development of institutions. History matters if one wants to understand any policy process in a meaningful way (Pierson & Skocpol, 2008).

2.4.2.2 Institutional analysis and development (IAD) framework

Institutions design the interactions with agents, while repeated social behaviors of agents formulate the institutional environment. Therefore, the analysis of mutual interactions between institutions and actors provides the insights for planning and modifying of intervention measures. Insight-based actions and action-based insights both affect institutional reform. This concept is utilized for institutional analysis.

Ostrom suggested the institutional analysis for resource usage and management. The institutional analysis and development (IAD) framework propose to simplify the institutions with their complex structure in a broader aspect of analyzing the interaction and outcomes."The IAD framework helps to organize diagnostic, analytical, and prescriptive capabilities. It also aids in the accumulation of knowledge from empirical studies and in the assessment of past efforts at reforms" (Ostrom, 2011, p. 9).

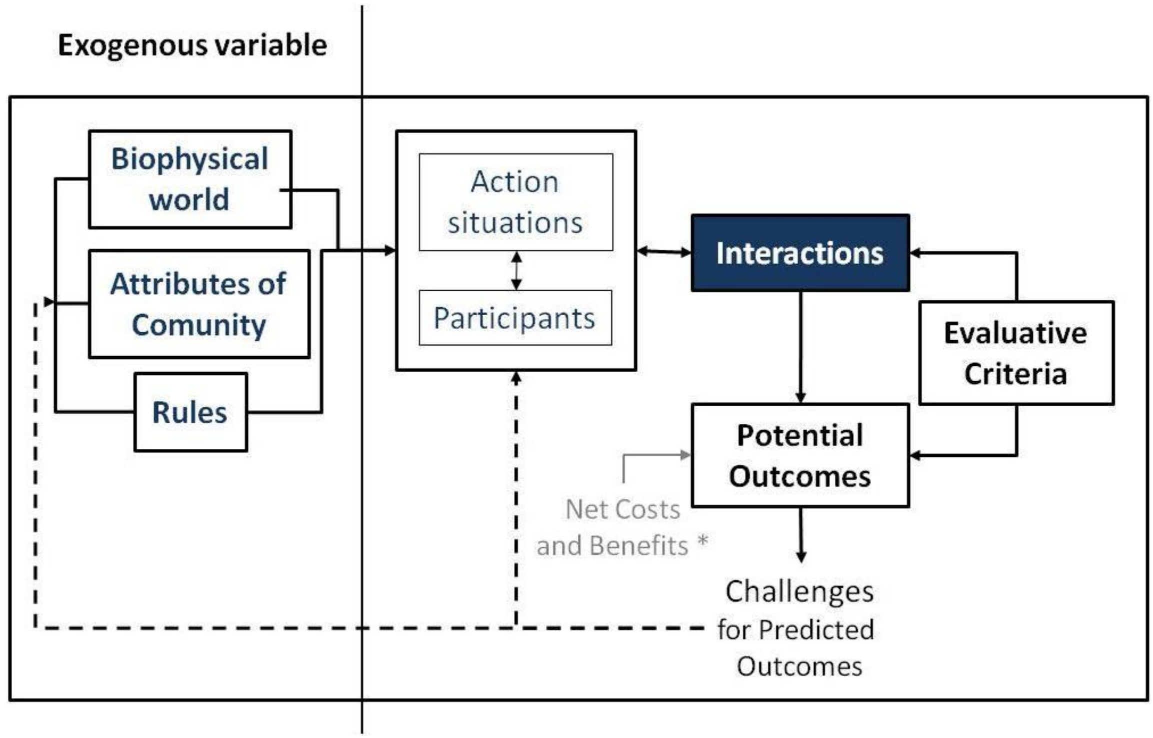


Figure 2.9:A Framework for Institutional Analysis
Source: Adapted and modified from Ostrom (2005)

Figure 2.9 depicts the IAD framework. The Exogenous (external) variables explain the external factors including physical attributes (resource unit), institutional attributes (positions), and participants attributes (actors, communities) (Ostrom, Benjamin, & Shivakoti, 1994, p. 51). The core part of IAD is the action arena (action situation) in which the individuals and organizations interact and communicate to generate incentives and outcomes.The IAD framework guides to understand the linkages between the physical world (resource unit either goods or services), the rules in use by officials (appropriators), and the communities (participants, actors). To summarize, "The IAD framework assigns all relevant explanatory factors and variables to categories and locates these categories within a foundational structure of logical relationships" (McGinnis, 2011)(For more details see, Bravo, 2002;Cole, 2014;Mccord, Dell'Angelo, Baldwin, & Evans, 2016;Ostrom, 2005, 2011; Partelow & Winkler, 2016).

Multilayered interactions across institutions and players can anticipate, that how a current or future development change can affect institutional circumstances. Analyzing institutions and their interactions with agents is not an easy task with reference to a specific aspect. Williamson (2000) explained four levels of social analysis along the time horizon (Figur 2.7).

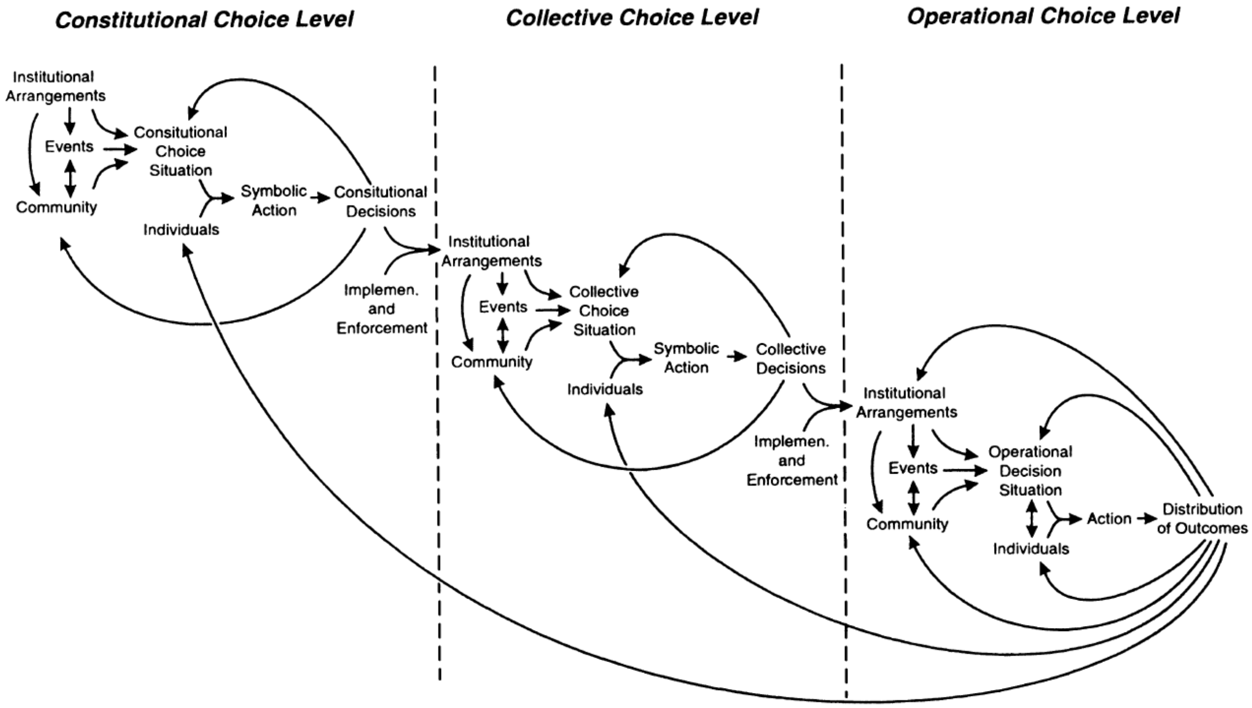


Figure 2.10:Levels of institutional analysis
Source: Adapted from Sabatier (1991, p.152)

Figure 2.10 explains the level of institutional analysis within the framework of existing dynamic interaction between institutions and actors.Rules are semantic statements (either written or not) for participants to follow repeated interaction with one another. Enforcement of rules generates the outcomes. Rules categorized indifferent levels arepresented in Figure 2.10. All these levels are linked to one other. For example, a collective-choice rule,guided by constitutional rules— used by officials— directly affects the operational rules (For detail reading, see Bandaragoda, 2000, p. 12).

An institutional analysis report regardingfecal sludgemanagement in Burkina Faso concluded that, in the absence of proper coordination among all stakeholders, coinciding liabilities of governing organization created chaos. A large number of stakeholders were involved due to a lack of clear legal regulations demarking the responsibilities of each stakeholder. Stakeholder analysis and focus group discussionswere used for the institutional analysis report (Bassan, Mbéguéré, Tchonda, Zabsonre, & Strande, 2013).

Exactly, Ostrom (1992) defined institution as “simply the set of rules actually used (the working rides or rules-in-use) by a set ofindividuals to organize repetitive activities that produce outcomes affecting those individuals and potentially affecting others” (p. 19). In reality, informal rules or rules-in-use are working rules that are hidden but they directly affect the interactions among the actors in the action arena. Informal rules, based on the settings within the society such as culture, beliefs, personal attitudes, awareness, convention, and working habits, are derived from repeated actions. They also influence the grounds and implication of formal rules (Ostrom, 1992, 1; Polski & Ostrom, 1999; Yin, 2014).

It is hard to include informal rules such as working attitude and behavior in the analysis of the institutional environment. Only activities based on working rules are observable.Ostrom(1992) explained that rule-in-use or working rules are hard to define because they are usually hidden, unexplained, and complex. Activities and organizations are visible, whereas institutions are invisible. Ostrom uses another term "knowledge-in-use," which refers to the level of knowledge of an individual. One can detect or observe the knowledge-in-use through interviews or texts regarding the individual. A single observation is not enough to check the knowledge. Long-term observations are required to check the knowledge-in-use for individuals on how they are working and organizing the activities. The perfect system or the 'rule of law' surfaces when formal rules and working rules perfectly coincide (Elinor Ostrom, 1992). In Figure 2.11, interactions between formal rules, norms, and informal rules are explained. Cole (2014) concluded within the study that these three types of relationships mostly exist in various situations.

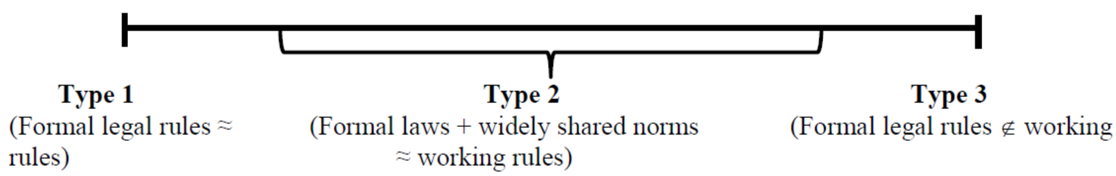


Figure 2.11:Interaction among formal rules, norms and working rules
Source: Adapted from Cole (2014, p.27)

Some studies have explored the variation between formally declared rules and hidden working rules. Along these lines, Devi & Samad (2006)conducted an institutional analysis regarding wastewater treatment and use in Hyderabad, India. The study concluded that gaps between declared rules (formal) and rules-in-use (informal)exited due to the weak institutional framework, the absence of public awareness, and financial budget constraints.

2.4.2.3 Social/governance challenges identification

To implement policies for environmental protection and sustainable development, an efficient public administration is needed.Recall the term "governance" defined by UNDP (1997) cited by UN system Task team (2012) as "it contains mechanisms, processes and institutions, through which citizens and groups articulate their interests, exercise their legal rights, meet their obligations and mediate their differences"(p.3).Here, the notion of 'governance'can explain the term 'management through institutions' in the above-mentioned manner.Governance as 'power relationships,' 'formal and informal processes of formulating policies and allocating resources,' 'processes of decision-making' and 'mechanisms for holding governments accountable' (United Nations Educational,Scientific and Cultural Organization UNESCO, 2009; Weiss, 2000).

An efficient governance system is required to achieve the goal of sustainable development (Ahmed & Basit, 2012). Wittmer et al., (2005) studied governance issues for water resource management in Chile and suggested the guidelines on infrastructure investment for policymakers.Lapses in governance are actually the reasons of unsustainability in the management system. There is a need to look at the formal setup of institutions and their interactions with individuals. The analysis of aninstitutional framework of any region/country with regard to some specific aspect could guide the role of the state and existing institutional behaviors within that social circumstance(Ménard & Shirley, 2014).

Table 2.2:Indicators for evaluation of institutional framework

Parameter	**Evaluative criteria using IAD framework**	**Governance criteria**
Equity	• Equity in decision making process • Benefiter should pay towards the service provision	• Negotiating Public Support • Task funding
Accountability	Institutions should be accountable for their actions	• Legislative actors' resources • Media reporting • Intra-party democracy • Association competence • Voicing opinion to officials
Adaptability, stability, sustainability	Institutions are capable to respond the variations	• Domesticadaptability • International coordination • Sustainability check
Efficiency	• Economic efficiency • Administrative efficiency	• Government efficiency • Ministerial compliance • Inter-ministerial coordination • Monitoringministries, agencies, andbureaucracies • Constitutional and national standards
Policy outcomes	• Feedback and learning	• Policy communication • Policy knowledge • Strategic planning • Scholarly advice • Self-monitoring • Institutional reform
Sources	Evans, (2016); International Fund for Agriculture development [IFAD](2009);Imperial & Yandle, (2005)	Bertelsmann Stiftung (2016); IFAD(2009)

Table 2.2 elaborates the majorevaluative criteria for analyzing the institutional framework. Such analytic approaches can be applied to explore wastewater management structure. No doubt, the decision to construct treatment plants, feasible solutions for effective governance by the

publicsector, and the choice of wastewater for irrigation can vary from location to location.The following section portrays such variations at regional or national level for wastewater management around the world.

2.5 Regional disparities and data constraints

The situation in developing countries, particularly in newly growing economies, is complex. Such countries are already facing high population growth rates, which makes it a challenge to manage limited freshwater resources. The condition is alarming in those areas that are facing water scarcity, either physically or economically. Within these areas, non-renewable resources (land and water) are at risk (WWAP, 2012).

The wastewater governance varied widely depending on local economics, financial conditions, physical infrastructure, and political intentions. The lack of data has also made targeting and estimating MDGs challenging due to regional disparities.WWAP (2017)documented the regional challenges in Africa, Asia, the Arab countries, South America, Europe, and North America. UN-Water (2014)outlined the overall achievement of MDGs regarding water and satiation. Theyfound that the main obstacle for achieving MDG targets was low coverage and high population growth in the least developing countries. Half of them wereclassified as "fragile situations". The same constraintsalso hamper the progress of MDGs on water and sanitation targets. To estimate improvement, there is also a need to monitor the effect of interventions on different socio-economic (rural or urban area) backgrounds of people. Furthermore,inequalities among people (wealthiest&poor) affect the access to facilities or services. Such conclusions were drawn with a retrospect analysis of 25 years of evolution in water, sanitation and hygiene monitoring (WHO/UNICEF, 2015; WWAP, 2015b).

Likewise, the World Health Organization(2012) already assessed the global drinking water and sanitation situation in its "GLAAS 2012" report. It gave importance to increasing sanitation coverage, managing assets, and sustaining services. The main constraint in its assessment was the lack of data availability, especially on financial aspects.

The other constraint, policymakers wouldface the absence of specific information/data. As, UNEP (2011) noticed that the most significant constraint in development programs was the lack of orinadequate information oncity population, public sanitation services, and the status (extent and scope) of treatment facilities. Such constraints also affected advanced analysis with available data.Moreover, Sato et al. (2013) indicated that information on wastewater generation, treatment, and reuse at the national level is lacking in most developing and least developed countries. About only one-third of countries,have data about all threeabove-mentioned aspects. About 38 percent of them have information about one or two aspects. However, 31 percent have no information regarding any aspect. Mostly, the information on industrial discharges or a register of industries is missing (UNESCO, 2009).Sato et al. (2013)also underlined the issue of missing information on the volume discharged, quality of effluents,and location of wastewater reuse in agriculture.Certainly, the lack of information further created hurdles for detecting the impact of poor wastewater management oncommunities and natural resources (at the micro-level). Sound policy can only be recommended based on necessary reliable data (from raw data to informed decisions).Concisely, water and sanitation (environmental degradation) managementhave suffered from poor and insufficient data(Graham & Polizzotto, 2013).

As an alternative option, FAO has set up a database AQUASTAT on local wastewater generation, collection, and treatment. Mateo-Sagasta & Salian (2012) explained the methodology for the global database. For this purpose, peer-reviewed articles, workshops, expert seminars, and global databases have been organized. To maintain quality assurance, all collected informationwere analyzed, authenticated, and properly arranged. Then, validated data wasuploaded to AQUASTAT. Also,the latestcountrywide information on secondary and non-prevalent sources of water wasavailable. No doubt, this effort extended the spatial and temporal perspective and looked at the maintenance capability of water resources.However, the problemwasstill there. It was reported during 2008-12, only 37 percent of the data was updated by countries (Sato et al., 2013).

In sum, sustainable management of water resources, including wastewater, requires a comprehensive strategy and an institutional approach at local level because many of the obstacles based on local diverse conditions (Mateo-Sagasta et al., 2013). Implementation of a comprehensive strategy with desired global goals can only be successfully achieved through local support (think globally, act locally). Although regional disparities may vary and complex like in Pakistan, but the devlopment procedure should not stop at any cost.

2.5.1 Pakistancontext

The water economy of Pakistan is getting drier bythe day (Briscoe & Qamar, 2005).Undoubtedly, all freshwater resources are being withdrawn. Only the quantity of wastewater or 'wasted-water' has increased. Some alarming slogans such as "everyone is fighting over water" or "by 2025, no water will be available" illustrate the concerns (Khan 2016). Even water scarcity is becoming a war threat between Pakistan and India (Kugelman, 2016). In fact, Pakistan is facing three water-relatedhotspots, which are increasing water scarcity threat, high water utilization, and deteriorating water quality (WWAP, 2012, p. 197). Water availability is also linked with poverty in Pakistan (World Bank Group, 2018). Environment sustainability index for Pakistan is 39.9 (UNEP, 2014, p. 34). Environmental sustainability index expresses the eco-friendly performance of a country.

Table 2.3:Population, urbanization, industrialization and water scarcity in Pakistan

Year	Population (Million)	Population Growth rate (%)	Urbanization (% of population)	Industrialization (share of manufacturing in real GDP %)	Water demand for domestic use (MAF)
1980	84.9	3.0	24.1	13.8	-

1990	110.8	2.6	34.7	17.4	4.1
2000	140.5	2.1	47.5	23.0	5.2
2025*	228.8	2.4	-	-	9.7

Data sources: Population Reference Bureau (2004); Ministry of Finance & Economic Affairs (2004, 2001); Federal Bureau of Statistics (1991); Kahlown and Majeed (2002)
Note: * Estimated

Source: Adapted from Siegmann & Shezad (2006, p.3)

Indicators such as population growth, urbanization, industrialization and water demand in Pakistan are summarized in Table 2.3. During the last few decades,along with water scarcity, water pollution hasbeen a critical issue. Untreated wastewater from houses and industries are directly dumped into either agriculture fields or rivers. Wastewater dumping has been a threatening situation in big industrial cities such as *Karachi, Lahore, Faisalabad*, *Sheikhupura*, *Gujranwala*, *Kasur*, and *Rawalpindi*. The Indus river basin has faced a high level of ecosystem deterioration.

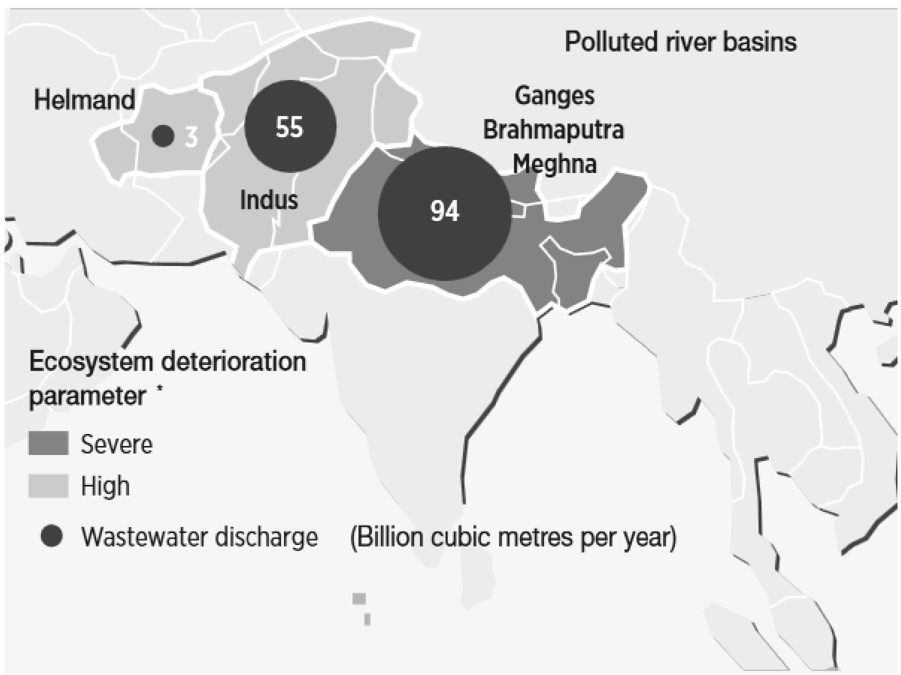


Figure 2.12:Indus plains in Pakistan as polluted river basin

Source: Adapted and modified from WWAP (2012, p.417)

In Figure 2.12, water pollution in Pakistan isdepicted. In this report, ecosystem deterioration parameter has been estimated as land area without vegetation. Such loss of vegetation has been caused by vulnerable conditions of available water resources (WWAP, 2012).

A study on the sediment of River *Ravi* exposed heavy contamination of Cu, Co, Cr, and Cd. Effluent tributaries carry polluted discharges and affect aquatic ecosystems(Rauf, Javed, Ubaidullah, & Abdullah, 2009). Eleven municipal drains just from Lahore (four from other cities) have discharged municipal and industrial effluents directly into River *Ravi*.The statement “once

Ravi was River, now it is a drain" to some extent elaborates the current situation of River Ravi (Raza, 2015).

The largest manufacturing and the second-largest employment-generating sector of Pakistan is thetextile sector. There are about 600-800 wet textile units within the country to produce the final fabric. Such industries make up 50 percent of Pakistan's export. However, these wet textile units are creating a high level of water pollution by releasing industrial effluents. The Ministry of Industry and Production in 2010documented the annual discharge of industrial wastewater to about 7.6 billion m^3. In accordance with this estimate, one-third of the industrial effluents are generated from the textile sector (Samad, Ahmed, & Gulzar, 2015). Such big textile units are mostly located in *Karachi, Faisalabad*, and*Lahore*. Out of the 475 registered units by APTMA, 135 are located in Faisalabad.

Law enforcement according to the NEQS is weak due to limited financial and human resourcesof administrating bodies. In a study "An Analysis of Environmental Law in Pakistan-policy and Conditions of Implementation," Sohail, Delin, Talib, Xiaoqing, & Akhtar (2014) expressed their concerns ofthe weak role of institutions in the management of commons and community problems. Another Study "Drinking Water and Sanitation Sector Review of Policies and Performance and Future Options for Improving Service Delivery" provided the baseline information about the quantity and quality of wastewater generated in three major cities (*Karachi*, *Lahore*, and *Faisalabad*)(Briscoe & Qamar, 2005: Background paper no. 8). In addition, a study conducted an institutional analysis of Pakistan's irrigation water management (Bandarogoda, 1992; Bandaragoda & Firdousi, 1992).

More than 90 percent of the available freshwater resources (175 billion m^3or 142 MAF)is utilized by the agriculture sector (Briscoe & Qamar, 2005). As wastewater treatment facilities are limited, irrigation with untreated wastewater is widespread because of high population pressure. The number of cities with wastewater treatment facilities is meager(only 4 of 7 cities over a million inhabitants). Major cities such as *Lahore, Faisalabad, Multan, Sheikhupura, Kasur, Rawalpindi* and *Gujranwala* are facing this dilemma on a massive scale. Almost all the towns and cities (>10,000 inhabitants) have sewerage systems to collect discharges from residents. As reported by the International Water Management Institute, approximately one-third of the total wastewater produced has been directly used for irrigation purpose. The remaining wastewater has been discharged into freshwater resources (rivers) (Ensink et al., 2004; Scott et al., 2009). Confirming this survey, about 32,000 hectares of land has been irrigated with untreated wastewater. However, a number of studies identified that accessible information on wastewater generation, collection, treatment, and disposal are lacking or insufficient.

Another field study about the impacts of wastewater on health, natural resources (soil, groundwater), and economic conditions was carried out in *Haroonabad*, Pakistan. Farmers were irrigating their agricultural fields with untreated sewage. The concentration of coliform bacteria and helminthes eggs werehigher than the WHO guidelines(Feenstra, Hussain, & van der Hoek, 2000). The impact of wastewater irrigation on land rents was also reported. The rent rate of wastewater-irrigated farms was six or seven times higher than canal-water-irrigated farms. This was due to higher cropping intensity. Usually, three crops per year could be harvested with wastewater irrigation due to wastewater's continuous supply and high nutrients contents (Scott, Faruqui, & Raschid-Sally, 2004).

2.5.2 Faisalabad, controversial prospects

Although Faisalabad is the hub of textile activities, half of the population directly depends on agriculture for their livelihoods. A large number of textile processing units (including ginning. spinning, weaving) are situated in Faisalabad for easy accessibility to raw cotton. Subsequently, employment opportunities from the industrial sector have stimulated the rural-urban migration, which has pressured cities for proper urban development, including wastewater management.

Untreated wastewater irrigation has been an essential feature of peri-urban agriculture in most developing countries like Pakistan (Hamilton et al., 2007). Likewise, peri-urban farmers of Faisalabad also support wastewater irrigation because of its continuous supply. Undoubtedly, the current researchin this area has been advocated the poor health condition of the farmers and the environmental degradation of natural resources (soil and groundwater). Consecutivewastewater irrigation,year after year, has affected the chemical composition of soil and groundwater(Gallegos et al., 1999; Li et al., 2018).

Public health studies supported the evidence of health riskslinked to wastewater irrigators from water-borne diseases (Saravanan et al., 2011). In his dissertation "wastewater quality and the risk of hookworm infection in Pakistani and Indian sewage farmers", Ensink (2006) concluded that the hookworms infection rate among wastewater irrigators was five times higher as compared to the non-wastewater irrigators. Furthermore, the infection rate was much higher among children of wastewater irrigators than other farmer's children(Clemett & Ensink, 2006; Ensink, Mahmood, & Dalsgaard, 2007; Ensink et al., 2004). The study was conducted in *Chokera* village in Faisalabad, where farmers were receiving wastewater from WASA drains, and such conclusions were made by analyzing counts of E. coli and helminthesfrom crops in the fields (wastewater irrigated) and markets. The E. coli count remained the same but Helminthes were higher in markets.The health risksfrom E. coli and helminthesincreased due to the unhygienic handling of agricultural produce in markets (Ensink et al., 2007). The hookworm infections were relatively higher among wastewater irrigators, while protozoaninfections were equal in both communities due to unsafe drinking water and unhygienic conditions (Amerasinghe et al., 2009).

One study investigated the quality of groundwater in Faisalabad by collecting groundwater sample within the 10 m circumference of wastewater drains. The results showed higher values than WHO-recommended limits of So^4, Chlorides, Sodium, Potassium, Cadmium, Chromium, Iron, Manganese, and Lead in most samples(S. Farid, Baloch, & Ahmad, 2012)(For more details see Butt, Sharif, Bajwa, & Aziz, 2005; Canfieldet al., 1999; Hanjra, Blackwell, Carr, Zhang, & Jackson, 2012; Mateo-sagasta, 2010).

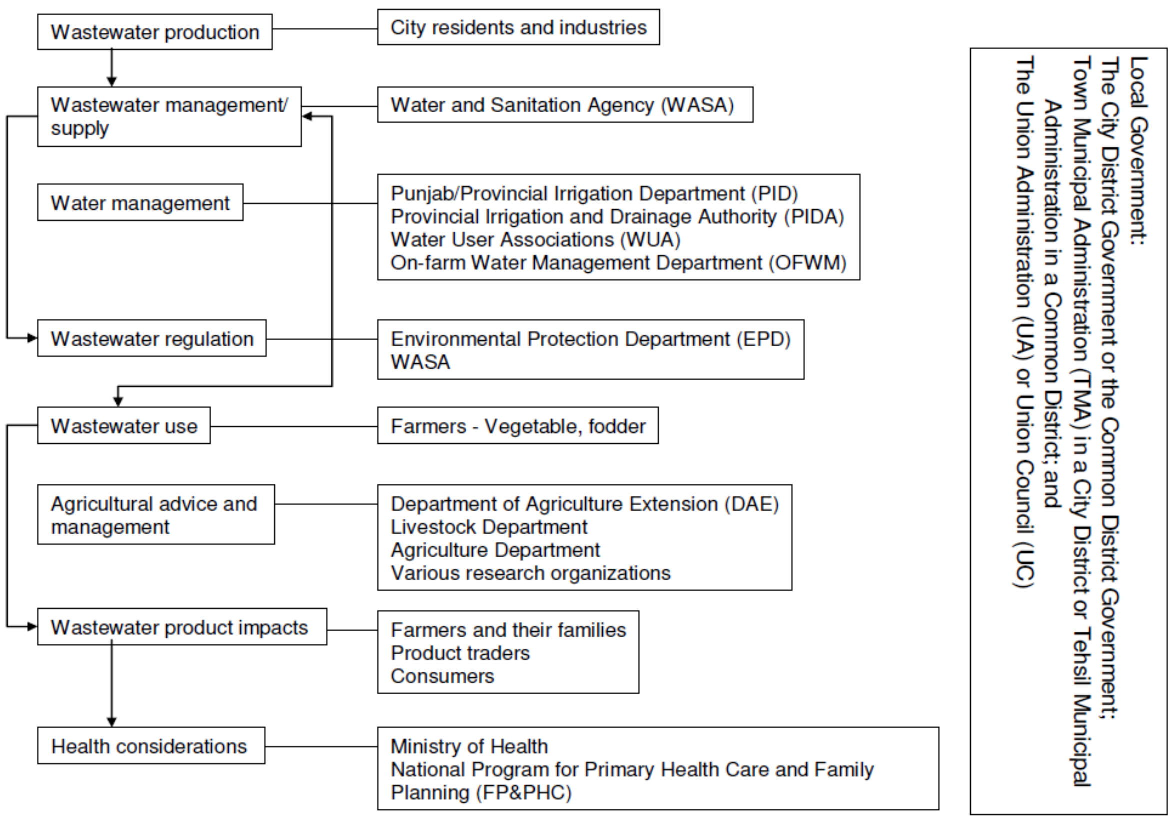


Figure 2.13:Stakeholder, institutions, and interactions in the wastewater irrigation
Source: Adapted from Amerasinghe et al., 2009, p.6)

Another collaborative study of IWMI and BMZ in India and Pakistan comprehensivelystudied the risks and opportunities of wastewater irrigation. In Pakistan, Faisalabad was selected as the study area. Two villages, *Chokera* (as wastewater irrigation) and *Kehala* (as canal water irrigation) near Faisalabad, were selected. The stakeholders, institutions, and linkages among them are elaborated in Figure 2.13.

Within this study, a few limitations were found. First, siteselection for domestic wastewater irrigation was limited and industrial wastewater irrigated areas were not included in investigation. Second, the main emphasize of institutionalanalysis was to review the aspect of wastewater irrigation. The other aspects of wastewater management (generation, collection, treatment, and disposal) were not addressed at institutional level. This study also did not take into account of the legislative background of institutions, governance challenges, and poor law enforcement.Ultimately, there is a need to discuss all the benefits and costs related to wastewater irrigation before suggesting any solution.Because of the limited public investment in the sewer system, municipalities (agencies) received all types of discharges in the same drains. Municipalities focused on cost-effective options for wastewater disposal instead of environmental conservation.

In 2005, the local government entirely banned the use of wastewater for irrigation purposes due to its negative externality. In response, farmers claimed their right through a judicial proceedingto use wastewater as irrigation water in the absence of any other alternate water supply. In 2012, the local government of Faisalabad forbade to grow vegetables with wastewater irrigation. Now, farmers instead are frequently growing wheat and fodder crops.

2.5.3 Gaps

The purpose of this chapter wasto review the theoretical and empirical literature pertaining to assessing the legal and institutional scenarioof poor wastewater management.The review revealed a significant knowledge gap in the wastewater management system of Pakistan.

A body of literature regarding the information onthe generation, treatment, and disposal of wastewater for Faisalabadwas missing. First, there was a prerequisite to collect all possible city-based information regarding population, sewer system, type of industries, the topology of wastewater, the volume of wastewatergenerated, treatment facilities, and disposal or reuse options. Identifying the required information can be done through a needs assessment of the study (Chapter 3).

The impact assessment of wastewater on health and environment aimed to capture the complex environ-socio-economic evidence across different contexts. The studies reviewed dated as far as 1986 and as recent as 2018.Many ofthe studies focused on wastewater irrigation and its effects on human health, soil, crops, groundwater, and freshwater resources.However, available informationon the impact of wastewater in terms of human health, resources, and the socio-economic condition were quite scattered. There was need to wholly visualize the harmful impacts in a comprehensive manner (Chapter 5).

The review of Pakistan'slegal framework focusing on wastewater management was not available even though legal progression with respect to the overall environmental conservation has been reviewed. Thus, the review of the legal framework with respect to wastewater management would be the next goal of this study. It would further proceed towards identifying legislative gaps for the poor implementation of laws (Chapter 6).

Thus, legal and institutional analysis literature in the field of wastewater management was limited;the scope of available literature on institutional analysis was limited to the water/irrigation management sector. Hence, regarding institutional analysis on the wastewater management sector, aspects such as inbuilt governance challenges within institutions and potential interactionsamong the stakeholders could be explored. Thus, identifying the challenges in the wastewater management sector of Faisalabad was another focusin this study (Chapter 7).

The interdisciplinary aspect of wastewater management was not consideredduring policy formulation at any administrative level. Likewise, governanceinthe wastewater management sector had never been addressed at any policy level. Recently, policymakers have oriented management policies towards constructing collective treatment plants. There was little known about other possible policy solutions at the grass-root level. Thus, there was room for exploringpotential solutions at the local level. (Chapter 8)

Based on the literature review, a list of targeted research questions (objectives) was prepared, which helped to keep the research on track.

3. AN INTRODUCTION TO RESEARCH METHODOLOGIES

With in this chapter, all applied approaches/methods/techniques to achieve the objectives are mentioned. Using a multistage analysis for this research, this chapteris further comprised of sixsections. The first section presents the overall picture of the research design/framework of the study. The next four sections elaborate comprehensively the methodological tools used in fourdifferentstages of research (Chapter 5, Chapter 6, Chapter 7, and Chapter 8). In the second section (3.2), quantitative analysis techniques used to detect the influence of untreated wastewater irrigation on the community and environment are mentioned. Third, the methods and investigation procedures are explained toreview the legal framework for wastewater management in the study area (3.3). In the next section (3.4), methods for qualitative data collection and analysis (institutional analysis) for all involved actors (stakeholders) in wastewater management are introduced. Fifth, few potential techniques for policy intervention using the already collected information are stated (section 3.5). Lastly, a review of the applied methodology and limitations of the study are briefly described.

3.1 Research designand framework

A research designand framework refer to the theoretical and conceptual framework for analyzing the research problem. The criterion for the selection of research methods was based on the objectives of the research and available data/information (Symonds & Gorard, 2008).

3.1.1 A case study approach

A case study approach was adopted to identify the challenges in wastewater management and strategies for improving the wastewater management practices in Faisalabad. This study contributed to a sustainable ecosystem of Faisalabad as well as a better living condition for urban farmers. Case study approach generally involves two options, either to stretch out for broader outreach or to intensify the frame of analysis. The former strategy refers to comparative case studies whereas the latter was applied to this case study.

3.1.2 Research design

This study adopted a mixed method approach by applying both qualitative and quantitative research methods as shown in the following Figure 3.1.The research is divided into five parts, which target the research objectives. Each part isaddressed in the subsequent chapters. The italicized text (next to the chapter title) represents the data/information required for analysis. Analytical tool/methodological approaches arementioned within black boxes. Then, the outlined boxes signify the expected output/finding for each part. The direction of arrows explains the interlinked connection among these components.

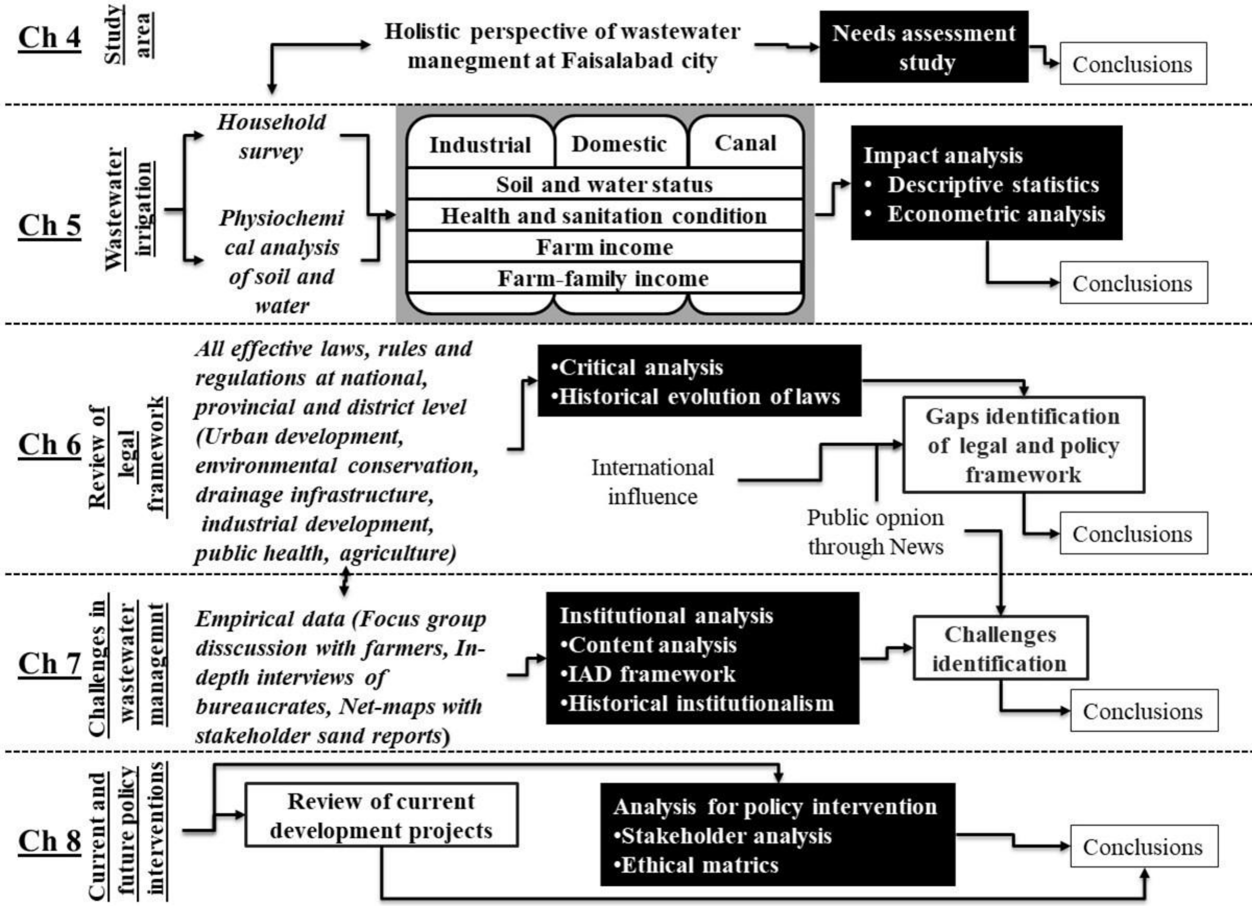


Figure 3.1: Research design

The first part of Figure 3.1 displays the needs assessment study of the problem (Chapter 4).The next part elucidates the process of quantitative analysis using a household survey to explore the impact of wastewater irrigation (Objective 1). The household survey was conducted among farmers who use and do not use wastewater for irrigation within the peri-urban areas of Faisalabad(Chapter 5). The next segment aims to review the prevailing legislative framework for wastewater management(Objective 2). The reviewof legislationtargets the aspects of wastewater management such as freshwater pollution, urban drainage, treatment facilities, and safe use of wastewater in agriculture, public health, food alteration, and institutional change of public administration in Pakistan. Desk research was done to find the gaps in the existing legal framework (Chapter 6). The second-to-last section portrays the steps involved with empirical data to identify the challenges (qualitative data collection techniques) in wastewater management sector using the IAD framework (Chapter 7). The last part shows the overview of current and potential future policies (Chapter 8) using the already collected information. This part links to the fourth objective of the research.

3.1.3 Research layout or framework

The following Table 3.1 precisely explains the targeted research questions, types of data/information, methodological tools, and the potential findings of the research.

Table 3.1:Research framework

No	Research question	Data/information	Methods/ techniques/ approaches	Potential outcomes
Needs assessment study (Chapter 4)				
i	What was the background information of the study area regarding irrigation and drainage system, agriculture, population growth and industrial status?	Literature review, departmental reports	Desk research	Background information
ii	Where was the problem and how much gap exists between real and desired (legal) situation? (Need assessment)	Survey, focus group discussion, in-depth interview, personal observation, literature review, departmental reports	Desk research, Critical analysis	Current condition of wastewater, the system of collection and treatment, and its direct & indirect use
iii	What were some general characteristics and issues related to wastewater irrigation in each site of the study area?	Direct observation, focus group discussion, survey data	Narrative approach	Overview of sites irrigating using domestic and industrial wastewater
1- To evaluate the impact of poor wastewater management on community and natural resources (Chapter 5)				
i	What was the impact of wastewater irrigation on the socio-economic condition of farmers?	Survey data of socio-economic condition of each farm household	Descriptive analysis	Effect of the quality of irrigation water on socio-economic condition of farm households
ii	What was the condition of natural resources (such as soil, groundwater) in the study area?	Samples of groundwater, irrigation water and soil for each respondent	Physiochemical analysis (EC, BOD, COD, SAR, pH, Cl, SO_4,), descriptive statistics (Mann-Whitney test)	Comparison of irrigation water, groundwater and soil condition across the categories
iii	What was the health status of farm households who reside in the study area?	Survey data for health status of each farm household	Prevalence rate, Ch^2Test	Influence of the quality of irrigation water on the health

No	Research question	Data/information	Methods/ techniques/ approaches	Potential outcomes
				of farm households
iv	What were the total costs and benefits during a farm year (land tenure system, crop diversity, net crop income, and farmincome)?	Survey data for each farm for one year	Cost benefit analysis, descriptive statistics (Mann-Whitney Test),	Differences in the farming system across the categories (Influence of the quality of irrigation water on farm income)
v	What was the financial status (income and expenditure) of farm households across the categories applying different quality of irrigation water?	Survey data for total income and household expenditures of each farm household	Descriptive statistics (Mann-Whitney Test),	Influence of the quality of irrigation water on farm household income
vi	What was the impact of the quality of irrigation water on crop yield and farm income (Dose response analysis)	Survey data	Econometric analysis (semi-log production function)	Impact of the quality of irrigation water on crop yield and fam income
2-	**To evaluate the gaps in the legal framework of wastewater management (Chapter 6)**			
i	What kind of legislation existed to address the issues of water pollution, untreated wastewater irrigation, public health, sanitation and drainage system, and wastewater generation?	Literature review, formal rules (Acts, Ordinance, rules, regulation)	Critical review, narrative approach (chronological)	Current status of the legislative framework
ii	What were national policies addressing the wastewater management sector?	National policies, news articles, literature review	Critical review	Gaps in national policies towards a sustainable wastewater management
iii	How had the international community influenced national policy formulation?	Literature review, departmental reports	Narrative approach	Role of the 'Foreign Hand'
iv	What kinds of gaps existed in legal framework responsible for the poor implementation of laws?	Literature review, qualitative data (in-depth interview), formal laws	Critical analysis	Gaps in the legislative framework
3-	**To identify the challenges in wastewater management under the scenario of city**			

No	Research question	Data/information	Methods/ techniques/ approaches	Potential outcomes
	Faisalabad (Chapter 7)			
i	Was wastewater management a social/governance dilemma?	Literature review, general observation of study area, quantitative data	Comparative analysis (observed vs desired)	Wastewater management is a social/governance dilemma in Faisalabad
ii	What was the nature of goods and services linked to wastewater management?	Literature review, focus group discussion, net-maps, in-depth interview, departmental reports, information about types of involved goods and services	Institutional analysis using the IAD framework	In-built problems due to properties of goods and services
iii	What were the attributes of the community in Faisalabad?	Departmental information (official websites), news articles, evaluation reports, publications, literature review	Institutional analysis using the IAD framework	In-built problems due to the attributes of the community
iv	How did the working rules of institutions affect the desired outcomes?	In-depth interview, departmental reports, projects evaluation reports	Comparative analysis	Formal rules vs working rules
v	What was happening within the action situation of wastewater management in Faisalabad?	Literature review, focus group discussion, net-maps, in-depth interview, departmental reports, and information about types of goods and services, stakeholders (their positions, actions, working rules, their linkages with other individuals)	IAD framework, historical institutionalism, content analysis	1-Agenda, 2-Organogram 3-Historical context 4-Resources 5-Challenges (stakeholder wise)
vi	What kind of interaction between institutions and individuals existed?			
vii	What were the challenges in sustainable wastewater management in Faisalabad? (Structured conceptualization)	Literature review, focus group discussion with farmers, in-depth interviews with bureaucrats, net mapping with	Evaluative criteria of the IAD framework, governance indicators, content analysis	Challenges in wastewater management

No	Research question	Data/information	Methods/ techniques/ approaches	Potential outcomes
		stakeholders, potential outcomes		
4-	**To review the current development projects and to assess a few potential approaches for future strategies (Chapter 8)**			
	What were some internationally sponsored interventions for sustainable wastewater management, and how much have they influenced the situation?	Project information by departments and donor agencies	Critical analysis	An overall look at the proposed solutions
	How should the policy reform to address the problem? Reexamine existing data to address new policy formulation options (Secondary analysis)	Questionnaire,resear cher'sopinion	Stakeholder analysis, Ethical Matrix	Predicted outcomes

The objectives, research questions, data/information, methodological tools, and potential outcomes are organized in Table 3.1. As mentioned, the corresponding objective and research questions are tabulated at the start of each chapter.

3.1.4 Frame of analysis

The frame of analysis was intensified, including environmental and human interactions, institutional and organizational analysis, and the legislative framework of sustainable wastewater management in Faisalabad.

Figure 3.2:A multilevel governance structure in the study area

Based on the objectives, this study had a multilevel (administratively) analysis and Figure 3.2 portrays the overall levels of analysis.

3.2 Needs assessment study

Needs assessment is the study of gaps between real and desired (legal) situation. Prior to any analysis, a need assessment of the problem wasrequired to identify the gaps between the real situation of wastewater management and the desired (legal) framework for wastewater management. Previous studies and available scattered information were utilized to address the problem statement (gaps=current vs. desired) for this research.

Desk research

Desk research was done using the secondary data collected for other purposes. Desk research is slightly different from review of literature. As, literature is reviewed for exploring the conceptual and methodological framework. Desk research (secondary research) has been done using the primary data/information collected by other for different objectives (Gandhi, Sucahyo,and Ruldeviyani, 2018). Hence, it was done due to absence of primary data. The collection of primary data regarding wastewater at city level was quite expensive and time consuming.

Therefore, such information was collected using the context of four fundamental pillars (stages) of wastewater management: wastewater production, collection, treatment, and final discharge through secondary sources. The information/data collected from authentic sources (government, research reports, web pages) had further normalized before analyzing (Ruggiano & Perry, 2017). Secondary research had done not only at this phase of study but it carried out through the entire research such as finding the gaps in legal framework, comparing results with other's research findings, exploring the institutional framework, and reviewing the development projects (Talakvadze, 2013).

The next step was to explore the ground realities of communities involved with wastewater irrigation. The first objective of the studywas to evaluate the influence of poor wastewater management on community and natural resources; the methodological approaches and techniques adopted are mentioned in the next segment.

3.3 Wastewaterirrigation, intertwined threats and opportunities

One aspect of wastewater management, wastewater irrigation,was selected to gain a deeper understanding of wastewater management at the micro (household) level. Actually, the farm households involved with wastewater irrigation have directly faced risks and potential benefits associated with poor wastewater management. The first objective, the connected research questions, and the targeted analyses are described below (Chapter 5).

1- To evaluate the impact of poor wastewater management on community and natural resources

i- What were the socio-economic conditions of farm householdswho irrigate their farms with different qualities of irrigation water?

- What were the socio-economic indicators (age, education, experience, family size) of farm households among the different categories?

ii- What was the condition of natural resources (soil, groundwater) in the study area where water with different qualitiesis used for irrigation?

- What kind of variation existed in the quality of irrigation water?
- Did physiochemical characteristics of groundwater vary due to different qualities of irrigation water?
- What was the variance on the soil properties across the areas irrigated with different qualities of irrigation water?

iii- What was the health and sanitation status of farm households across the categories?

- What was the general availability of safe drinking water in the study area?
- What was the sanitation and hygiene condition in the study area?
- What was the health status of farm households across the categories?

iv- What were the total costs and benefits during a farm year (land tenure system, crop diversity, net crop income, and farm income)?

- What was the land tenure system within the study area?
- Did the cropping pattern vary with the quality of irrigation water?
- What was the variation of cropping systems across the different quality of irrigation water?

v- What was the financial status (income and expenditure) of farm households across the categories irrigating with different qualities of water?

- Did the role of non-farm income in household income vary across the categories?
- How did the structure of farm household income differ depending on the quality of irrigation water?
- What was the share of household expenditure in household income?

vi- Impact valuation (Dose response analysis)

- Evaluating impacts of irrigation water on crop yield
- Evaluating impacts of irrigation water on farm household income

Such analysis helped to assess the impacts (positive or negative) of wastewater management on natural resources and health and socio-economic conditions of farm households.

3.3.1 Sample size and design (survey data)

Primarily, study areas were identifiedgeographically (location of drains) using previous research findings (Appendix E). Three sites—Eastern, Southern, and Western—were recognized around the city center (Figure 5.1). The household survey aimed at the 'with and without' approach. The ideal situation for impact analysis was the 'before and after' of the activity (untreated wastewater irrigation). However, any records regarding the condition of natural resources, the farmers' health and the farm systembefore wastewater irrigation were unavailable. Therefore, the 'with and without' approach was adopted to capture the impacts of the 'before and after'.(Paulus et al., 2014). As, 'With and without' approach can only be used to detect the 'before and after' impacts, if the targeted situation is not self-selective.

The areas where farmers had been using untreated wastewater for irrigation purposes for a long time(more than 25 years)were selected for data collection. These areaswere mostly situated at the tail of the canal water channel. The targeted areas wereunevenely dispersed throughout the peri-urban areas along the wastewater drains (see Figure 5.1). The goal of the sampling was to cover the variation across the categories (irrigation with different water qualities).

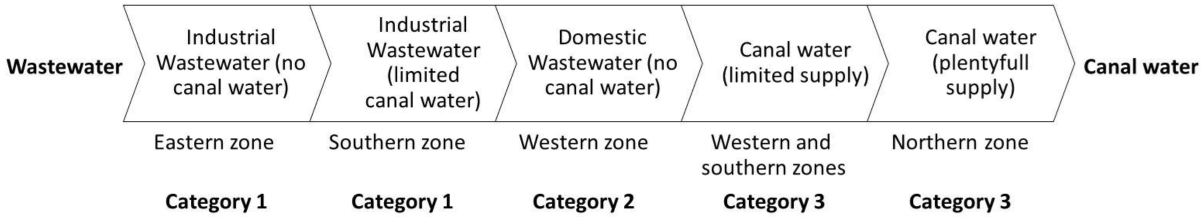


Figure 3.3:Categorization of study areas

Figure 3.3 elaborates the details of categorization of each group based on the characteristics concerning thequality of irrigation water (from wastewater to canal water). Category 1was titled as 'Industrial wastewater,' Category 2 as 'Domestic wastewater' and Category 3 as 'Canal water.'

Table 3.2:Sampling framework

Industrial wastewater		**Domestic wastewater**	**Canal water**	
Industrial wastewater (no canal water)	Industrial wastewater (limited canal water)	Domestic wastewater (no canal water)	Limited canal water	Canal water (control group)
Eastern (E)	Southern (S)	Western (W)	Southern (S) and Western (W)	Northern (C)
E1	S1	W1	S4	C1
(n=30)	(n=13)	(n=40)	(n=23)	(n=15)
	S2	W2	S5	C2
	(n=17)	(n=6)	(n=1)	(n=10)
	S3	W3	W5	C3
	(n=22)	(n=10)	(n=10)	(n=5)
	W4		W6	W6
	(n=5)		(n=4)	(n=11)
With		**With**	**Without**	
N=87		**N=56**	**N=79**	

N = total number of respondentswithin each category
n = number of respondents from each site
E, S, W, and C = abbreviation for Eastern, Southern, Western, and Canal irrigated areas

Selection of villages within each category is elucidated in Table 3.2.

Table 3.2 explains the allocation of respondents across the study sites. These respondents at each site were chosen through random sampling. The total sample size was 222. Out of these, 87 used untreated industrial wastewater for irrigation, 56 used domestic wastewater, and the remaining 79 farmers used canal water or groundwater for irrigation. (see table 3.2).The western site farmers irrigated theirfields with domestic wastewater, and southern and eastern site farmers irrigated with untreated industrial water. All three sites in the control group were located along the *Rakh Branch* (RB) canal in the northeast of Faisalabad. Within this area, groundwater was also fit for irrigation due to continuous recharge from the canal. Approximately 16 sites were selected.

A survey was conducted around the peri-urban area of Faisalabad, within the range of 50 km around the city area. The data was collected from May 2008 (*Kharif* 2008) to April 2009 (*Rabi* 2008-09).First, the general information for each village was enumerated through a general questionnaire (Appendix I1) from the focal person (mostly *Numberdar* of that village). Next, a household survey was conducted using a structured questionnaire (Appendix I2) for each household accompanied by trained staff. The questionnaire covered aspects of farm household health status, cost-benefit analysis at farm level, household income and expenditures.The data were obtained by interviewing the household head. Additionally, soil and water samples (irrigation and groundwater) were collected for each respondent using a structured questionnaire (Appendix I2).

3.3.2 Parameters for physiochemical analysis of soil and water samples

One of the objectives of the study was to review the effect of untreated wastewater irrigation on natural resources such assoil and groundwaterof farms in the study area. Ayub Agricultural Research Institute (AARI) in Faisalabad helped to test the soil and water samples for this study. AARI was established for agricultural research and testing farmers' irrigation water and soil samples at subsidized rates(Ayub Agriculture Research Institute).The objective of such a facilityhas been to provide technical assistance to the farmers. The facility for soil testing (nutrient level) was designedto advise suitable amounts of fertilizer to the fields; the facility forgroundwater analysis checked the quality (salinity) of water during the burrowing of a tube well for irrigation purpose.

For analysis, as suggested by AARI staff, soil samples were collected at two depth levels, first at 0-6 inches and another at 6-12 inches. The parameters included electrical conductivity, soil pH, organic matter (OM), available phosphorus (P), available potassium (K), and soil saturation. The parameters of physio-chemical analysis for water samples were electrical conductivity (EC), calcium (Ca), magnesium (Mg), sodium (Na), carbonate (CO3), bicarbonate (HCO), chloride (Cl), sodium absorption ratio (SAR) and residual sodium carbonate (RSC).

On behalf ofthe farmers,the AARI facility was used for soil and water (irrigation water and groundwater) testing. Using the instructions[2] by AARI staff,samples of soil and water (irrigation

[2]First, five soil samples fromeach was collected at two depths (0-6 and 6-12 inches) using proper instruments. Then these labelled (farmer code) soil samples properly sealed in desired weight using plastic bags and transported to

water and groundwater)were collected fromeach respondent. All the samples were submitted to the AARI laboratory in Faisalabad for physio-chemical analyses. Later on, the result of analysis were received from the laboratory of AARI and also delivered to the respondents.Excel files were prepared for presenting the physio-chemical analysis of irrigation water, groundwater, and soil for each farmer. Further analysis was performed to explore the effects of wastewater irrigation on natural resources.

3.3.3 Descriptive statistics

The first objective of the study was to estimate the opportunities and risks involved with poor wastewater management. For this purpose, a comparative analysis was carried out using the available data (see Hayat et al., 2016; Scott, Faruqui, & Raschid-Sally, 2004;WWAP, 2012). Average social and economic characteristics, such as age, education and family size, farming experience, cropping intensity, cropping pattern and non-farm income, were compared using statistical analytical techniques. Furthermore, information on landholdings, the source of irrigation, and off-farm income status wasalso gathered to evaluate the socio-economic status of the farmers. The following hypotheses were statistically tested to identify the association among the variables of different categories:

a) The continuous use of untreated wastewater for irrigation purpose alters the soil condition (such as pH, EC, SAR, carbonates, bicarbonates) and groundwater composition.

b) Untreated wastewater irrigation in urban agriculture causes chronic ill health and loss of labor productivity among farming communities.

c) Quality of irrigation water influence the socio-economic (land tenure system,cropping intensity, cropping pattern, farm income, and farm household income) conditions of wastewater users in the peri-urban area of Faisalabad.

These hypotheses were developed based on previous findings (see Section 2.1). The descriptive analysis was conducted using statistical techniques. Since the available data were not normally distributed, the Man-Whitney test was conducted to test the significant difference between two independent groups. These groups were named as ‘industrial wastewater’ (Category 1), ‘domestic wastewater’ (Category 2), and ‘canal group’ (Category 3) (see Figure 3.3). Statistical analysis was performed to further find out the significant differences among these three categories.

AARI labs.Water samples were collected in specific bottles (provided by AARI staff) from the running water resources at specific depth. These air-tight-labelled bottles promptly submitted to AARI lab for analysis.

3.3.4 Health analysis

Furthermore, health issues caused by untreated wastewater irrigation in urban farming areas were addressed. The prevalence of an attribute/disease/case is normally calculated by comparing the existing cases to the total population (UNDP, 2006). Prevalence (sometimes referred to as prevalence rate) is “a measure of disease occurrence; in fact, a measure of the occurrence of any type of health condition, exposure, or other factor related to health (e.g., prevalence of depression, of smoking): the total number of individuals who have the condition (e.g., disease, exposure, attribute) at a particular time (or during a particular period) divided by the population at risk of having the condition at that time or midway through the period”(Last, 2014, p. 223). The general calculation for the prevalence of an attribute/disease/case is:

$$Prevalence = \frac{\textit{all new and pre-existing cases during a given period}}{\textit{Population during the same period}} \times 10^{n}$$

The formula for the prevalence rate of an attribute is:

$$Prevalence\ rate = \frac{\textit{Persons having a particular attribute during a given period}}{\textit{Population during the same period}} \times 10^{n}$$

The value of 10^n is usually 1 or 100 for common attributes[3].

The health status of the farming community (farmers and their families), in terms ofspecific water-borne diseases, was measuredto calculate the prevalence rate during 2008-09.The prevalence rate of health risks, days of illness, and expenditures on healthcalculated to observe the poor health status amongcommunities irrigating with wastewater(Weldesilassie, Boelee, Drechsel, & Dabbert, 2010).The findings were compared using the Chi^2 test for variables with non-normal distributions to find the significant difference among categories.

3.3.5 Farm income appraisal

The cost-benefit analysis was assessed to calculate net crop benefits associated with industrial wastewater use, domestic wastewater use, and canal water use. Wheat income was appraised by multiplying the gross margins (Rs.) received per unit area (ha) by the total area grown by each respondent. Wheat gross margins were estimated after deducting the total variable cost (TVC) from thetotal value of product (TVP), which is the yield (in mounds) of wheat per unit area (ha) multiplied by the actual price received by the farmer (rupees per mound). During 2008-09, the price of wheat was 900 rupees per mound.For TVC, data regarding inputs (physical units) and prices (paid by the farmer) were collected on a per hectare basis. A huge variation on the level of

[3]The value of 10^n may be 1,000,100,000, or even 1,000,000 for rare traits and for most rare diseases.

inputs was found due to different production techniques across the villages. Then, TVCwas calculated by adding up all costs such as sowing,ploughing, irrigation, fertilizer, harvesting, and transportation costs. Hence, the opportunity cost for family labor and land ownership was excluded to simplify the analysis. Additionally, net returns per unit of rupee (ratio of gross margin per unit area to the variable cost per unit area) invested in crop production were also estimated;income from all crops (wheat, fodder, cash cops, and vegetables) forone year was the summed up for each respondent. Finally, a farmer's farm income was calculated by adding incomes from crop production and livestock production.

3.3.6 Dose responsemodels

Within this section, dose-response models aredescribed to feature the relevance of the quality of irrigation water and its impact on crop production and income. The subsequent econometric models provide evidence to evaluate the impacts of the quality (industrial wastewater, domestic wastewater, or canal water) of irrigation water on crop (wheat) yield and farm income.

First, the impact valuation was derived by econometrically modeling the yield as a function of major inputs such as fertilizers, labor, seed, irrigation water (wastewater), and other factors of production. The semi-log Cobb-Douglas production function was used to represent this function, where *Y* is the Yield, and *A,F, S, L, WW*, are factors of production, such as, area, fertilizer, seed, labor, and irrigation water (wastewater) respectively (while *i ……n*is indicating number of respondent). However, X_j*……Xp* are other inputs and *βs* are the partial elasticities of inputs with respect to output (Hussain *et al.,* 2001).

A semi-log Cobb-Douglas production function for wheat crop used in this study is given as:

$$ln(y_i)= B_0+B_1ln(a_i)+B_2ln(s_i)+B_3ln(if_i)+B_4ln(of_i)+B_5ln(p_i)+B_6ln(ir_i)+ B_7ln(h_i)+B_8D_{1i}+B_9D_{2i} + U_i \qquad (Eq.\ 3.1)$$

Where

ln(y) = Natural log of yield of the *i-th* farm measured in mds. per hectare

ln(a) = Natural log of area sowing cost of the *i-th* farm (rupees per hectare)

ln(s)= Natural log of average sowing cost of the *i-th* farm (rupees per hectare)

ln(if)= Natural log of inorganic fertilizer cost of the *i-t*h farm (rupees per hectare)

ln(of)= Natural log of organic fertilizer cost of the *i-t*h farm (rupees per hectare)

ln(p) = Natural log of pesticide cost of the *i-th* farm (rupees per hectare)

ln(ir) = Natural log of irrigation cost of the *i-th* farm (rupees per hectare)

ln(h) = Natural log of harvesting cost of the *i-t*h farm (rupees per hectare)

D_1= Dummy variable for the category of irrigation,*D1= 1* if farmer uses industrial wastewater for irrigation, otherwise 0

D_2= Dummy variable for the category of irrigation, If $D_2 = 1$ if farmer uses domestic wastewater for irrigation, otherwise 0

U_i = Error terms

Each variable has taken the natural log form of its value except the dummy variables. Two dummy variables were included in the model as there were three irrigation groups (industrial wastewater irrigation, domestic wastewater irrigation, and canal water irrigation). The canal-water-irrigated areas were the control group. Thus, the canal-water-irrigated area was the baseline category. The first dummy D_1—canal vs. industrial—was introduced to compare the impact of industrial wastewater irrigation on crop production. Similarly, D_2 was introduced to compare domestic wastewater irrigation with canal water irrigation.

Hence, farm income would be the function of income received from different crops, livestock income, family labor, and the quality of irrigation. The variable *fn* is the farm income, and the main factors of contribution such as cropped area, family labor, and irrigation water (dummy variable), are added to the function, while *i ……n*is indicating each respondent.

A semi-log regression was used in this study and is given as:

$$Ln(fn)= B_0+B_1ln(as)+B_2ln(w_i)+B_3ln(f_i)+B_3ln(sc_i)+B_4ln(cc_i)+B_5ln(v_i)+ B_6ln(tlu_i)+B_7ln(fl_i)+B_7D_{1i}+B_8D_{2i} + E_i \quad \text{(Eq. 3.2)}$$

Where

$ln(fn)$ = Natural log offarm income of the *i-th* farm (rupees),

$ln(as)$ = Natural log of area sown of the *i-th* farm (hectare),

$ln(w)$ = Natural log of income from wheat of the *i-th*farm (rupees),

$ln(f)$ = Natural log of income from fodder of the *i-th* farm (rupees)

$ln(sc)$ = Natural log of income from sugarcane of the *i-th* farm (rupees)

$ln(cc)$ = Natural log of income from cash crops of the *i-t*h farm (rupees)

$ln(v)$ = Natural log of income from vegetable crops of the *i-th* farm (rupees)

$ln(tlu)$ = Natural log of TLU of the *i-th* farm

$ln(fl)$ = Natural log of family farm labor of the *i-th* farm (numbers)

D_1 = Main source of irrigation of the *i-th* farm (dummy-1 if industrial wastewater user, otherwise 0)

D_2 = Main source of irrigation of the *i-t*h farm (dummy-1 if domestic wastewater user, otherwise 0)

E_i= Error term

Each variable has taken the natural log form of its value except the dummy variables. Specification of dummy variable is the same as the preceding model.

3.4 Review of the legal framework (formal rules)

By reviewing the current situation of wastewater management (chapter 4 and 5) in Faisalabad, this study canassess the mismanagement in the wastewater sector. However, one cannot argue that it is due to weak law enforcement before reviewing the existing laws regarding pollutioncontrol. The second objective, related research questions, and targeted inquiries are mentioned below.

2- To evaluate the gaps in the legislative framework of wastewater management

i- What kind of legislation existed to address the issues of water pollution, untreated wastewater irrigation, public health, sanitation and drainage system, and wastewater generation?

- How did the various aspects of wastewater management function within the legislative framework?
- How had this legal framework developed over time?

ii- What were the national policies addressing the wastewater management?

iii- How had the international community influenced national policy formulation?

iv- What kinds of gaps in legal framework existedthat were responsible for the poor implementation of laws?

The first step was to explore the legal context of the current institutional framework regarding the sustainable wastewater management. For that reason, the research focused on the administrative departments (at any hierarchy level) whose departmental duties are related to sustainable wastewater management. Wastewater management facesvarious disputes, such as untreated dumping into public or storm drains, irrigating agricultural fields with wastewater, polluting freshwater resources, and threatening public health. Accordingly, a list of governmental organizations (see table 6.1) was prepared to identify who is responsible, for which aspect (related to four fundamental pillars, which are wastewater production, collection, treatment, and dumping) of wastewater management.After identifying the concerned departments, all current legislationsand the responsible organizations were critically reviewed. The primary goal was to evaluate two significant aspects: (1) to evaluate the legal framework for the establishment of institutions and (2) to explore the gaps within the legal framework which cause the poor implementation of laws.

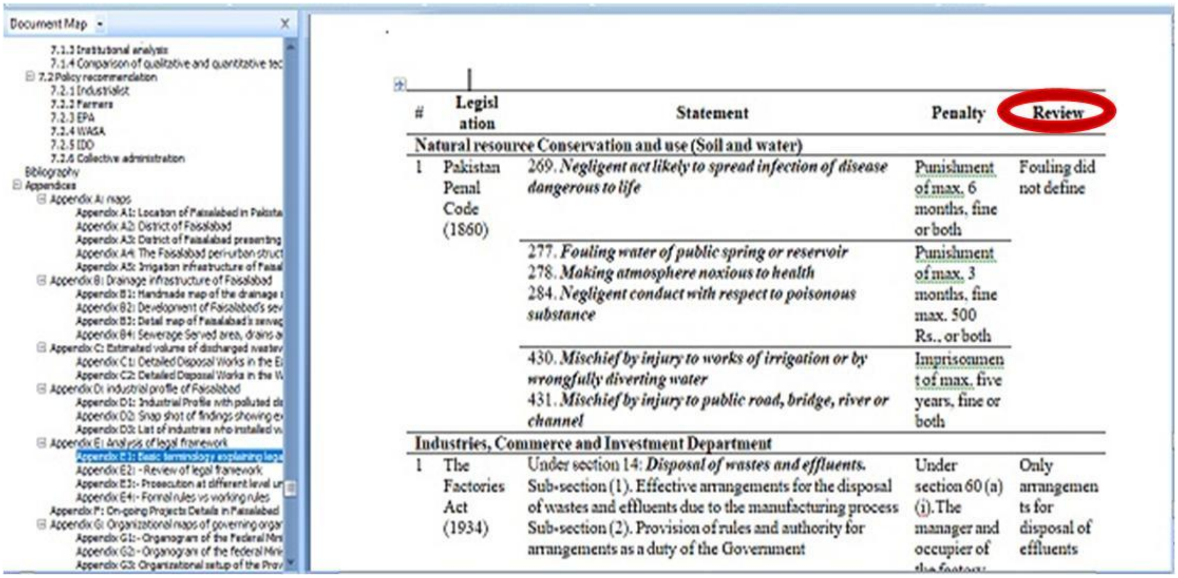


Figure 3.4:Critical review of legal framework

Figure 3.4 shows an example of how the legal framework was critically reviewed. The detailed review of acts, ordinances, rules, regulations, and policies that are directly linked to wastewater management are attached in Appendix E. The statements and punishments under these laws are listed in the third and fourth column (Appendix E2). The last column presents the final interpretations after analysis. Frequently used to find out the causes of a problem and proposed solutions,a critical analysis technique was applied to summarize the final comments.

The subsequent phase of the investigation was to comprehend the legal progression regarding wastewater management. A narrative approach (chronological) was used to explain the promulgation of laws in chronological order. A narrative consists of three main elements:an original set of circumstances, an incident, and the subsequent set of circumstances(Barbra, 1998, p.2; Letts et al., 2007). Therefore, the historical evolution of legislation concerning freshwater pollution, treatment of industrial effluents, administrative responsibilities, public health, environmental laws, and use of natural resources wasdocumented to support the review of the legal framework. For this purpose, key legislation or significant incidents have been described chronologically using a timeline technique (SPDC, 2012). Chronology describes what can be observed over time. It is the telling of a story from the start until the end (Chou & Melbourne, 2000). Hence, the important events were chronologically arranged across three main phases. The first phase elaborates the era for the evolution of institutions, the second phase details the period whenthe consideration of environmental conservation was included in the legal framework, and the third phase indicates the implementation hurdles of these laws due to the coinciding event of decentralization in Pakistan. The assessment provided an in-depth investigation of the legal framework over time. The overview of the development of the legal framework also explained the improvement process of the framework over time. Each new regulation was approved to fill the gaps in the preceding legal framework. Using this design for the study,it has proved to be helpful to explore the legal flaws in detail and offer opportunities to develop suitable recommendations.

3.5 Challengesin wastewater management

Previously, a review of the legal framework and the organizational setup delivered the legal status of each institution and a deep understanding of the role of each involved actor linked with wastewater management. However, it could not explain the whys and wherefores of the poor governance in wastewater management sector because reviewing the legal and institutional frameworkfocuses on the circumstances of the problem. Therefore, the IAD framework and institutional analysis were adopted to address the next objective of identifying the challenges in the management of wastewater. The third objective, associated research questions, and targeted analysis are mentioned below.

3- To identify the challenges in wastewater management in Faisalabad (Chapter 7)

i- Was sustainable wastewater management a social/governance dilemma? (Define the objective of sustainable wastewater management)

- What was the objective of the policy targeting sustainable wastewater management?
- How did observed outcomes (Chapter 3) compare to desired policy objectives?
- Which outcomes were satisfactory? Which were not?
- Which outcomes were most important?

ii- What was the nature of goods and services linked with wastewater management? (analysis of physical and material conditions)

- What was the nature of the wastewater-related activities (wastewater generation, collection, treatment, irrigation, and dumping)?
- How was the good or service (drainage facility, pollution control, wastewater irrigation) provided/produced?
- What physical and human resources (participants) were available to provide and produce this good or service?
- What was the scale and the scope of the provision and production activity?

iii- What were the attributes of communities in Faisalabad? (analysisof communal traits)

- What knowledge and information did participants (stakeholders) have about the relationship among policy-oriented strategies, actions, and outcomes?
- What were the participant’s values, beliefs, and preferences towards achieving a strategicgoal of others as well as themselves?

iv- What were the working rules of institutions?(analysis ofrules-in-use)

v- What was happening within the “action situation” of wastewater management in Faisalabad? (analysis integration)

- What positions/roles did actors play in wastewater management at different levels of analysis?
- Who were the participants, either individuals, group of individuals, or organizations?
- What was the level of control (authority) of each participant?
- What were the actions of the participants and how are these linked to outcomes?
- What kind of information about the mismanagement in wastewater sector was available to the participants?

vi- What kind of interaction between institutions and individuals existed?(analysis of patterns of interactions)

vii- What were the challenges in sustainable wastewater management (outcome analysis)

3.5.1 Sample size and design for qualitative analysis

The subjects of this study are all individuals (stakeholders) who are either directly or indirectlylinked to wastewater generation, collection, distribution, and utilization; they are also linked to the decision-making process of future policy formulation. The primary goal was to identify all actors involved in wastewater management and their roles within the governance framework.

Table 3.3:Qualitative data collection size and design

No	Stakeholders	Representative	Focus group discussion	In-depth interview	Net-mapping	Stake-holder analysis
1	National Research Institutes	laboratory in charge of AARI	-	1	-	-
		Director of PCRWR	-	1	-	-
2	University (UAF)	Director of Soil Science Researcher, Junior researcher	-	3	-	-
		Researcher	-	1	-	-
3	EPD,Punjab	Director planning	-	1	-	-
	EPA, Faisalabad	District Officer	-	1	-	-
		District Officer, Assistant District Officer	-	2	1	1
4	WASA, Faisalabad	Director of Revenue, Senior worker of	-	3	-	-

No	Stakeholders	Representative	Focus group discussion	In-depth interview	Net-mapping	Stake-holder analysis
		drainage				
		Laboratory assistant				
		Director of Drainage,	-	3	1	1
		Director of Planning,				
		Officer of Planning				
5	Industrialist	Chairman of FCC	-	1	1	1
6	IDD	Irrigation Department,	-	3	1	1
		Drainage Department,				
		Planning Wing				
7	Politician	MPA	-	1	1	1
8	Agriculture department	Extension officer	-	1	-	-
		ON-FWM	-	1	-	-
9	The Urban Unit	Senior officer	-	1	1	1
10	Farmers	The key informant	-	3	-	-
		Focus group discussion	4	6	4	4
	Total		**4**	**33**	**10**	**10**

UAF= University of Agriculture, Faisalabad
AARI= Ayub Agricultural Research Institute, Faisalabad
PCRWR=Pakistan Council of Research in Water Resources
FCC= Faisalabad Chamber of Commerce
MPA=Member of Provincial Assembly
ON-FWM=On farm water management wing of Agriculture department

Table 3.3 presents an overview of respondents, the period of investigation, and applied data collection techniques. In-depth interviews were conducted in 2009 and 2015, indicated by the parentheses. Focus group discussion, net-mapping, and stakeholder analysis were carried out in 2015.

3.5.2 Qualitativemethods for empirical data collection

In Faisalabad, data regarding governance indicators was lacking. Departmental reports were mostly prepared to perform routine duties. Focus group discussion, in-depth interviews, net-mapping, and stakeholder analysis helped to collect the inside information regarding the problem.

A semi-structured question was asked to all involved actors (during focus group discussion, in-depth interview, and net-mapping). A questionnaire (Attached in Appendix I3) helped to keep the discussion on track. The researcheralso observed the subject’s behaviors and tried to approach their tacit knowledge during the data collection process.The following techniques were adopted to identify the challenges in sustainable wastewater management.

3.5.2.1 Focus group discussion

Focus group discussions(FGD) were held with the groups of representatives of each village. Overall, a FGD for each village was arranged based on the location of village and type of wastewater irrigation. Four villages across three sites (western, eastern, and southern) were selected(Table 3.2). The size of the group was normally 15 to 25 members. Theoretically, it should either be small so that everyone gets a chance to participate or large to cover more variation of opinions. These focus group discussions proved to be a great technique to obtain information, to understand problems, and to suggest further policy formulation. Using a semi-structured questionnaire to keep the discussion on track,a directed set of questions was asked. Open-ended questionswere also asked about their current health status, law implementation, administrative control of governing organizations, the potential future policy as well as their perception of those problems.

3.5.2.2 In-depth interviews

In this study, in-depth interviews were conducted with the public representatives, government officials, regulatory authorities, law enforcement agencies, researchers, industrialists, water management institutes, and other stakeholders. Such in-depth interviews searched for a holistic and detailed understanding of the complex circumstances. The respondents were either key informants/focal personof an area or representatives of an organization. These respondents must have a good understanding of the existing problem. Such exploratory investigation aimed to capture stakeholder's opinions towards the issue, their visions about other involved actors, reasons forweaklaw enforcement, organizational capabilities, recommended policies, and possible future solutions.

3.5.2.3 Net-Maps and stakeholder analysis

The Net-Map method was selected to identify the principal actors (stakeholders), their organizational set-ups, their influential behavior, and conflicting goals (Schiffer and Hauck 2010;Schiffer and Peakes 2009).

Net-Mapswere prepared by the stakeholders to position themselves and others on influence and interest scale.Fourcentral questions were addressed to develop the Net-Maps. First was to identifythe main stakeholders, while looking at all involved actors. Afterward,a list of stakeholders was prepared.

Secondly, the 'links' among these stakeholders were mapped. These prescribed 'links' provided the details of interactions among the stakeholders. Three kinds of 'links'—financial flow, information flow, and formal lines of command—were considered in this study.

Thirdly, the influential status of the stakeholderswas also inquired. Influence or power is referred to as the capacity of an actor to affect decision-making in policy implementation. The level ofinfluence was evaluated by estimating the status of resources (financial and human) and salience of each stakeholder (Schmeer, 2000).

Finally, the stakeholder's (formal) goals/objectives were asked. Different institutions, organizations, or individuals target different goals, such as economic benefit, environmental protection, and social development. Their interests may also compete against one another. Within this study, their goals and interests theoretically go together; however, the interests or stake of each stakeholder varied over a range of interests or objectives (for detail regarding Net-Maps, see Schiffer 2007; Schiffer & Peakes, 2009; Schiffer, Hauck, and Abukari 2007; Schiffer and Waale 2008).

Net-Map preparation took approximately two hours. Other activities, including in-depth interviews and site visits,took place before or after the Net-Mapping process. The primary role of the researcher was to serve as a moderator, facilitator or a silent observer during the preparation of Net-Maps. The required materials such as colored charts, colored markers, chess pieces, and coins were provided to the participants according to their needs.This technique provided essentialinformation regarding conflicting agendas among different stakeholders.

3.5.2.4 Personal observation

A field survey started with the visit along the main drains. With the support of photographs and videos about the condition of wastewater discharge,personal observations were made andthe situation at the study sites along these drains was observed. Three field assistants were hired to facilitate the data collection procedure. These field assistants also provided support during the focus group discussions and recording the complete Net-Mapping process. Field reports by field assistants were collected as written reports, videos of the meeting, and photos of sites.

During in-depth interviews with public servants (bureaucrats) and industrialists, the researcher noticed a pattern of exclusive behavior that they displayed. Many of them took approximately the first ten minutes of the interview just to describe their recent development work and appreciated their department or industry in full function. During the next ten minutes, they provided answers tothe open-ended questions related to wastewater management. In that session, they also advocated forthe previously mentioned activities. For the next ten minutes, on questions related to their role in poor wastewater management, they showed signs of arrogance. Moreover, around half-an-hour later, no one was ready to talk more. The respondents just refused to continue and abruptly informed the researcher about their next scheduled meeting or some departmental responsibilities.

3.5.3 Analytical approaches for instituional analysis

Such empirical data collection methods typically generate abundant information, which then poses a challenge when deciding where to focus. Analytical approaches (theory/conceptual framework-based) were applied to explore the wastewater management structure. In Table 3.3, the applied methodologies are specified with each research question.

The study explored the complete and detailed description of the tragedy of commons in the wastewater management sector. The assumption for an institutional analysis was that poor wastewater management (commons) is caused by social, political, economic, institutional, and ethical factors.

The conceptual framework (Chapter 2) explained the grounds for qualitative analysis (Jabareen, 2009). Similarly, theoretical frameworks further explored insights around the problem based on the information. The institutional analysis and development (IAD) framework, critical analysis, historical institutionalism (HI), and content analysis provided the conceptual and theoretical framework for the qualitative analysis. These approaches and methods are briefly explained in the following subsections.

3.5.3.1 Institutional analysis using IAD framework

Institutions are instructions—utilized by humans—to govern or to organize the repeated interaction with others (family member, friends, markets, and government officials). The institutional framework is a composite of rule, informal constraints (norms of behavior and conventions) and their enforcement characteristics (North, 1990, 1991). In this study, the institutional analysis and developmental (IAD) framework helped to understand and identify the institutions along with their legal status,institutional settings (positions), and participant status (actors, communities)(see Ostrom, 2005, p.3, 2010, 2011). Hence, the IAD framework guided the categorization of the theoretical clarification for a variety of collaborative problems in the wastewater management sector.

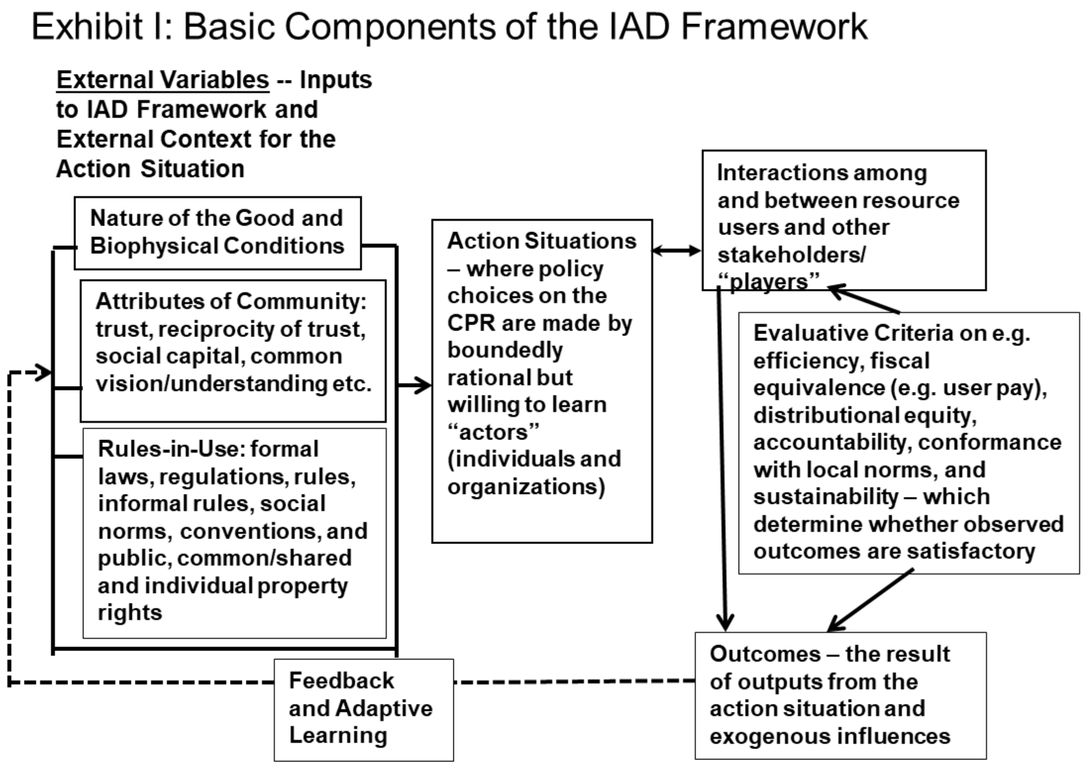


Figure 3.5:IAD framework

Source: Adapted from Hoffman & Ireland (2013) "Elinor Ostrom, Institutions and Governance of the Global Commons," Second Draft, p.9 (n. p.)

A detailed clarification of the IAD framework is interpreted in Figure 3.5. The framework is comprised of seven sets of variables: "(1)the set of actors/participants, (2) the specific positions to be filled by participants, (3) the set of allowable actions and their linkage to outcomes, (4) the potential outcomes that are linked to individual sequences of actions, (5) the level of control each participant has over choice, (6) the information available to participants about the structure of the action situation, and (7) the costs and benefits—which serve as incentives and deterrents—assigned to actions and outcomes" (Ostrom, 2011, p. 11). These variables wereappliedto the perspective of wastewater management in Faisalabad; consequently, the seven-step analysis (using this IAD framework) was adopted to explore the insights in the wastewater management sector (Ostrom, 2011; Polski & Ostrom, 1999). The steps are as follows:

1. Define the sustainable wastewater management objective (analytic approach)
2. Analyze the nature of good or service (wastewater management services)
3. Analyze the attributes of community in study area (farmers, residents)
4. Analyze 'rules-in-use' (working rules) affecting the outcomes
5. Analyze action situation
    i. Partricipants/Actors (stakeholders)

ii. Their positions (under legal instructions)
iii. Their actions linked to outcomes (practicing roles)
iv. Level of control (authority)
v. Potential outcomes (policy objectives)
vi. Information availibilty
vii. Cost and benefits of actions and outcomes

6. Analyze linkages (interactions)
7. Analyze outcomes using the evaluative critera (gaps between potential and real)

Such analysis requiresspecific data over time. The historical progression/regression with respect to all involved stakeholders was conceptualized to cover this gap.

3.5.3.2 Historical institutionalism approach

The second approach,historical intuitionalism (HI),was used to demonstrate the evolution process of the institutions over time (Pierson & Skocpol, 2008;Steinmo, 2008; Thelen, 1999).

This approach wasadopted to gain knowledge regarding all-existing formal and informal institutions that govern the wastewater management sector.It helped to search out the inbuilt flaws and strengths of each organization. The historical background of institutional development briefed the story of their establishment, working environment, stated duties, and foundation rules for the establishment. Another main aspect was to examine the role of responsible authorities who make decisions (Hall & Taylor, 1996; Pierson & Skocpol, 2008).

The legal framework for the administrative organizations was already discussed in the sixth chapter of this thesis. Hence, the agendas, organogram, the historical context, andthe challenges for each organization (presented in Appendix G) are explained using the critical analysis and HI approach.

3.5.3.3 Content analysis

Content analysis is a qualitative research technique which assists the researcher in drawing significant inferences of concern from the text data (Krippendorff, 2004). (for detail read the guide for content analysis by Colorado State University, 2004). Hence, content (conceptual) analysis technique was adopted to explore the issues/challenges in sustainable wastewater management.Krippendorff (1989) defined six steps—design, unitizing, sampling, coding, drawing reference, and validation—for content analysis. The researcher also followed these steps to conclude thechallenges in the wastewater management sector.

Design (context): Based on prior research findings,this studywas initiated with a few pre-assumed views, ideas or hypotheses about the study area. At the time of the first visit to the study area, the researcher was only aware was about the poor-quality wastewater in public drains, which was dumped into either fields or the river without any proper treatment. The management issues were hidden from the researcher at that time. The context of this study,then, aimed for investigating the causes of negligence in the wastewater management sector.

Unitizing (sampling unit)**and sampling** (selection of sample): Empirical data (qualitative) collection and analysis are narrated as the 'opening of the black box.' Text data was collected in different forms, such as transcripts of in-depth interviews and focus group discussions, photos, copies of departmental presentations, copies of maps, video recordings, and field notes from the researcher's direct observation.

As mentionedearlier, identifying the stakeholders was the first target to be informed about the wastewater management sector in Faisalabad. Detailed features of each group were further provided for a deep understanding of the system;a semi-structured questionnaire withopen-ended questionsalso helped to organize the discussion with different stakeholders.

For analyzing the collected information, a field report was first transcribed verbatim. The transcription included verbal communication as well as non-verbal expressions, behaviors, and experiences. During data collection, metadata (log) was prepared, which carried all records about the date of interviews, respondent contact details, members of the team, methods of data collection, and any other specifications. All these steps helped to understand and organize the data for analysis(see Table 3.1).

Coding (categories of analytic constructs): Initially, a categorization approach (coding) was adopted at a primary level by making a group of stakeholders (Glaser, 2013) such as, industrialists, wastewater irrigators, agencies and so on.Based on a fixed set of queries, the categories were identified after the discussion with stakeholders. The poor management of wastewater was depicted through all collected information such as quality and quantity of wastewater, farmer's perspectives, and administrative/organizational analysis.

During the documentation procedure, the first field report prepared using the codes naturally surfaced from the field study and observations. Later on, information had distributed under different heads (coding) as wastewater management's challenges, which further helped to consolidate the evidence around the main codes.

Drawing inference (relation between coded data and phenomenon): Based on the evidence provided, analyzing the data helpedto decide whether the theory explains the evidence best or if some other theories shouldbe observed(Charmaz, 2006). The researcher drew from this theoretical rationale to infer the findings(discussion of results).

A generalized opinion could only be described based on the analysis of specific data while ignoring the least concerned information (extracting logical conclusions from analyzing the bulk quantity of unstructured information).

Validation (reliable and replicable): Identical criterion also helped to compare the various situations; missing information was continuallysearched and added untila logical saturation endpoint was reached. Therefore, the data collection process was frequentative (Biernacki, 1986). Afterward, information gaps were filled using secondary sources, such as visiting the official website or contacting resource persons (telephonic communication). The purpose of this was to compare the situations and organizations (institutional analysis) (Basurto, Kingsley, McQueen, Smith, & Weible, 2010).

Qualitative data quality was verified by confirming the explanations through other sources, triangulation, member check, and interrelating the data with existing knowledge (Anastas, 2004; Bitsch et al., 2006;Kirkevold & Bergland, 2007; Lincoln & Guba, 1990; Ryan & Bernard, 2000; Seale, 1999).

3.5.3.4 Critical analysis

A qualitative analysis(QA) approach was designated to disclose the mismanagement in the wastewater sector (Zhang & Wildemuth, 2009). Hypothetically, QA is an inductive approach with no exact preconceived ideas about the results (Biernacki, 1986). The critical analysis was an important tool of qualitative analysis on text information, which assisted making concluding remarks while evaluating departmental reports, official documents, and web-based data. The personal weighing of evidence was also the main feature of critical analysis. The data including documents, departmental presentations, interviews, and earlier studies were critically analyzed. The analysis was done using the following prescribed rules used and suggested by different scholars (see Anastas, 2004; Berg, 2001; Fossey, Harvey, McDermott, & Davidson, 2002; Sofaer, 2002; Thorne, 2000; Vaismoradi, Turunen, & Bondas, 2013).

3.6 Analysis of policy intervention

This section relates to the possible research-based policymaking. These policy interventions have been suggested using the collected information/data. The primary goal was to introduce possible methods/techniques for some planning-based solutions. Such research-based policy intervention was proposed using Ostrom's design principles (commons), stakeholder analysis and the Ethical Matrix, which are explained in the following subsections. Ostrom's eight design principles were applied to the current mismanagement of the wastewater sector in this case study.

3.6.1 Stakeholder analysis or Interest-Influence Matrix

A stakeholder analysis was accomplishedwith the Net-Mapping technique. "Stakeholder analysis is a process of systematically gathering and analyzing qualitative information to determine whose interests should be taken into account when developing and/or implementing a policy or program". (Schmeer, 2000, p. 4)

After identifying the interest of stakeholders during the Net-Mapping session, a structured questionnaire (attached in the Appendix I4) asked each stakeholder to rank one another on an interest and matrix scale. Each stakeholder had to evaluateevery stakeholder's level of interest and influence on the decision-making process.This wasassessed by assigning a number (ranking) to each stakeholder. Each stakeholder categorized himself and the other stakeholder's level of interest and influencebased on hisown judgment. The level of influence and interest ranked from zero to four points (questionnaire attached in Appendix I4) (Schmeer, 1999).

The level of interest represented the legal and institutional goals/objectives(concern, duties, priorities) of each stakeholder (Loudjeva & Jorgensen, 2005); influence was evaluated by estimating the status of resources (financial and human) and salience of each stakeholder for the decision and policy-making process (Schmeer, 2000).

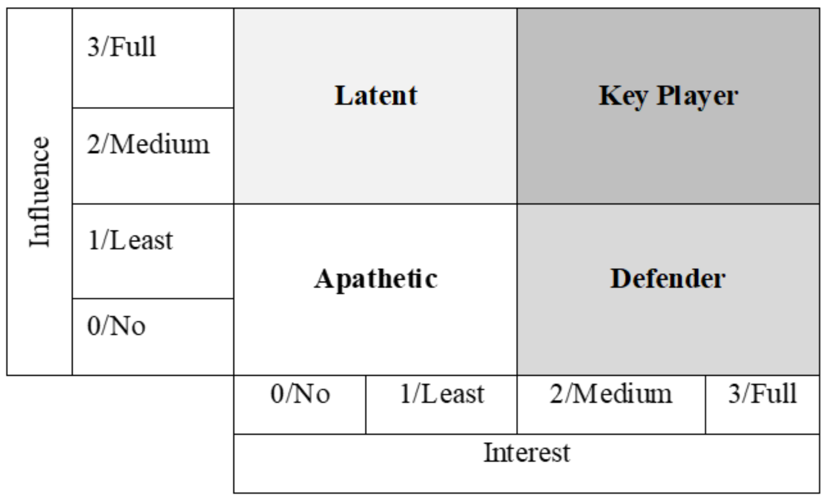


Figure 3.6: A generic stakeholder matrix or interest-influence matrix

All stakeholders were ranked from 0-4 as shown in Figure 3.6.The average position—based on ranking collected by each stakeholder (for himself and for others) on influence and interest grid—was expressed through the stakeholder matrix (see Figure 3.6).The matrix provided grounds to involve and improve the stakeholder positions for future policy formulation (for detail see Bryson et al., 2011; Espinosa-orias & Sharratt, 2006; International Institute of Environment and Development [IIED], 2001; Schmeer, 2000).

A deep understanding regarding their power, influence, and interestwas portrayed through information provided by key informers (like *Numberdar*, political agent, or village leader). The stakeholders at first were grouped based on the same interests (Bryson, Patton, & Bowman, 2011) and then ranked (based on stakeholder's concern for his objective). Stakeholders' interests may compete with one another. Afterward, their interestswere classified using a questionnaire. Finally, a stakeholder matrix was mapped, showing his level of influence and interest on grid lines.

3.6.2 Ethical Matrix

The second method used for framing possible future policies for sustainable wastewater management was the ethical matrix. Principally, "it is a scheme that specifies and interprets selected ethical principles according to every stakeholder's situation." This approach is based on the ethical principles proposed by Beauchamp and Childress (Beauchamp and Childress, 1998).Further, it has been modified in Ben Mepham's matrix for biotechnological issues

(Mepham, 2008). Fundamentally, the ethical matrix is based on the perceptions of the researcher. Lately, it has been modified so that stakeholders could also construct it at the same time. The main principles for the specified principal matrix (see Table 3.4) are well-being, autonomy, and fairness or informed consent (legal status) (Kaiser, Millar, Thorstensen, & Tomkins, 2007). The researcher or stakeholder both can suggest that an activity either benefited on specified principles or not.

Table 3.4: A generic ethical matrix for use in issues concerning food and agriculture

Respect for	**Well-being**	**Autonomy**	**Fairness**
Producers	Satisfactory income and work	Managerial freedom	Fair trade laws
Consumers	Safety and acceptability	Choice	Affordability
Treated Organisms	Welfare	Behavioral freedom	Intrinsic value
Biota (environment)	Conservation	Biodiversity	Sustainability

Source: Adapted from Mepham (2010, p. 18)

In Table 3.4, a generic ethical matrix is presented with the point of view of food and agriculture issues. For example, the well-being of producers (farmers) is measured by satisfactory income and working conditions. Correspondingly, other parameters indicate each principle from the viewpoint of a specific stakeholder.

These three pillars were designed to shape the following policies.Hence, the researcher suggested outlining the matrix around three basic principles. Then, a matrix was prepared to illustrate whether a prescribed goal was achieved or not. In case of a failure, future policy or strategies wererecommended to achieve that specific goal.

Methodologies for assessing/evaluating sustainability in wastewater management sector are based on such methods/techniques/approaches which can only be applied using particular information/data. Such specified data availability is lacking in developing countries like Pakistan.Possible methods/techniques/approaches have applied to estimate the current scenario of wastewater management in Faisalabad. These methodologies can be applied on other cases.

3.7 Limitations of the study and critical review of the applied methods

For this study, a framework was designed to capture the complex inter-sectoral phenomena with respect to different aspects (legal, social, health, economic, environmental,institutional,and organizational) of wastewater management.

The statistical and econometric (quantitative) analysis of wastewater irrigation communities disclosed the potential interaction among wastewater, human, and the environment at the micro-level. The study conducted had certain limitations due to physical, financial, and time constraints. One limitation was the time lag between the data collection phases. During the first phase, ahousehold survey wasconducted during May 2008–April 2009, whereas the empirical (qualitative) data were collected during June-August 2015. However, the time lag of six years did not affect the significance of the research. The other limitation regarding data was the absence of biological and heavy metal analysis of wastewater, soil, and groundwater. Unfortunately, it was not possible to include all these analysesdue to financial limitations.Additionally, the Public Health Department was not included in the frame of research regarding the prevalence of water-borne diseases (consumer's health) in the study area. To cover this gap,it was assumed that wastewater irrigators (farmers) were also consuming their own produce (crops).

The critical review of the legislative framework was also challenging for the researcher (outsider from the judicial system). The evaluation of formal laws (acts, ordinances, rules, and regulations) might have been a trouble-free task for a law scholar but not for everyone. Formal laws were reviewed considering other legal reviews. Eventually, this exercise changed the disciple-orientedresearch, which ultimately can enhance the scope of academic research. Such interdisciplinary study can offer a unique approach when looking at the problem. Hence, gaps in the legal framework were pointed out using a holistic lens.

Lastly,the institutional analysis, aimed to explore the challenges in the wastewater management sector in Faisalabad, also faced challenges. In the absence of verified data at any level regarding governance indicators in Pakistan,searching required information was challenging. Only scattered information or few publications were accessible. With the help of theoretical frameworks and qualitative data collection tools, using such scattered information proved to be an exceptional exercise for suggesting future policies.

Overall, the qualitative and quantitative analyses aimed ataddressing different kinds of diagnoses. Qualitative and quantitative techniques supported the study to address the type and extent of the problem. In fact, the cause and effect relationship and the intensity of influencing factors were the focus of many research questions, especially in Chapter 5. Hence, the statistical inferences helped to compare situations and compute causal interactions. On the other hand, data addressing human and societal behavior (interactions among individuals and institutions) was hard to get through quantitative techniques, especially in the absence of specific data. Under such conditions, social behaviors and verbal information (reasons, consequences, and recommendations) could not be judged using numerical and quantitative approaches. Here, the targetswere organizational and institutional failure, poor management strategies, legal and policy gaps for better policy recommendations. To achieve these goals, qualitative data collection tools and techniques were successfully applied. Briefly, the selection of data analysis tool/techniques was entirely depended upon the objective of the research and the type of available information.

4. STUDY AREA AND NEEDS ASSESSMENT

This chapter contains three sections to explain the specific characteristics of the study area, Faisalabad. The first part covers the broad-spectrum background of the research area, including geographical location, agricultural systems, irrigation infrastructure, industrial activities, and wastewater drainage facilities in the whole district Faisalabad. The second part describes the overview of current wastewater management circumstances in Faisalabad city, which ultimately advocates the need for this research.Third, the general consequence of villages (selected for household survey) practicing wastewater irrigation has interpreted. The research questions and targeted inquiries are tabulated in Table 4.1 for explaining the chapter’s structure.

Table 4.1: Research questions and targeted inquiries

Research questions	Section
1- What was the background information of the study area regarding irrigation and drainage system, agriculture, population growth and industrial status?	4.1
What was background of existing irrigation system and agriculture within study area? What kind of drainage infrastructure existed around Faisalabad (IDD infrastructure) and within Faisalabad (WASA infrastructure)? What was the background of rapid urbanization and industrialization of Faisalabad?	
2- Where was the problem and how much gap existed between real and desired (legal) situation? (Needs assessment)	4.2
What was the extent of problem (holistic perspective) within Faisalabad city? What was drainage infrastructure (WASA drainage system) in Faisalabad? What was the quality of sewage in Faisalabad? What kinds of treatment facilities for wastewater were available in Faisalabad? What was the condition about reuse and final discharge of wastewater effluents in Faisalabad?	
3- What were some general characteristics and issues related to wastewater irrigation in each site of the study area?	4.3
What were the general issues related to untreated industrial wastewater irrigation in southern and eastern areas of Faisalabad? What were the general issues related to untreated domestic wastewater irrigation in western areas of Faisalabad?	

4.1 Background of study area

Within this sub-section, the background of study area (Faisalabad) has reviewedwith three main features of wastewater management. The first one is the development of canal irrigation system and agriculture within this area. The second aspect is the growth of industrialization and urbanization within Faisalabad. The last of all is the assessment of the existing surface and public drainage system within this region.

Pakistan is primarily an agricultural country. In particular, Punjab province—approximately one-third of the entire nation— is famous for its agricultural production. It is the land of five rivers and a vast human-made irrigation system.

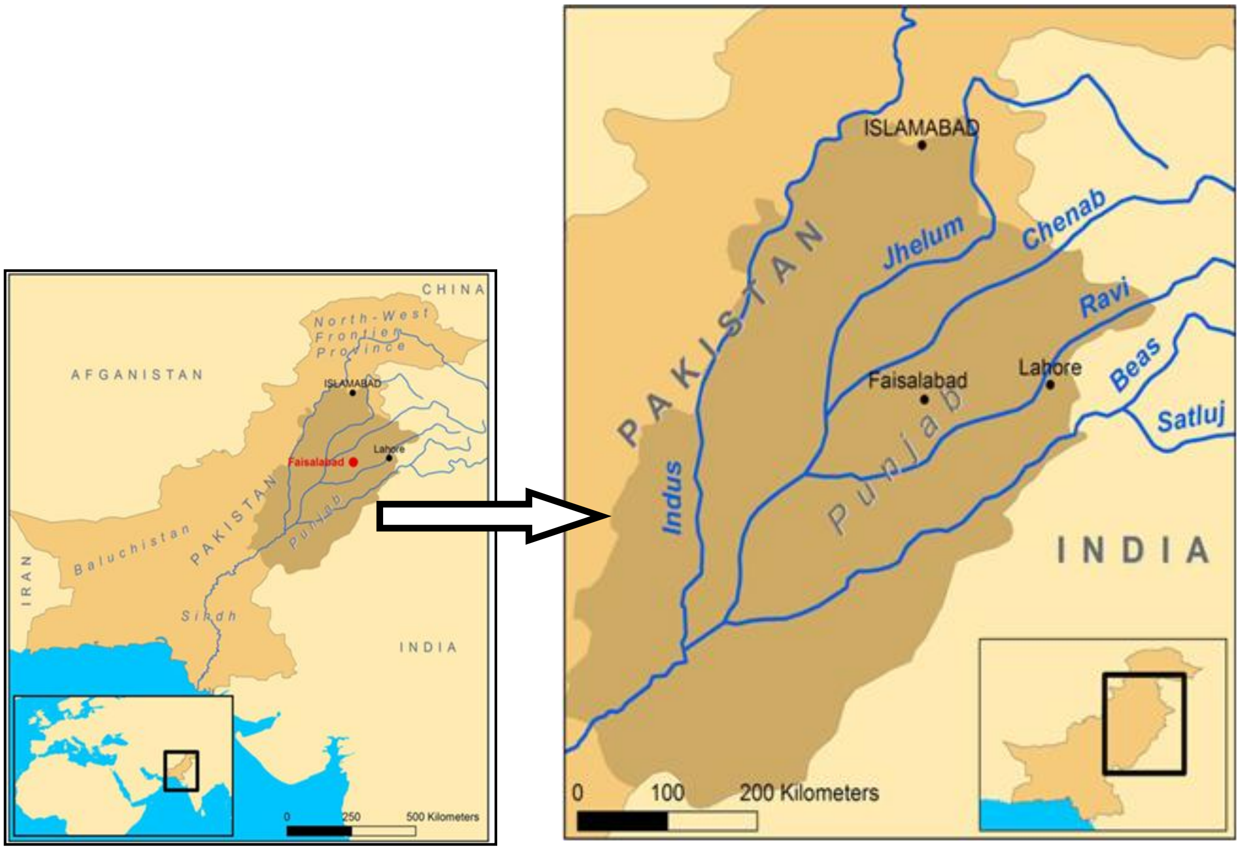


Figure 4.1: Location of Faisalabad

Punjab (highlighted dark brown area in Figure 4.1) covers 57 percent of the total cultivated area and 69 percent of the total cropped area of Pakistan (Pakistan Economic Survey 2013-14, 2014).The study wasconducted in the Faisalabad, located in central Punjab.

There are three main reasons for selecting this study area. First, Faisalabad is the hub of industrial (textile) activities that predominantly cause water pollution. The second reason is its vast rural area. About 52% of its population still lives in rural areas around the urban areas. This rural population engages in agricultural activities as its primary source of income and livelihood. For that reason, Faisalabad is unique for its industrial activities as well as its agricultural activities. Besides this, Faisalabad is the only city where farmers attained their right of wastewater irrigation through judicial proceedings. Therefore, the third main reason was the controversial opinions of stakeholders over the wastewater management.

According to the Köppen-Geiger classification, Faisalabad has a BWh category, i.e., dry tropical dessert. It is located just outside of the tropics at a latitude of $31^{o}26$’, a longitude of $71^{o}06$’ and an altitude of 184.4 m. The summer is hot, with the average temperature in Junebeing 34^{o}C. Most of the rainfall occurs during the monsoon season in July and August(Cheema, Farooq, Ahmed, & Nisar, 2006). The soil is very fertile but some areas are affected by salinity and waterlogging. Underground water is saline in most areas.

Faisalabad lies in a geographical depression between the River *Ravi* and the River *Chenab*, which is known as *'Rechna Doab'* (see Figure 4.1). The natural slopes move down from the northeast to the southwest. The *Chenab* River supplies the irrigation water to all canals of *Rechna Doab*(Ahmad, 2002).

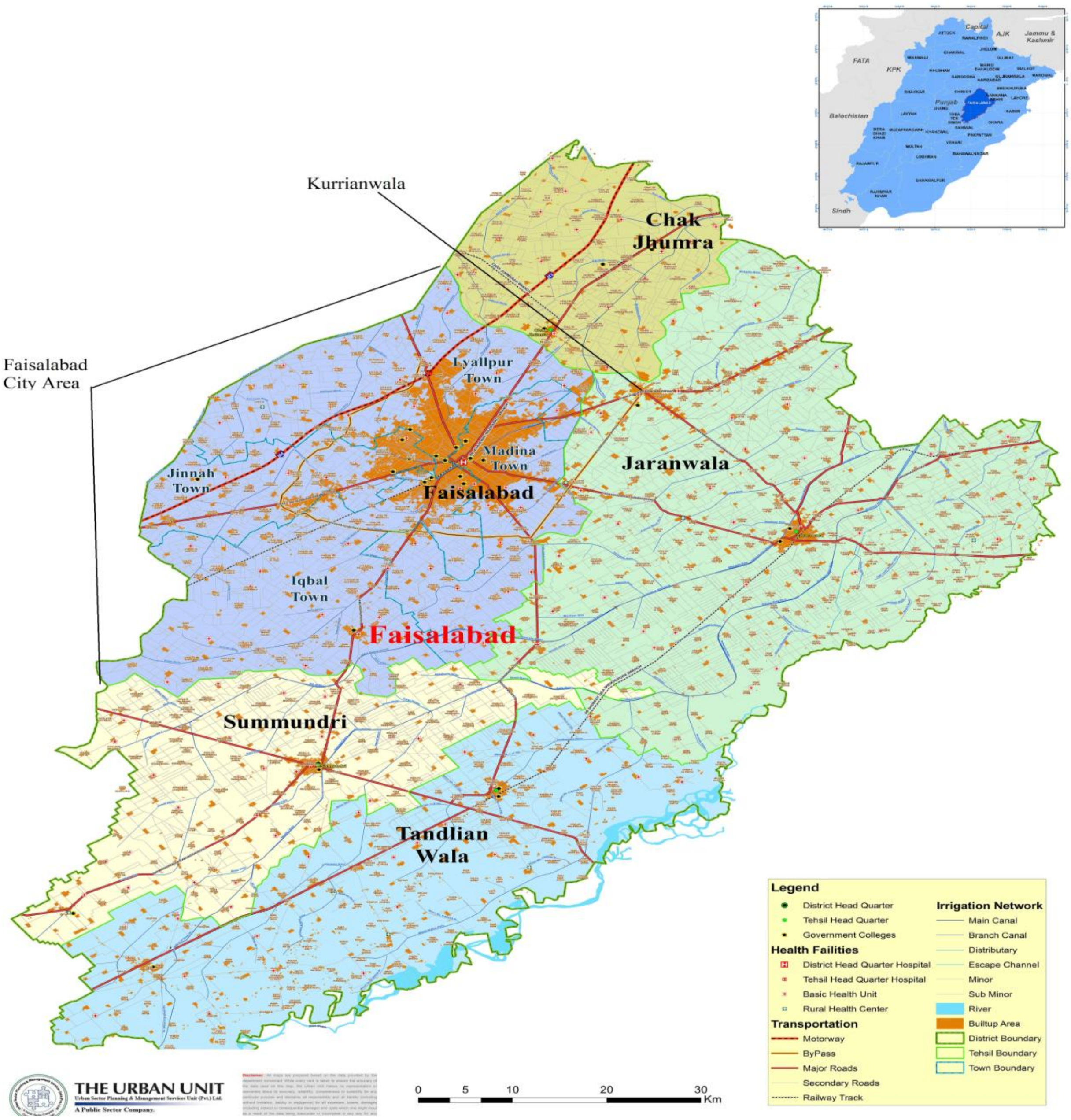


Figure 4.2:Map of Faisalabad District

Figure 4.2 explains the infrastructure of Faisalabad District including city area and tehsils. The orange shading indicates densely populated areas. Orange and red lines indicate main roads and motorway. Figure 4.2 also displays the population concentration and industrial establishments along the main roads.City area (around Faisalabad center) includes four towns: *Madina Town*, *Lyallpur Tow*n, *Jinnah Town*, and *Iqbal Town*.The city district government administrates these towns (shown in purple in figure 4.2).

Four tehsils (*Chak-Jhumra*, *Jaranwala*, *Samundri*, and *Tandlianwala*) situate around the city. Administratively, Tehsil Municipal Administration (TMA) manages at each Tehsil level. Tehsil Jaranwala and Samundri are also facing weak wastewater management practices due to the untreated discharge of effluents from industrial units.

The study mainly focuses on the city area including four towns and an industrial area (*Khurianwala*) situated within *Jaranwala Tehsil*.

The district of Faisalabad has surrounded by the districts of *Hafiz Abad*, *Jhang*, *Okara*, *Sheikhupura*, *Sahiwal* and *Toba Tek Singh*. Faisalabad-Sheikhupura-Lahore (industrial development) has shown rigorous economic growth during the last few decades.

4.1.1 Irrigation system and agriculture

The first development within this area came about the end of the 19th century (1885) with the establishment of irrigation infrastructure. Before it, this area was just a *Tehsil* of *Jhang* District. British colonial government decided to cultivate these fertile plains of Indus basin with irrigation water. The primary purpose of constructing such a vast irrigation infrastructure was to overcome the aridity problem (Mushtaq & Tohidahma, 2012).

To irrigate the area of *Rechna Doab*, the earliest *Marala* Barrage (headwork) was constructed in River *Chenab* in 1887, which started to supply water in the *Upper Chenab Canal* (UCC) in 1915. The second irrigation project within *Rechna Doab* was to divert the water of River *Chenab* at *Khanki* through a weir in 1889. The project of the *Chenab Canal*, later named as the *Lower Chenab Canal*approved in 1890, started supplying water within just two years later (1890-1892). Initially,the two canals, the *Lower Chenab Canal* (East) Faisalabad and the *Lower Chenab Canal* (West) Faisalabad, were constructed (1892-98) to irrigate the Faisalabad District. Later, the *Rakh Branch* (RB) canalwas constructed from the *Lower Chenab Canal* (West), which irrigates the central area of Faisalabad District (see Figure 4.3).

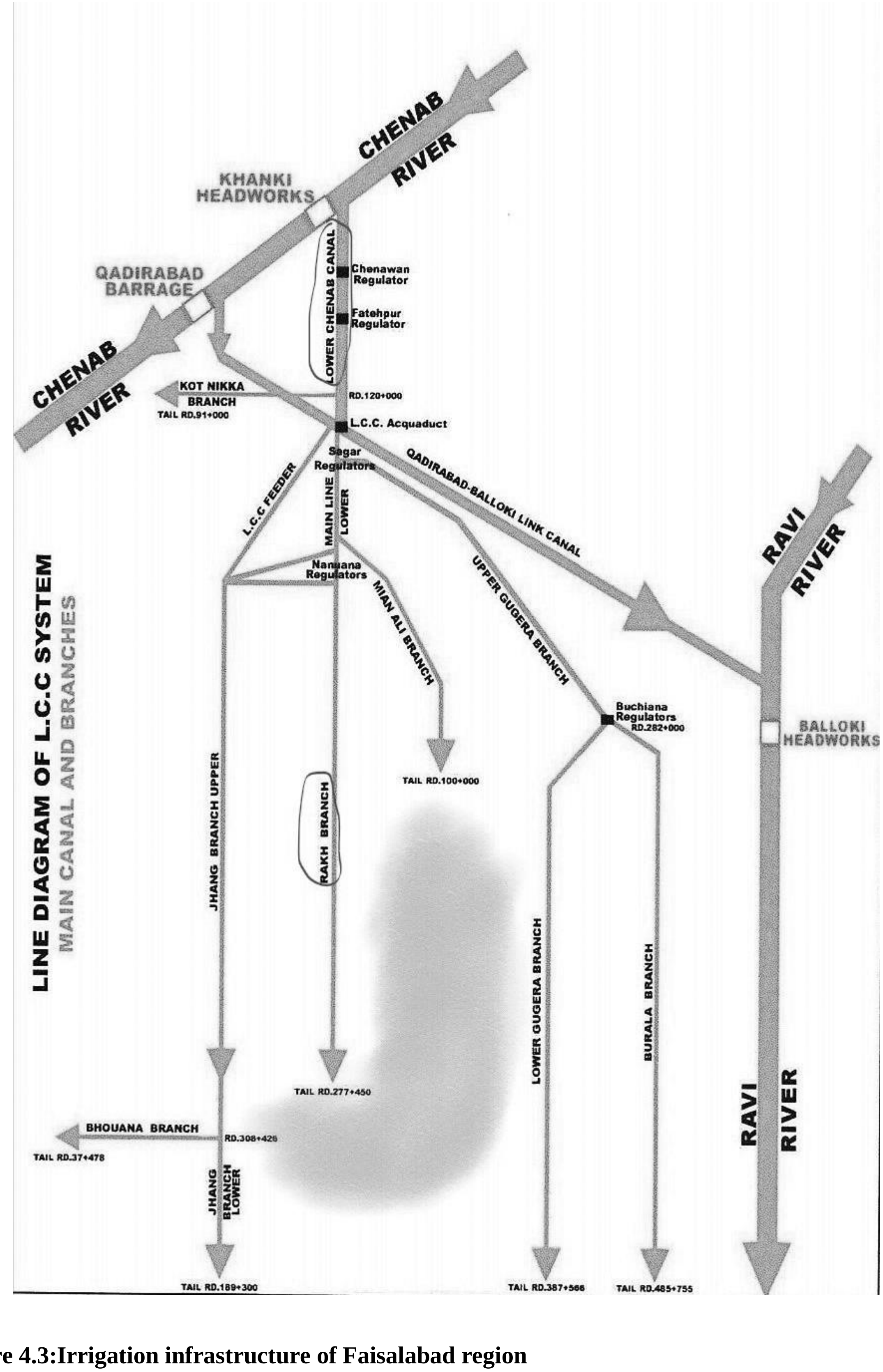


Figure 4.3:Irrigation infrastructure of Faisalabad region

Source: Irrigation and Drainage Department (IDD)

Figure 4.3 elaborates the line diagram of *Lower Chenab Canal*. *Rakh branch* canal (encircled in Figure 4.3) passes through the center of Faisalabad city. In figure 4.3, the grey-shaded area represents the areas of limited supply of canal water for irrigation.

At the provincial level, under the Canal and Drainage Act 1860, irrigation and drainage department (IDD) has had the responsibility to control and maintain the whole system and ensure the canal water supply reaches the farm. Later, Farmer's Organizations (FOs) and Water User Associations (WUA's) have formed to solve the water supply issues at the farm level. With the support of USAID,a project named 'On-farm water Management' launched in 1980 for the lining of watercourses and precise land leveling;the development of WUA's and water management practices improved water supplies to farmers(Merrey, 1997). Currently, all watercourses have paved within the study area under this project.

Under the PunjabIrrigation and Drainage Authority (PIDA) act 1997, the next significant reform 'Integrated Participatory Management (IPM)' within the irrigation sectorwas introduced. As a result, the Punjab Irrigation and Drainage Authority (PIDA) was established. In 2005,a pilot project of area water board (AWB) at Lower Chenab Canal (East) Circle with 85 FOs(Raza, 2008). After this experience with the pilot project, the government enhanced the irrigation sector reforms program and established 67 more FOs in the Lower Chenab Canal (West) area water board. IDD, PIDA, and the Punjab Monitoring and Implementation Unit (PMIU) collectively regulate and monitor the distribution of the canal water supply. The irrigation department monitors the canal water supply allocation until *Rajbah* (distribution point at the'distributary' to water channel). From *Rajbah* to each *Mogha* (outlet for the farmer at water channel), it is regulated by PIDA. With the help of FOs, PIDA monitors the flow of water in the water channel, cleans the channels, and turns scheme of water application. The Punjab Irrigation Monitoring Unit checks the daily measurement of water supply (gauge data) from head to tail of the water channel. Superintendent Engineer (SE) at the provincial level through a 'Complaint Cell' directly deals with the complaints aboutthe canal water supply (Bandaragoda, 1999a). All this system operates very well in LCC (West) region, but numerous complaints from LCC (East) region proves its failure within this region(IWMI, 2014).

Formerly, this region was famous for cotton production. It was the reason for the establishment of the first textile unit in Faisalabad at the start of the 20th century. Later, wheat-cotton cropping system shifted to wheat-sugarcane or wheat-fodder due to the salinity, water logging and a limited supply of canal water (Badruddin, Skogerboe, & Shafique, 1996). The increase in cropping intensity of the area enhanced the demand for canal water supply. These canals have been initially designed for the irrigation of areas which have 40 to 75 % cropping intensity (Sahibzada, 2002). Recently, farmers demand the canal irrigation water to fulfill their crop water requirements with 100-150 % cropping intensity.

Peri-urban farmers prefer to grow vegetables and fodder for commercial basis. Such urban agriculture demands high water requirements under a limited supply of canal water. In northeastern Faisalabad (near the Rakh branch canal), ample water supply is available because agriculture farms are located at the head of watercourses. These farmers manage big commercial farms for urban agriculture.

Moreover, agricultural lands in the entire Punjab Province are facing problems of salinity and waterlogging because of the perennial canal irrigation system (Perennial canal system which lined up to control the water supply throughout the year by constructing dams, barrages and canals). The purpose was to irrigate a vast area for cultivation. Leaching of water from unlined water channels and the percolation of water from irrigated fields caused the underground water table to rise and accumulate salt. As a result, the groundwater of *Rechna Doab*has become saline and declared as unfit for irrigation (Ahmad, 2002;Douglas & James, 1986). Thus,waterlogging and salinity made the groundwater unfit for irrigation for the entire Faisalabad city(Wolters& Bhutta, 1997).

4.1.2 Surface drainage and public sewage system

The topography in Rechna Doab is almost flat, requiring a proper drainage system to pump out all sewage water from this area. During the expansion of perennial irrigation system in the early 19th century, proper drainage facilities were not. At that time, the water table of the Indus Basin was about 50 feet below the surface (Greenman, Bennett, & Swarzenski, 1967). Waterlogging and salinity issues emerged due to the absence of subsurface drainage and minimal provision of surface drainage (Waqar & Horinkova, 2002).Somestormwater drains dug in *Rechna Doab*since the 1950s. However, these surface drains have had a low impact on controlling the waterlogging and salinity issues and have only provided minimal relief to prevent flooding. Lately, about 22% of the areas in Indus Basin have had an underground water table within six feet and about an additional 30% of the areas possessed a water table within 10 feet until the 1980s (Asrar-ul-Haq, 1998; Wolters& Bhutta, 1997).

The proper drainage project to control the waterlogging and salinity issues of *Rechna Doab* launched after the 1950s. Salinity Control and Reclamation Project (SCARP) and the WAPDA Project addressed the issue of high underground water table. Under SCARP, public tube wells were installed during the 1950s, but waterlogging and salinity issues in this area could not be resolved due to some complications. Later, the ‘Revised Action Program for Irrigated Agriculture’ (RAP) was launched during the 1980s (Byrnes, 1992). It highly prioritized subsurface drainage in irrigated areas that possessed waterlogging and salinity issues. The World Bank also provided loans for the agriculture and water sector to solve the critical drainage problems. However, the SCARP project could not achieve the desired goals due to secondary salinization and poor operation and maintenance (Douglas & James, 1986;Garbus, LeeMoigne, & Bargoutti, 1992; Waqar & Horinkova, 2002).

The process of constructing surface drains or stormwater drains started at a broader level after the 1950s through internationally funded projects. Two main surface drainage projects within this region launched the *Sukh-Beas* Drainage Scheme and the *Left Bank Outfall Drain* (LBOD).

WAPDA planned these projects during 1969. Under the Sukh-Beas Drainage Project, the entire region has been subdivided into five phases. *Centre Bari Doab Canal* (CBDC), *Pandoki* Unit, *Sukh Bea*s below BS Link, *Sukh Nai* Outfall channel, and the remaining CBDC were the recommended stages. According to a feasibility report of this project, the first two phases completed untill 1997 (International Commission on Irrigation and Drainage [ICID], 1999). Whereas, the remaining phases of the project mentioned above could not proceed from the initial stages. In conclusion, this project could not solve the drainage problem on a broader scale. Subsequently, in 1997 another nationwide program called the National Drainage Program (NDP) was implemented. Under this program, it was planned to cover the entire canal-irrigated areas (Indus Basin, Baluchistan, and NWFP)(The World Bank, 2005). Unfortunately, drainage projects were neglectedwith the institutional change in PID. A detailed investigation report of drainage project has been documented by Memon& Scheumann (2003).

The drainage infrastructure in Faisalabad(including *Paharang*, *Samundri I* and *II*)was constructed for the rehabilitation and extension of surface drainage system in *Rechna Doab* (study area). The *Paharang* drain covers about 138,000 acres of total area. About 113,000 acres of that area is canal command area, located north of Faisalabad City. The *Paharang* drain receives irrigation from the Rakh Branch Canal (perennial), supplied by the Lower Chenab Canal (LCC) and it finally discharges into River Chenab. The *Madhuana* drain, which originates from*Khurianwala* (*Tehsil Chak Jhumra*), passes through the eastern side of the city and ends up into River Ravi (Extracted from discussion with IDD staff and IDD departmental reports). In reality, *Paharang* and *Madhuana* drains are surface water drains or stormwater drains, which are dug for reducing the drainage issues of canal-irrigated areas. Nowadays, both drains collect the untreated water from industries and residential areas and dump into River Ravi and Chenab. These drains collect untreated wastewater not only from city area but also from all industries located in the rural area along their way.

At the city level, the Faisalabad Development Authority (FDA) is responsible for the sewerage and drainage system; under the FDA, the Water and Sanitation Agency maintains the water supply and sewage systems. The Rakh Branch Canal flows from north to south and divides the city into the eastern drainage system and western drainage system at WASA Faisalabad. Recently, about 70% of municipal (urban) areas connect with the WASA sewage system (WASA tariff report). The remaining population dumps directly in nearby agricultural fields or local drainage ponds. However, the WASA drainage system cannot differentiate between domestic or industrial effluents.

4.1.3 Industrialization and urbanization

The history of Faisalabad is not so old. British government kept the foundation of this city in 1904 and named this city '*Lyallpur*' on the name of 'Sir James Lyall' (Lieutenant governor of the Punjab in1885) (DAWN, 2003).Pakistan's third most populated city, Faisalabad has over 7 millioninhabitants. Approximately, 3 million inhabitants live in city area and the remaining in its tehsils.The reason for such a prosperous population growth lies in the industrial development within this region.

The first textile industrial unit was set up in this region in the early 20th century. It was the first agro-based industry to utilize local cotton production. The technical and financial workers that were required to run this industrial unit migrated from regions across the country (sub-continent). It was the first time that industrial labor migrated to this region. After independence in 1947, it became a popular destination for Indian migrants, because of ample employment opportunities.

The next historical turn in the industrial sector came during the 1970s due to the effect of nationalization (Public ownership of private entities) in 1972. Sectors like textile, which were excluded from nationalization, prospered within this area (Hussain, Khan, & Malik, 2012). Until the end of the 20th century, government supports the medium and small enterprises which flourished textile sector within the municipality (Khan, 2013).As a result, more than 175,000 power looms are now functioning in this division.

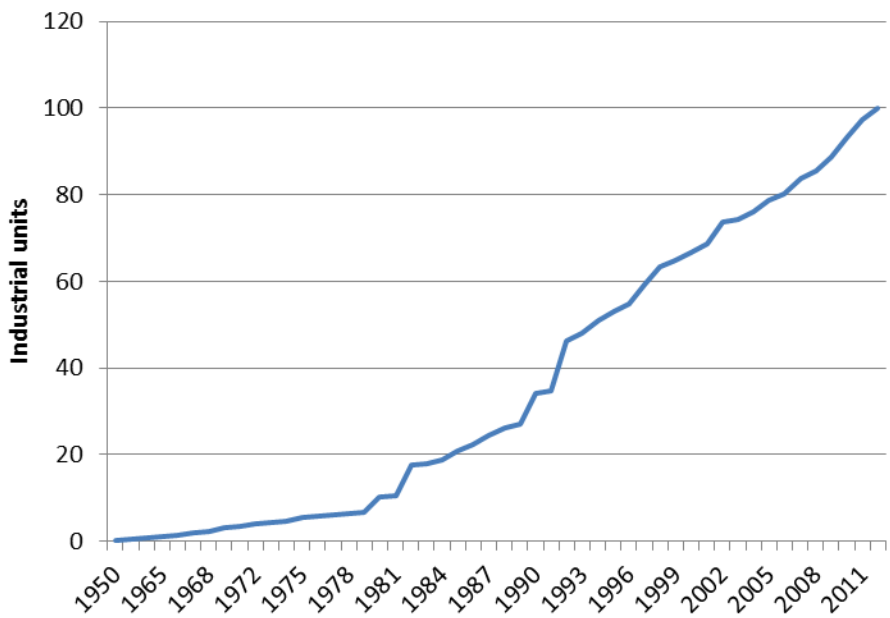


Figure 4.4:Number of industrial units established in the Faisalabad District
Data Source: Directorate of Industries, Faisalabad office

Figure 4.3 depicts the rapid industrial growth (mainly textile) after the 1970s in this area (Aftab, Ali, Khan, Robinson, & Irshad, 2000). Appendix D categorizes the industries along with significant effluent within Faisalabad.

Consequently, the main reason for the rapid population growth of Faisalabad is the urban migration from rural areas due to better employment opportunities. Areas withhigh industrial job availability had high population pressure(Bhalli, Ghaffar, Shirazi, Parveen, & Anwar, 2012; Farooq, Mateen, & Cheema, 2005). Population pressure has led to adverse environmental effects. Inevitably, the unwanted effects— such as water pollution—of industrialization have surfaced.

Sustainable use of water also requires a balanced use of drinking water and irrigation water, especially in the absence of real water markets. The structural change from rural agriculture dwelling to industrialized urban cities affected the rural-urban population distribution, agricultural industry, and livelihood standards in the region (Mazhar & Jamal, 2009). New housing communities and societies have developed on former agricultural lands without proper urban planning.

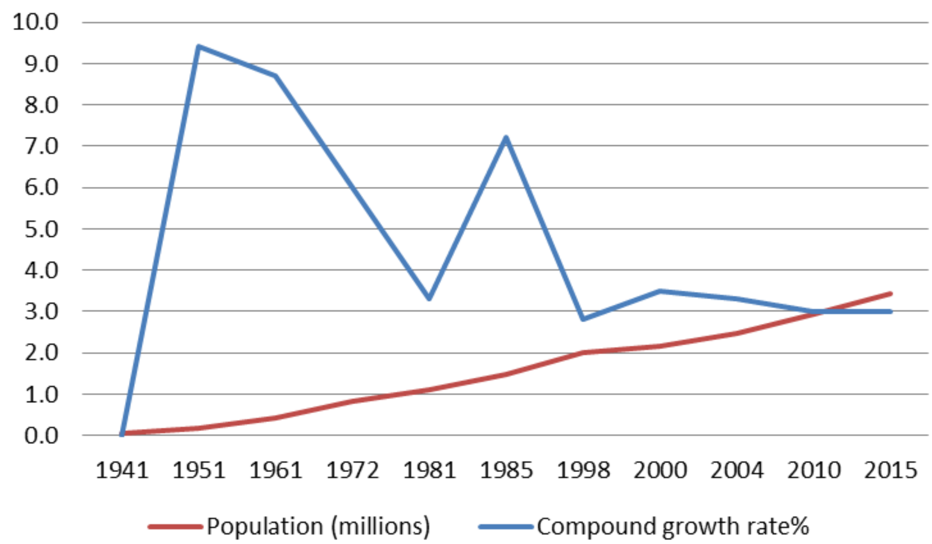


Figure 4.5:Population of District Faisalabad

Data Source: Faisalabad District Government Reports 2010

As shown in Figure 4.4, the high compound growth rate of the population after independence and during the nationalization policies in the 1970s contributed to the migration trend in Faisalabad(Anwar& Bhali, 2012; Ijaz, 1999). Similar situations also exist in the tehsils of *Jaranwala* and *Samundri*, where industrial units also have developed without proper planning.

4.2 Needs assessment for sustainable wastewater management

Within this section, a holistic overview of Faisalabad regarding its wastewater situation is considered. Then, the available information on drainage infrastructure and estimated volume of wastewater generated are mentioned in second sub-section. The third sub-section explains the quality of drainage water. Then, available treatment facilities in Faisalabad are reviewed. Lastly, the use and discharge of wastewater are addressed.

Needs assessment (gap analysis) for sustainable wastewater management—in a case study of Faisalabad city—highlights the gaps between the recent status and the desired status of wastewater management (Alzheimer's Association, 2016). The general terminology such as effluents, sewage, industrial activity, domestic sewerage, and wastes that are used in this study refers to the context as defined under PEPA 1997 (attached in Appendix E1).

4.2.1 Holistic perspective

Faisalabad is known as the "Manchester of Pakistan" because of its large textile industry. Of Pakistan's total export above 30 million dollars, 65% comes from Faisalabad (APTPMA, 2012). Since Faisalabad is the hub of industrial activities, untreated industrial effluents affect the environment (soil, groundwater, human health, fresh surface water resources) (see Al-Lahham, El Assi, & Fayyad, 2003;Amahmid, Asmama, & Bouhoum, 1999; Amoah, Drechsel, Henseler, & Abaidoo, 2007; Mahmood & Malik, 2014;Nasir, Sarwar, & Shaukat, 2014;Smith, 2009;Verma, George, Singh, & Singh, 2007).Along with its industrial sector, Faisalabad's agricultural sector is of importance: approximately half of its population is directly linked to agriculture. Such small to medium-size farms grow crops for their livelihoods.

Legally, each industry is responsible for treating its industrial effluents before discharging them into public drains. Likewise, each domestic household with an area of more than ten marlas (one Marla is equal to 272.25square feet *or* 25.2929square meters) is responsible for constructing a septic tank before disposing effluents into public drains. However, recent studies on the biochemical analysis of the wastewater of public drains in Faisalabad exposed the violation of (multiple) laws. All samples from public sewage drains (drains dug by WASA) and storm water drains (drains dug by IDD to reduce salinity and water logging issues)were exceeding national environmental quality standards (NEQS). (for detailed study see Ensink et al., 2004; Farid, Sarwar, Saifullah, Ahmad, & Rehman, 2015; Ghafoor, Raur, Arif, & Muzaffar, 1994;Hanif, Nadeem, Rashid, & Zafar, 2005; Kahlown et al., 2006; Nasir et al., 2014;Sadiq Butt, Sharif, Ehsan Bajwa, & Aziz, 2005).

Neither the local government nor the Environmental Protection Agency (EPA) can enforce the wastewater quality standards, especially in the industrial sector. Consequently, all treated/untreated wastewater is disposed into public drains, then Rivers.

On the other hand, farmers are demanding such untreated wastewater for irrigation purpose. Even they won their right—through judicial proceedings—to use wastewater as irrigation water in the absence of alternate water supplies (Weckenbrock et al., 2011). They favored wastewater irrigation for their monetary benefits due to its uninterrupted ample supply. However, studies revealed traces of heavy metals in cauliflower, cabbage and other leafy vegetables irrigated with wastewater (Ahmad et al., 2016; Jadoon et al., 2013; Tehseen et al., 2013; Waseem et al., 2014). As a result, of such research findings, the district government of Faisalabad in 2012 banned the cropping with wastewater irrigation altogether (Personal communication with EPA official, June, 2015). However, farmers are still growing other crops like wheat and fodder with untreated wastewater irrigation.

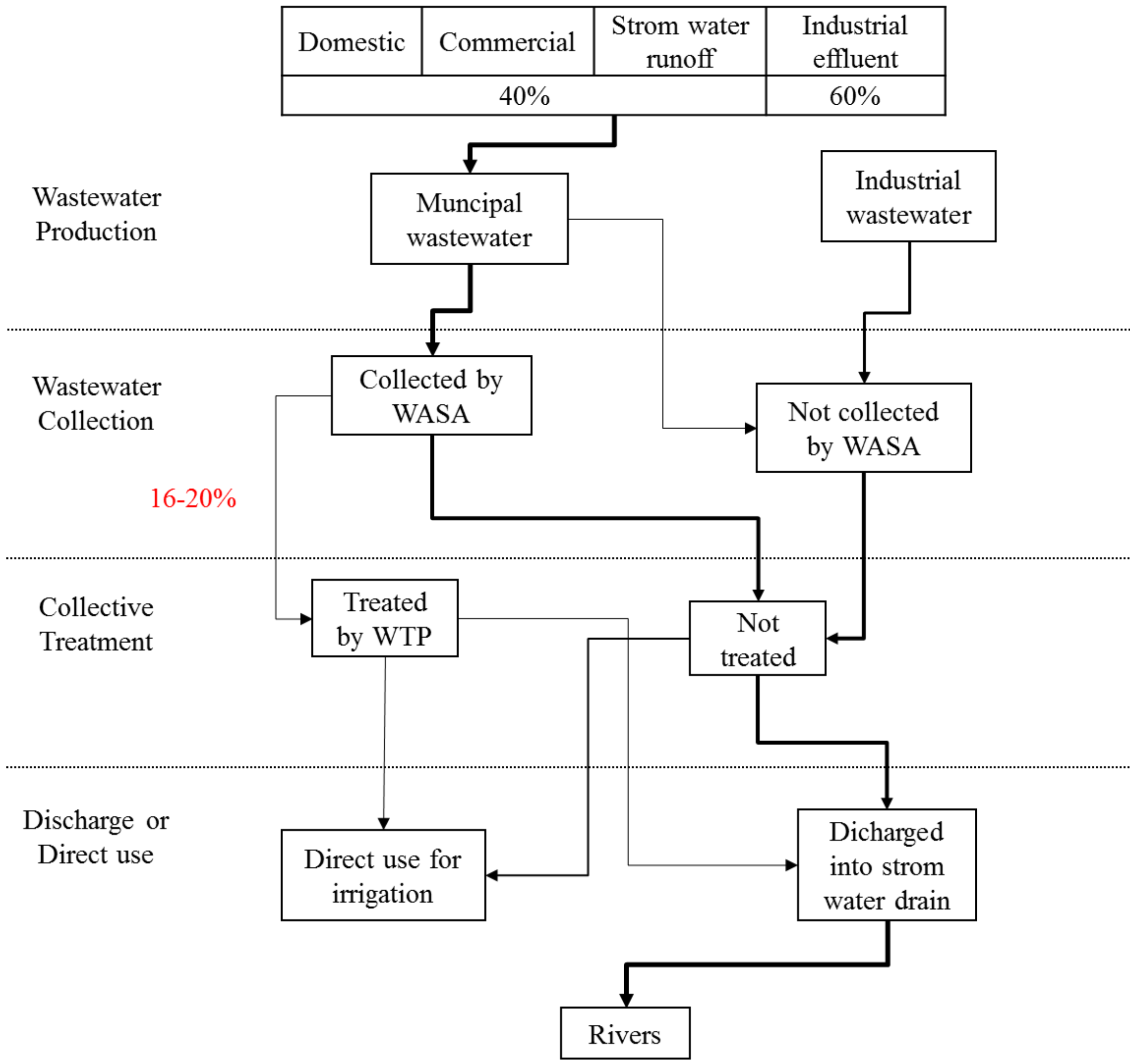


Figure 4.6:Flow diagram of wastewater in Faisalabad
Source: Author

A flow diagram (Figure 4.6) exposes wastewater flow, its sources and utilization patterns.The arrowhead denotes the flow of wastewater. The size of the arrow signifies the approximate volume of wastewater discharge. The wastewater flow chart includes generation, collection, treatment, and discharge of wastewater. A deep lookat Figure 4.6 reveals that most of the untreated wastewater from cities and villages is directly dumped into rivers

Mainly, information was collected from verbal communication with staff of the water and sanitation agency (WASA) of Faisalabad and through their departmental reports. A senior sanitary worker of WASA (see Appendix C1), for example, was a key informant about the drainage workstation and their volume. Other WASA officials correspondingly provided the estimates of treated effluents. According to WASA's departmental presentations, the average of total wastewater generated in Faisalabad is about 325 MGD (million gallons per day) during 2015. From this, 200 MGD (about 40%) are domestic, while the rest is industrial. Other measurements about discharge and direct use in agriculture were based on various secondary sources such as IIMI research findings (Ensink et al., 2004), PCRWR research data (Kahlown et al., 2006), Farmer's observation (Weckenbrock, 2010) and other study reports.

4.2.2 Drainage infrastructure

The Faisalabad WASA records revealed that around 72% of the 2.23 million inhabitants in Faisalabad city can access several functional disposal stations located across the city (see Appendix B4).

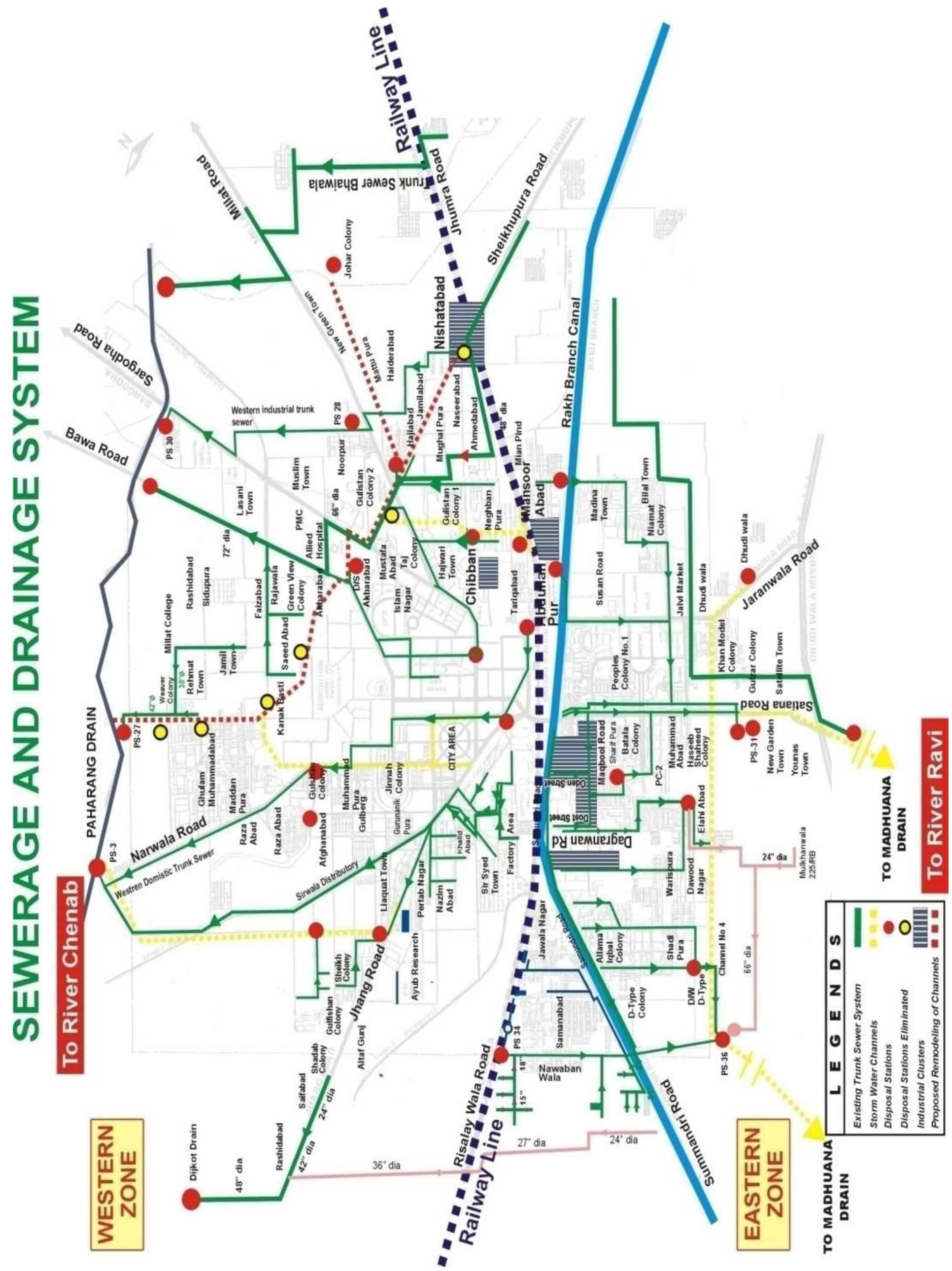


Figure 4.7:Detail map of Faisalabad's sewage and drainage system
Source: WASA departmental presentation on March 2015; provided by EPA officials

The layout of the drainage system in Figure 4.7 indicates the latest information regarding the location of drains, disposal works, and thearea served by WASA for sewerage facilities. Such information has provided awareness at the ground level. The drainage system of Faisalabad is divided into two zones, east and west, based on the pumping site of effluents into storm drain organized by IDD. The IDD is responsible for regulating water supply in canals and organizing a system of surface water drains to reduce waterlogging and salinity issues in the irrigated canal area (Section 4.1.1).

The northwestern area of Faisalabad drains into the *Paharang* drain (western side), which eventually discharges into the *Chenab* River. It originates at 144/RB near *Salarwala*. From the western side of the urban area, the main channels of WASA 1, 2 and 3 pump out the effluents and discharge into the *Paharang* drain. The average discharge from the western side into *Paharang* is about 2.37 (m3/sec) per day (Kahlown et al., 2006, p. 40). Approximately, 54 industries dump wastewater directly into the drain, and about 70 industries dump through WASA (WASA, 2015b)

The eastern side of the *Rakh Brach* canal slopes towards the southeast and drains into the *Madhuana* drain (eastern side), which further discharges into the *Ravi* River. Channel 4 and other industrial sewer tanks dump effluents into it. The average volume of discharge from the eastern side of the *Madhuana* drain is about 2.91 (m3/sec) per day (Kahlown et al., 2006).

The total volume of generated wastewater from Faisalabad has increased during the last decade (2005-15). Actually, there were no records of the discharged volume of wastewater over time at any departmental level. Therefore, all possible recorded values (at different department level, at a different time) were collected and compared after harmonizing their units of measurement.

Table 4.1: Estimation of wastewater discharge in Cusec (ft^3/sec)

Name of Drain	PCRWR (2006)		WASA, EPA* (2015)			IDD (2015)	
	At drain	At river	Industrial discharge by WASA	Direct industrial discharge	Total	Existing discharge	Average discharge
Paharang	84	114	285	38	323	196	300-350
Madhuana	103	143	256	115	371	465	350-400
Total	187	257	541	153	694 603*	661	

*The discharged volume of wastewater by EPA Faisalabad

Table 4.1 provides the information about current discharge from WASA and IDD with the same units of measurement. The comparison between 2006 and 2015 shows an approximate two-fold increase in the discharge from Faisalabad. In Table 4.1, discharge at drain level represents the total discharge from the city, including industrial and domestic effluents through WASA. The difference in 'at drain' and 'at the river' explains the industrial discharge directly into drains. The value of 257 cusecsdenotes the average discharge from Faisalabad to rivers.

PCRWR measured the average value of discharge using precise technology in 2006 under a project. WASA officials provided the current departmental information of discharge on an average basis. However, WASA records were prepared with the point of view about the maximum capacity and average flow of drains. The same situation was in IDD records. Both departments maintain their records to look at overflow during flooding seasons. IDD officials delivered the recent discharge information of at Madhuana and Paharang drains on an average basis.

Given the provided information (Table 4.1), it is clear that the amount of wastewater hasincreased during the last decade without any specific changes in the industrial or residential status of Faisalabad.

> From 2009 to 2015, wastewater generation has increased by approximately 20 to 30 percent volume, about three to four percent per year**. (**In-depth interview with the director of WWS, WASA, July 2015)

Officials from IDD, WASA, EPA, and all farmers dealing with the wastewater management also complained about the intensification in the volume of wastewater generated.

4.2.3 Typology of wastewater generation

Formerly, the highly populated area was located around the clock tower. Naturally, industries were established in these areas and then industrial workers started to live nearby. Therefore, the residential colonies came into existence next to industries. Most of the industrial units initially established without any proper treatment plan for water treatment and drainage; as a result, their untreated industrial effluents spoiled the ecosystem and social community over time (Urban Unit, 2015).

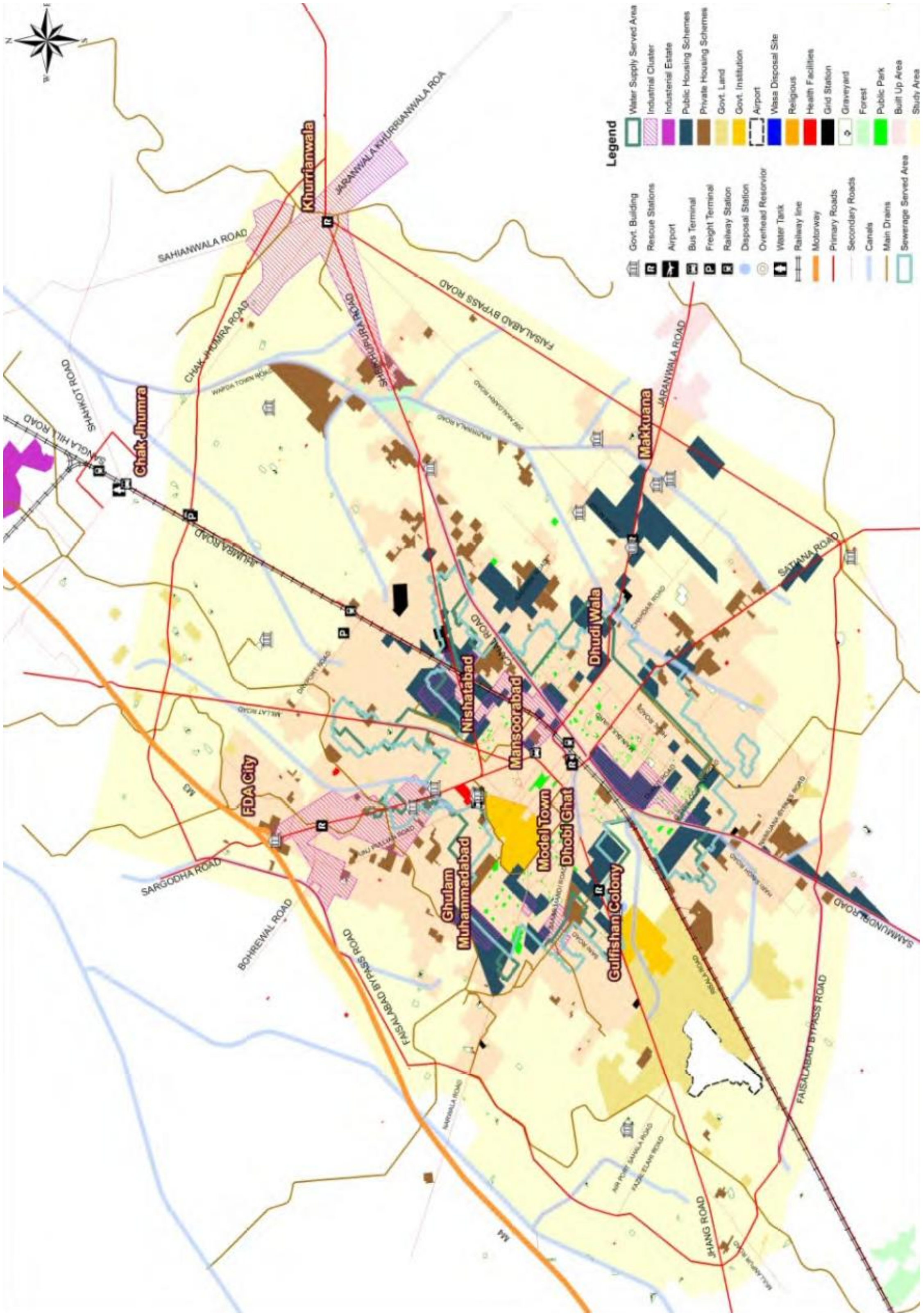


Figure 4.8:land-use map of Faisalabad
Source: Adapted from Urban Unit (2015, p. 42)

All industrial unitsin Faisalabad are located in a scattered pattern. The map of Faisalabad depicting the current land-use status of the city area displays the real complicated ground circumstances (see Figure 4.8). Even such a detailed map was prepared for the first time in 2013 by local consultants '4th Dimension consulting' for the preparation of 'Faisalabad peri-urban structural plan (FPUSP) 2035'[4]. Beforehand, such evidence was unavailable due to lack of data. In Figure 4.8, the pink lined area represents the industrial clusters. The brown and dark blue colors represent private and public housing schemes. Furthermore, light brown lines denote main drains. At a glance, the residential and industrial areas are randomly dispersed and overlapped. The yellowish, brown shade represents built-up areas. Mostly, such areas developed without any proper urban planning. Agricultural farmlands are not marked on this map, but yellow areas surrounding the built-up areas are agricultural land. Drainage facilities are available to most of the urban area, and the remaining areas privately install drains that further dump into the existing drainage system.

The typology of wastewater generated explains that what kind of water pollution exists at which location. The industrial profile of Faisalabad conveys the information regarding the kind of industry, the number of industries, and the nature of pollution created (The industrial profile of Faisalabad is attached in Appendix D). To prepare the current industrial profile, the Directorate of Industries at Faisalabad (district level) conducted the Census of Manufacturing Industries (CMI) from 2005 to 2006. Such data can inform what kind of industrial pollution is present. Based on this, the major industrial units who create a high level of water pollution in Faisalabad are chemical, paper/board, tanneries, vegetable ghee/edible oil, soap/detergents, and textile processing units.

The kind and location of industrial units would direct the focus towards the required management practices for a sustainable drainage system. The next Figure 4.9 also elaborates the details about the location of industrial clusters in Faisalabad city area. Each industrial clusterwith the different types of industrial units is situated randomly. There are also industrial units apart from these clusters that do not appear on the map.

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[4] 4th Dimension consulting are the private consultant who prepared the 'Faisalabad Peri-Urban Structure Plan 2035'. The project was funded by World Bank which implemented through The Urban Unit Punjab under PCGIP, Project duration was July 2013- February 2014 , 4th DIMENSION Consulting

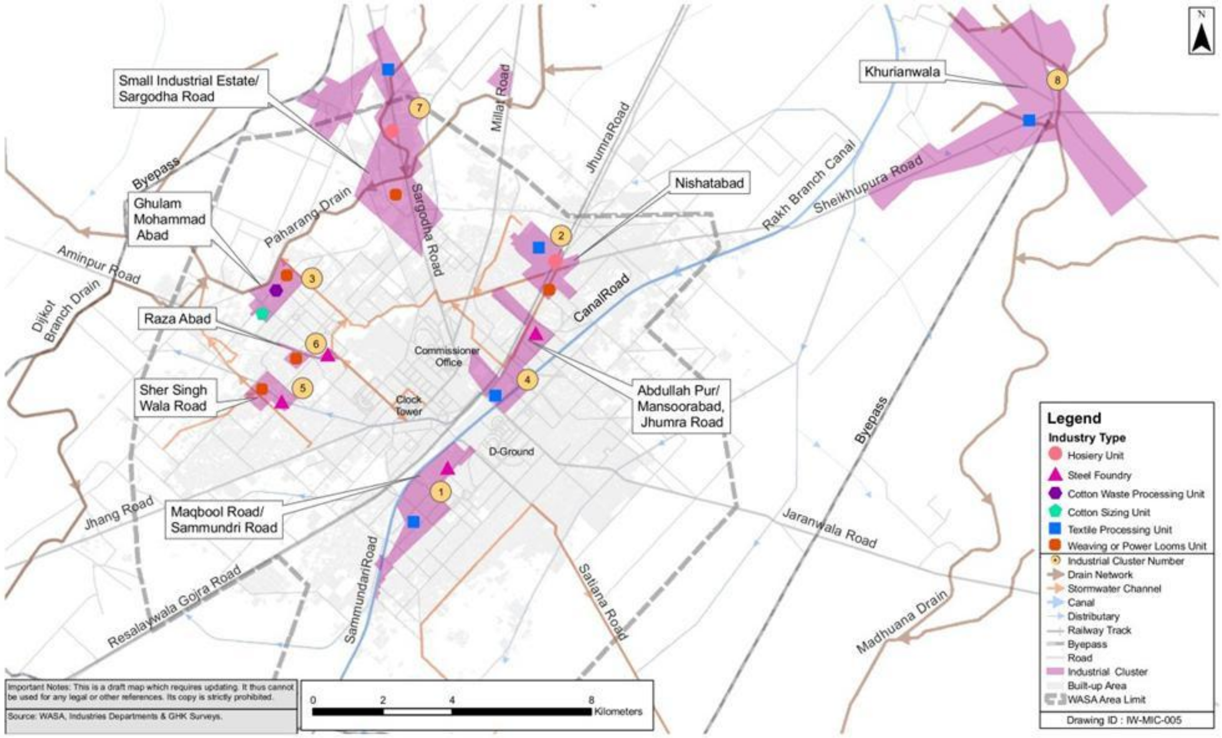

Figure 4.9: Industrial clusters and types of industries in Faisalabad

Source: Adapted from GHK (2010, Section 1, p. 1-5)

The list of each industrial cluster along with existing types of industries enumerated figure 4.9 as under;

1. Industrial Cluster, Maqbool Road/ Samundri Road (foundries & engineering works and textile processing units)
2. Industrial Cluster Nishatabad (weaving and power looms units, Textile processing units, hosiery units)
3. Sizing & Power Looms Cluster, Ghulam Muhammad Abad (weaving and power loom units, cotton waste processing units, cotton sizing units)
4. Textile industrial Cluster, Abdullah Pur/ Mansoorabad, Jhumra Road (textile processing units, hosiery units, weaving and power loom units)
5. Sher Singh Wala Road (steel foundry, weaving and power loom units)
6. Raza Abad (steel foundry, weaving and power loom units)
7. Small Industrial Estate, Sargodha Road (hosiery units, textile processing units, weaving, and power looms units)

Textile industrial Cluster, *Khurianwala Sheikhupura* Road (textile processing units)Industrial clusters two to six (indicated in figure 4.9) were established away from the residential area (city center, clock tower) during 1960-70s. Similarly, industrial units of *Maqbool* road (1) established later on. Recently, all these clusters have been surrounded by highly populated residential areas. Afterward, industrial cluster seven and eight developed after planning to some extent. However, these areas also pose a threat to the local environment due to pollution (Bhalli, Ghaffar, Shirazi, Parveen, & Anwar, 2012).

A WASA official (a senior official of the disposal-works section) communicated necessary, relevant information (during 2006) such as the relative volume of wastewater generated, different types of effluents (mixed, domestic, or industrial), and the location of disposal workstations. The total volume of discharge is estimated after adding up the approximate discharge at each disposal workstation (see Appendix C1 and C2).

Table 4.2:Type of effluent and use pattern of main drains

No	Name of channel	Zone	Type of effluent	Percentage composition		Percentage use for irrigation	Dumping site
				Domestic	Industrial		
1	Channel-1	Western	Mixed	25	75	0	Paharang
2	Channel-2	Western	Mixed	-	-	0	Paharang
3	Channel-3	Western	Mixed	85	15	20	Paharang
4	Domestic trunk sewer (P/S-3)	Western		99		58+10*	Paharang
5	Channel-4	Eastern	Mixed	25	75	80	Madhuana
6	Satiana Channel	Eastern	Mixed	5	95	25	Madhuana

- No information available, * untreated plus treated

Table 4.2 explains the types of effluents (such as industrial or domestic) and their utilization for irrigation purpose. Domestic trunk sewer (P/S-3) provides the wastewater to *Chokera* wastewater treatment plant. It contains 99 percent domestic effluents. About 68 percent of the wastewater from this drain is used for irrigation (58% without treatment, 10% with treatment). The remaining wastewater is released to Paharang drain.

In reality, every industrial site in the study area—regardless of its size or type—disposed its industrial effluents into public drains without treatment until 2013. Later, only 19 medium andlarge-scale industrial units installed treatment plants. The quality of discharge varies from drain to drain across the city. Overall quality of wastewater generated is substandard, having a high concentration of heavy metals and the quality is getting worse by the day. The quality of wastewater in drains also affect the quality of subsurface water along the drains (Asad, Chaudhary, Sattar, Nasir, & Rashid 2018;Farid et al., 2015;Hanif et al., 2005; Jamal, Durani, & Khan, 2013).

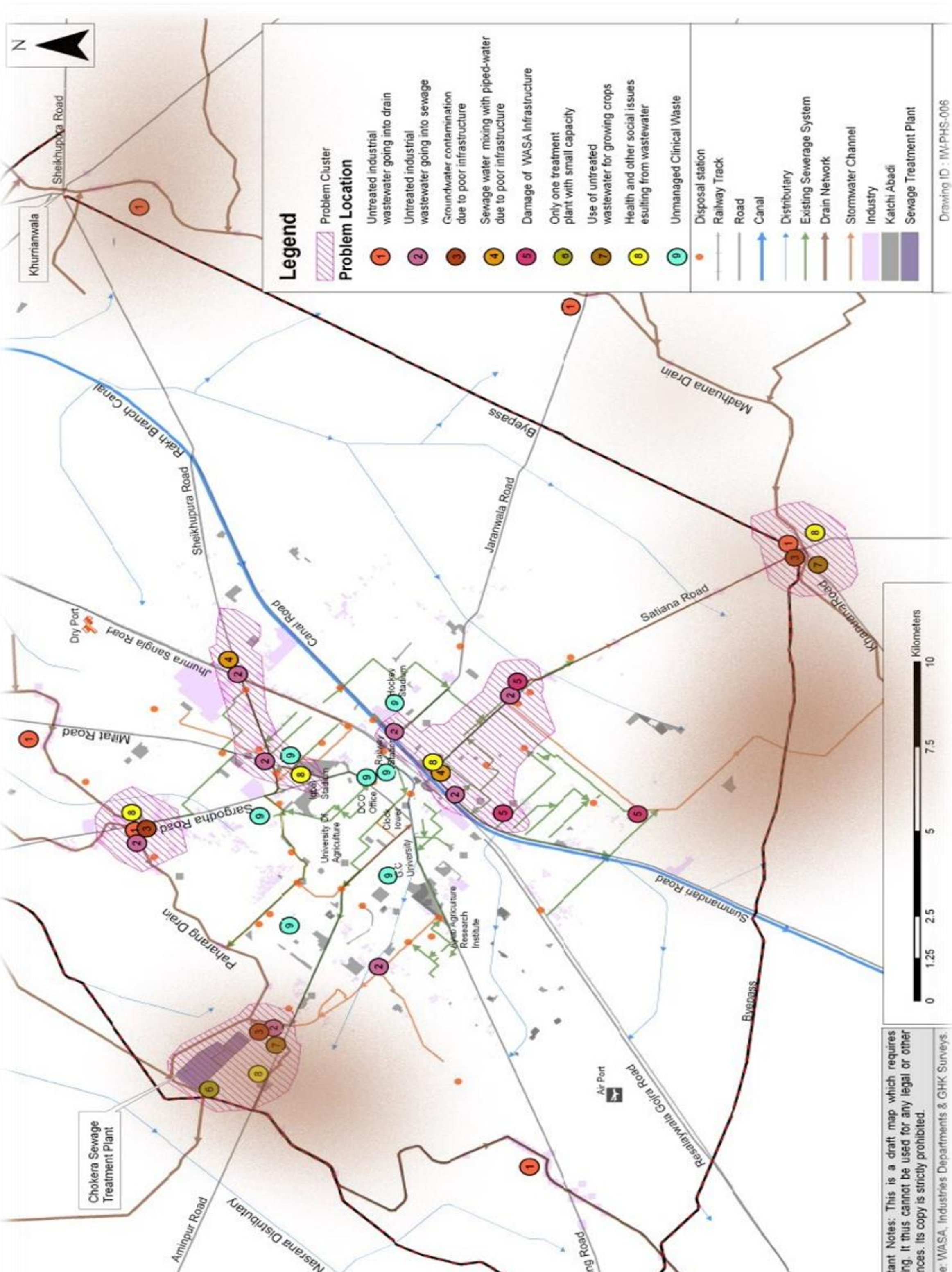

Figure 4.10:Problem areas resulting poor wastewater management
Source: Adapted and modified from GHK (2010: Section 1, p. 1-9)

Figure 4.10outlines the location of each problem associated with weak wastewater management in Faisalabad city area (GHK, 2010). The list of problems (1-9) is shown on the right side of Figure 4.10. The pink-lined areas represent problematic clusters. Light pink spots mark areaswhere untreated wastewater flow into public drains. A notable problem is ‘use of untreated wastewater for growing crops’ (problem number 7). Brown shaded area represents the vast extended area applying untreated wastewater irrigation. It is also clear from the map that all theproblematic areassuffer from water shortage due to their location at the tail of the water channel.

Indicators of worse-than-average wastewater—especially high pH level, totally dissolved solids, and ion concentration, such as sulfates (SO^4)— were higher in municipal drains than in Paharang and Madhuana drains. All wastewater samples exceeded the permissible limits for BOD and COD collected from different drains (Kahlown et al., 2006). The current condition is even worse than compared to 2006 (Asad et al., 2018).

> The quality of wastewater has worsened than before. (In-depth interview with director of WASA and FGD in villages *Kajla* and *Loukey*, July 2015)

For instance, a high level of mercury (Hg) was detected in the wastewater discharged by Sitara Chemicals (Abbas, Chaudary, Raza, & Mehmood, 2012). Consequently, due to high levels of mercury in blood, there is a potential threat of Minimata disease. To elaborate the situation, the snapshot of findings is attached in appendix D2. However, Sitara chemicals at Sheikhupura road possess the wastewater treatment plant within their industrial unit as mention by the list of large industrial units having WTP (attached in Appendix D3).

Figure 4.11 is a snapshot of offender ‘Sitara Chemicals’ at Sheikhupura road retrieved through Google map. The IDD drain is passing through Sitara Chemicals, and it is clearly displayed from the snapshot that the color of wastewater has changed after the effluents from Sitara Chemicals have been added.

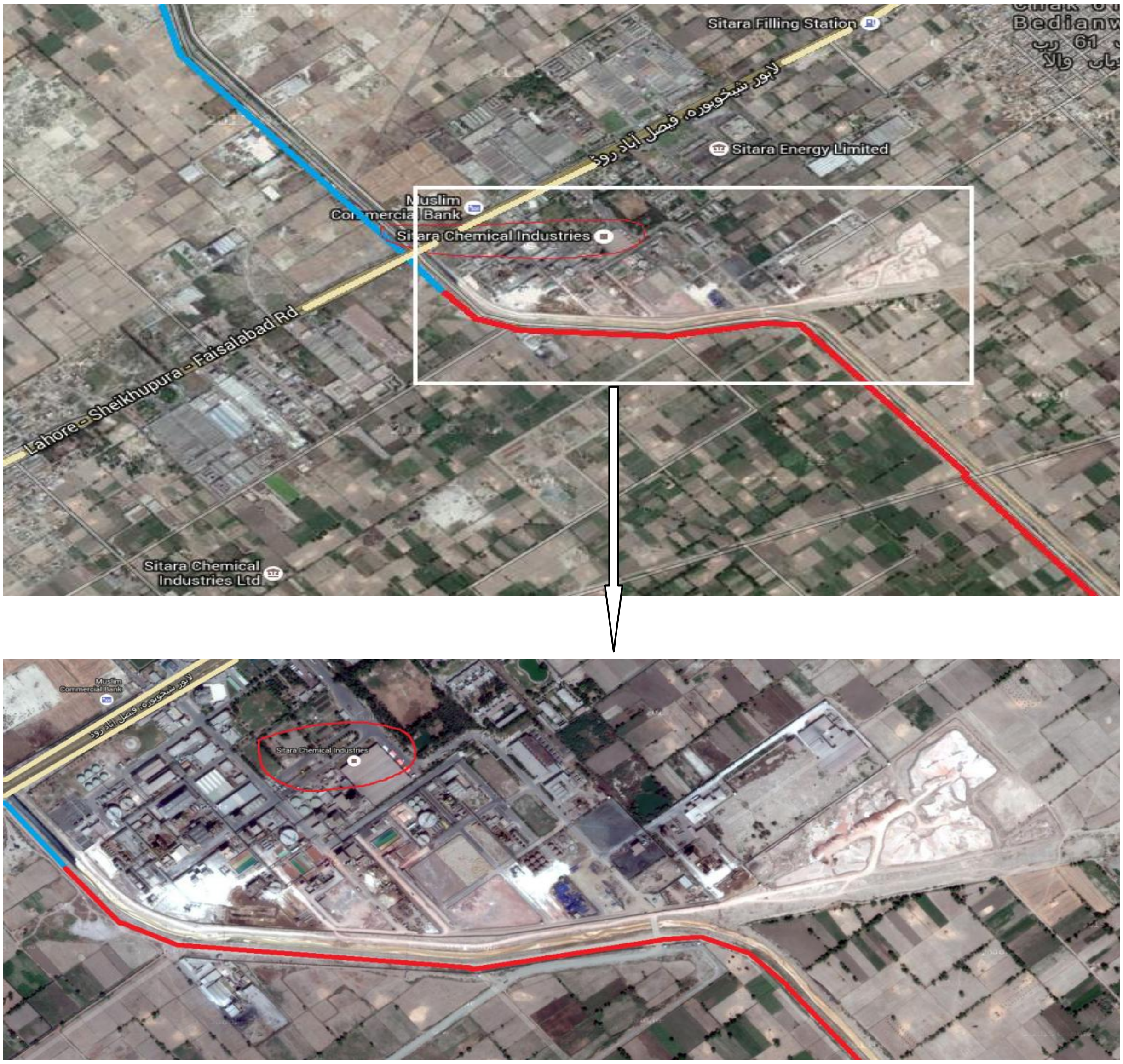

Figure 4.11:Snapshot of effluents discharged by Sitara Chemical into drains
Source: Google map, retrieved on February 8, 2016

After reviewing all available information, one can conclude that all drainage effluents from Faisalabad are thoroughly mixed. Therefore, it is difficult to treat the effluents collectively. Each site requires a specificconsideration for further policy formulation.

4.2.4 Treatment facilities

The study area contains only one collective treatment plant in Chokera village. The wastewater treatment plant in Faisalabad—funded by the Asian Development Bank (ADB) and the Government of Punjab—is a Waste Stabilization Pond (WSP) system. Designed by the Indus Engineering Firm, it consists of six anaerobic ponds. Among them, two are facultative ponds and the remaining four are maturation ponds. Though undoubtedly useful, it does require a vast land for ponds. The construction of the WSP was completed in 1998 and WSP began operating in

2004. It was designed for an inflow of 90,000 m^3 per day (about 24 MGD) with an average capacity to treat domestic effluents of 20 MGD. According to a formal statement, treated effluents are sold to farmers at a rate of 9,000,000 rupees per year. Farmers pay this amount for irrigating approximately 10 hectares of land (26 *marabba*); this payment contributes to the WSP operation and maintenance costs.(Excerpt from an in-depth interview with WASA officials and an overview of official documents, June and July 2015) (also see for details, Ensink et al., 2007; Clemett et al., 2010; Weckenbrock, 2010; Weckenbrock et al., 2010)

In the absence of other irrigation water sources within this area, farmers have relied on wastewater. However, they are applying untreated wastewater even with the availability of treated wastewater. Farmers claimed that untreated domestic wastewater irrigation actually minimizes their cost of production as it contains high nutrient contents of organic matter. It reduces the cost of chemical fertilizer. They argued that treatment plant increases the salinity of water by 100 percent and reduces the nutrients contents by fifty percent. Eventually, farmers are hesitant to apply treated discharge (from WSP) for irrigation and continue using untreated domestic wastewater (personal communication from FGD with farmers in *Chokera*, June 2015).

For this purpose, farmers in *Chokera* village have set up five underground ditches to pump out the water before the treatment (Figure 4.12) (Weckenbrock, 2010). Weckenbrock applied GIS anaylsis for estimating the long-term effects of wastewater irrigation on agriculture.

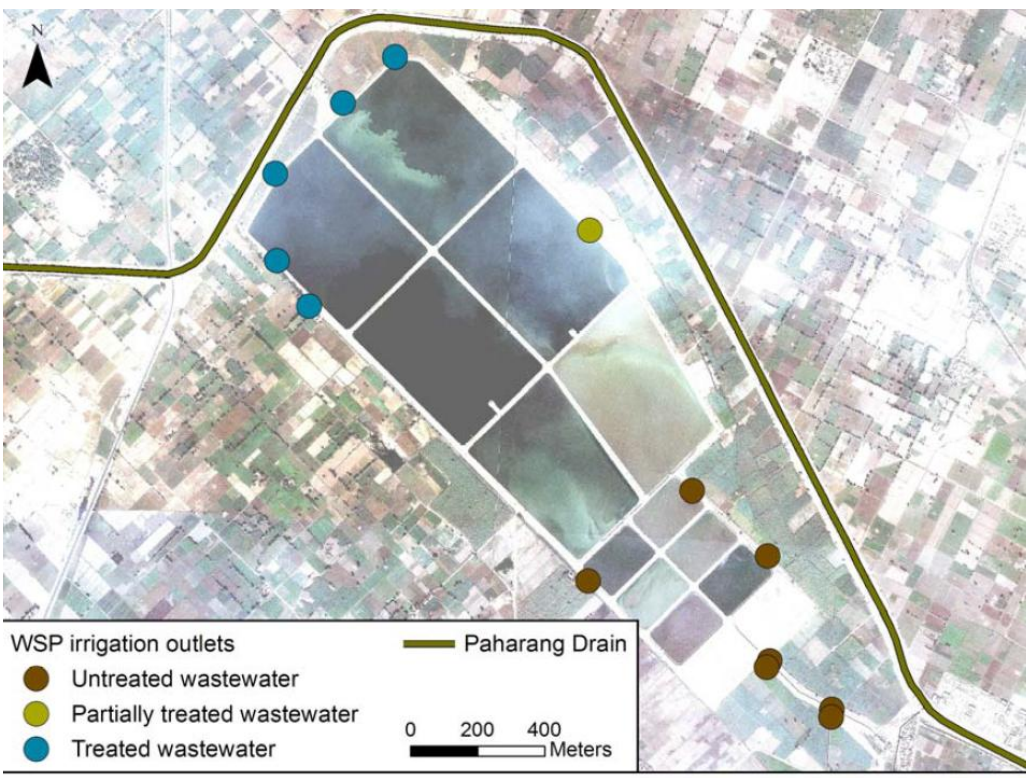

Figure 4.12:Outlets of untreated domestic wastewater from WSP
Source: Adapted from Weckenbrock (2010, p. 63)

Table 4.3 further emphasizes the intensification of untreated wastewater irrigation in *Chokera* exposed in Figure 4.12.

Table 4.3:Area under different types of irrigation in *Chokera* village

Irrigation water type	Area (hectares)	Area (%)
Untreated wastewater	456.6	71.3
Partially treated wastewater	3.4	0.5
Treated wastewater	24.8	3.9
Village wastewater	9.0	1.4
Canal water	11.6	1.8
Mix	87.2	13.6
Other water	3.7	0.6
No irrigation	44.3	6.9
Total	640.7	100.0

Source: Adapted from Weckenbrock (2010), p. 64

The interview also revealed that only limited farmers were able to use treated wastewater due to the elevation problem. Their farms are located at higher altitudes as compared to farmers in lower altitudes who have limited options other than untreated wastewater.As claimed by an estimate that more than fifty percent of total inflow into WSP diverts to agriculture fields before entering the stabilizing ponds. (In-depth interview with an official of The Urban Unit, July 2015)

This untreated wastewater application alters the levels of salinity, chloride, and nitrates in the soil and groundwater (Asad et al., 2018; Butt et al., 2005;Habiba et al., 2013). Subsequently, the final treated unused effluent is disposed into the Paharang drain, carrying untreated wastewater.

Consistent with the research done by IWMI, the reason lies in the faulty design of the facultative ponds. The retention period of the WTP is about 45 days, an additional 20 to 25 days to the standard retention period. This extended retention period increased the salinity level of treated wastewater. Therefore, during hot summer days, all the water ends up evaporating and salt accumulation increases (Ensink et al., 2007; Clemett & Ensink, 2006). However, WASA's wastewater management officer explained that the retention period depends on the inflow of water, which varies throughout the year (Extracts from an in-depth interview with director WWM of WASA, June 2015). The operational cost of this treatment plant is approx. 2.5 % of WASA's annual budget (Ensink et al., 2007).

As an alternative treatment option, activated sludge is a recommended treatment plant at an industry level that works efficiently in hot temperatures too (NSFC, 2003). It also requires less land compared to WSP. The main disadvantage of this treatment plant is its expensive installation and operational costs.

> The installation cost for activated sludge is about 30 to 40 million rupees, while daily operational cost is approximately 30,000 to 50,000 rupees. (In-depth interview with an industrialist describing the cost of wastewater treatment plant, July 2015)

Practically, only big industrial units can consider installing such expensive treatment plants. There are more than 2000 medium to large-sized industries within Faisalabad (Directorate of Industries, 2012). EPA official provided the official record of existing wastewater treatment plants (see Appendix D3). Since 2013, nineteen medium-sized and six large-sized industrial units have built treatment plants. There are still doubts that these industrial units are actually treating their industrial effluents to reduce the operational cost.

An employee (one industrial unit from the list of 19 industries holding wastewater treatment plant) commented that only drinking water treatment plant is working within the industrial unit. Moreover, he concluded that industrialists run RO plants and dilute their industrial influents instead of treatment before releasing into public drains. (Based on a telephone conversation with an employee of a large industrial unit, July 2015)

I tried to visit three large industrial units in the city to observe their wastewater treatment plants. As for the two sites, their employees simply confirmed the working of a treatment plant for drinking water but could not provide any information regarding wastewater treatment plant within that industry. Among them, one owner of an industrial unit provided some information but denied visitation access. He further justified that industrial effluents cause lower levels of pollution compared to other sources of pollution.

In fact, Reverse Osmosis (RO) plants installed treatment plants to treat the saline underground water to fulfill the water demands for industrial production and clean drinking water. It only produces 0.45 liter of drinkable water after using one liter of groundwater. The remaining amount is released with high COD into public drains. As a result, it also creates water pollution. Such water pollution is as severe as the wastewater released by our industries. (Extract from an in-depth interview with an industrialist, July 2015)

Costs of different treatment plants could not be compared because there were no official records of any kind submitted by industries to any governing organizations. Only SANDEE's study provided a cost comparison of wastewater treatment plant for five large textile industries (see Appendix D4). Five of the six large textile units had Effluent Treatment Plants (ETP). According to the study, average wastewater discharge from a textile unit is about 10,000-18,000 m^3/day (Samad et al., 2015a). It is an enormous amount. In short, dilution is considered as an alternative for wastewater treatment under current circumstances.

4.2.5 Direct use and discharge of wastewater

In a nutshell, one can concludethat, after assessing the current state of wastewater management and inadequate available treatment facilities at the collective level, most of the generated wastewater is dumped into rivers without any proper treatment (as shown in Figure 4.5). Predominantly, the direct use of wastewater in agriculture is common. Farmers irrigate their field with untreated water due to unavailability of ample amount of canal water. Salinity and waterlogging have created problems for farmers, especially for those who are situated at the 'tail' of the water channel. Such farmers are facing a limited supply of irrigation water. Even these farmers cannot apply groundwater for irrigation due to a high level of salinity. Therefore, the farmers utilize a considerable quantity of untreated wastewater to increase their returns (Anwar, Nosheen, Hussain, & Nawaz, 2010; Zafar & Akhtar, 2003). The untreated wastewater irrigation alters the physiochemical composition of soil and groundwater resources (Farid et al., 2015; Nasir et al., 2014;Parveen, Ghaffar, Shirazi, & MN, 2012). The farmers grow commercial crops (fodder and vegetables) on small-scattered plots around the peri-urban areas (Abbas et al., 2017; Jadoon et al., 2013), and the untreated wastewater irrigation affects crops such as cauliflower (Shahzad, Abedullah, & Samie, 2009), spinach (Amir et al., 2018; Nawaz et al., 2019), and rice (Akhtar, Khan, Naveen, Masood, & Khattak, 2018). Consequently, untreated wastewater irrigation influence the health risk to farmers (directly) and consumer (indirectly through crops) (Abbas et al., 2017; Amir et al., 2018;Jadoon et al., 2013; Rashid, Arslan, & Khan, 2018).

4.3 Wastewater Irrigation

The aim of this section is to look into the detailed and updated information regarding the context of reuse of wastewater in agriculture. A site-specific overview was briefed with highlighted issues. The following insights were observed in FGD with farmers in the four villages *Kajla*, *Aiwanwala*,*Loukey* and *Chokera*. Untreated industrial effluents directly were relevant to the first three villages. However, intensity of application varies depending upon the requirement of each farmer. The last village *Chokera* was the site of domestic wastewater irrigation where farmers officially buy the domestic wastewater from WASA. The city district government administrates the sites in the south (*Kajla and Aiwanwala*) and the west (*Chokera*). However, the study area in the east (*Loukey*) is under the Tehsil Municipal Administration (TMA) of *Khurianwala*. Untreated effluents from eastern *(Loukey)* and southern *(Kajla and Aiwanwala)* villages are disposed into local drains, which finally end up in River *Ravi* through the *Madhuana* drain. On the other side,effluents from the western village *(Chokera)*discharge into River *Chenab* through *Paharang* drain (Figure 4.13). None of these villages is connected to the drainage and water supply system of WASA Faisalabad.

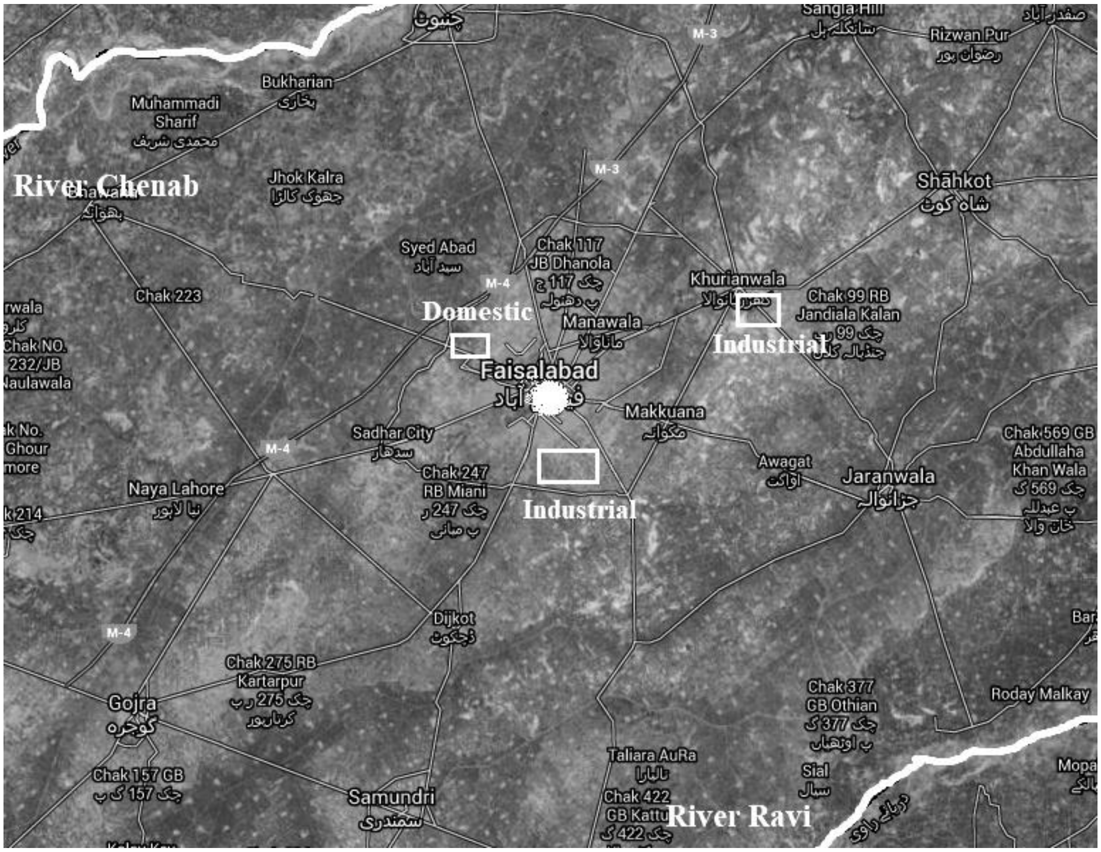

Figure 4.13:Location of study areas

Source:- Google map retrieved on 8th February 2016

In the Figure 4.13, the three main selected sites are represented. The *Loukey* is situated in the northern industrial site. Whereas, *Kajla*and *Aiwanwala* are located in southern industrial site. The last fourth village *Chokera* is positioned in domestic site.

4.3.1 Industrial wastewater (southern)

To the south of Faisalabad, *Kajla*village near the *Madhuana* drain has approximately six thousand inhabitants, and almost all the farmers utilize untreated industrial wastewater for irrigation.

Hence, farmers receive wastewater from the public drain of WASA named 'Channel 4' (black line in next Figure 4.14). The encircled villages are adjacent to the drains and irrigate with wastewater. WASA constructed 'Channel 4' in 1988 to provide the drainage facility to the industries located on *Maqbool* Road. Most of these are textile industries, which are involved with bleaching and dying. The size of these industries has ranged from small to medium. Roughly, none of them possessed any wastewater treatment plant. For that reason, Channel 4 carried the untreated industrial wastewater and was dumped into the *Madhuana* drain without any proper treatment (Kahlown et al., 2006).

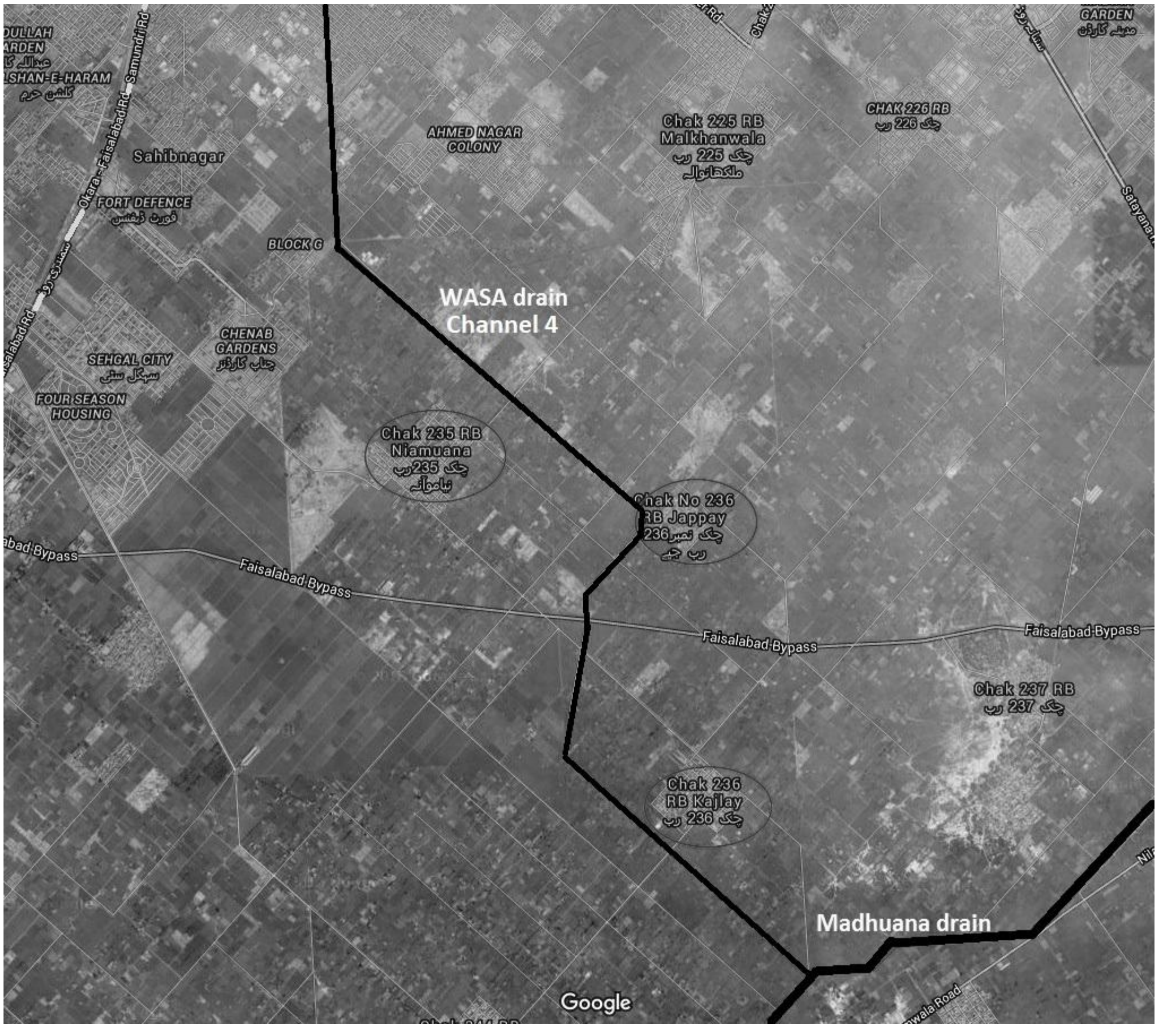

Figure 4.14:Location of southern site

Figure 4.14 shows the selected site in southern area of Faisalabad city.

Within this area, the villages situate at the tail of the *Dhudhi* minor, which originates through outlet number *Mogha* 38796 from *Rakh Branch* canal. Due to urbanization, the canal water channel has been under stress, and farmers living close to the tail of the water channel struggle with low supply of canal water. Consequently, farmers mostly irrigate their fields with available canal water combined with wastewater to fulfill the crop water requirement. Here, a critical point should be clear about mixed irrigation. Farmers never mix canal water with wastewater for irrigating the same crop on the same plot. For instance, if farmers use limited available canal water to wheat crop in one field, he would irrigate his fodder crop with wastewater in his other field. Rarely, farmers mix wastewater with groundwater for irrigation for cash crops like sugarcane. However, they never mix canal water with wastewater for crops. Within these areas, farmers are involved with such practice for more than two decades after the construction of Channel 4.

Figure 4.15:View of channel 4 of WASA and wheat crop in the southern side

Canal water shortage (being at the tail of canal watercourse) was the main reason for wastewater irrigation (see Figure 4.15). Otherwise, crops would not grow in the absence of amply canal water. Thus,water source for irrigation is one of the most highlighted issues for them.Without being informed of necessary safety measures by the extension officers, farmers continued using wastewater for irrigation. Agriculture department recommended them to pave the canal watercourse for reducing the seepage losses. For this reason, the On-Farm Water Management department (OFWM) asked farmers to pay twenty percent of the total cost of the project;the government would pay the remaining cost. Farmers agreed to pay one-fourth of the total project cost for the pavement of canal watercourse, which may improve canal water supply.

At the time of the construction of Channel 4, the farmers had no opinions about environmental issues related to wastewater management (Extracts from the focusgroup discussion with farmers of Kajla village on 14 June 2015).Recently, the farmers have been better informed about their issues. Local farmers discussed with each another at *Numberdar*'s Kiosk on weekends to find solutions to their current issues. Except for a few villagers who work in the city, most villagers heavily rely on agriculture as their primary source of income. Their very own livelihood becomes inevitably at risk following an unsuccessful year of agricultural production. Ultimately, they would be trapped in a vicious cycle of poverty and dependency. Farmers submitted their application to the office of District Government Faisalabad several times for their problems but without any fruitful outcome.

Another issue was regarding the use of motor pumps to pump out the wastewater from the channel. Formerly, the farmers used to break the bank of the drainage channel to get access to water. Afterwards, WASA and the city government banned this activity and placed a severe penalty upon violation. Consequently, farmers now must pay for energy consumption for using a motor pump, which is quite expensive for them. To this day, they pay the *Abiana* (official canal water fee).

In addition to financial concerns, the health status of farmers was also quite alarming. In fact, Hepatitis and abdominal diseases were common, possibly due to an absence of drinking water facility. They had to fetch drinking water from a nearby village, where water pumps were installedbeside the canal banks. The farmers were willing to pay one-fourth of the project for the provision of drinking water supply like *Chokera* village.Farmers also complained about the poor quality ofgroundwater and blamed the wastewater channel for seepage.

Likewise, farmers of this area also have lost trust in researchers. *Numberdar* expounded during a focus group discussion that even after ten years of studies and visitations by over 15 research parties, no significant policy implemented improved the farmers' situation. He further pointed to the lack of personal interest of researchers to bring about achange. They proposed that wastewater should drain out with large cemented diameter drainage pipes without affecting their land. Ultimately, they voiced that WASA and industrial units should pay the cost of such drainage piping.

The second FGD in the southern site took place in *Aiwanwala* village.A WASA storm drain that collects industrial discharges from industrial units of *Abdullahpur* and *Mansoorabad* passes along with Satiana road. About 30% of the village area is irrigated with wastewater obtained from the above-stated WASA drain. The remaining areas apply canal irrigation.

Figure 4.16:Focus group discussion at *Aiwanwala* village

The farmers who apply wastewater irrigation were facing the same issues as in *Kajla* (see FGD with farmers in Figure 4.16). They also had to pay the cost to obtain water through electric motors. The villagers had facilities with clean drinking water and drainage system.As, this village is situated along the *Satiana* road (main commercial area). Thus, the agricultural land alongside this road has transformed into residential housing colonies. The rise in land prices motivated the farmers to sell their agricultural fields. A tremendous shift from agriculture to urbanization was observed within this area.

4.3.2 Industrial wastewater (eastern)

Under the Punjab Government Industrial Act,the Punjab government initiated the 'Khurianwala Industrial Estate,' establishing many small and medium industrial units. The Khurianwala Industrial Estate (one of the largest industrial estate of Pakistan) is located in Tehsil *Chak Jhumra*, outside of the city. During the last two decades, industrial units were relocated from Faisalabad to this region for specific reasons. Primarily, industrialists preferred their industrial units to be located in Khurianwala because of the accessibility to energy (SUI gas) supply and drainage facilities (IDD storm drains) (Aftab, Ali, Khan, Robinson, & Irshad, 2000). For this purpose, they purchased the agricultural land along the Jaranwala road at higher prices and constructed their industrial units. Intended for drainage of industrial effluents, industrialists constructed private drains, connecting to storm water drains of IDD. These industrialists pay only discharge fees for the drainage facility to IDD. Legally, the government of Punjab has an obligation only to provide the drainage facilities, but not the treatment facilities. Ultimately, water and air pollution within this area are caused by industrial activities (Kahlown et al., 2006; Samad, Ahmed, & Gulzar, 2015).

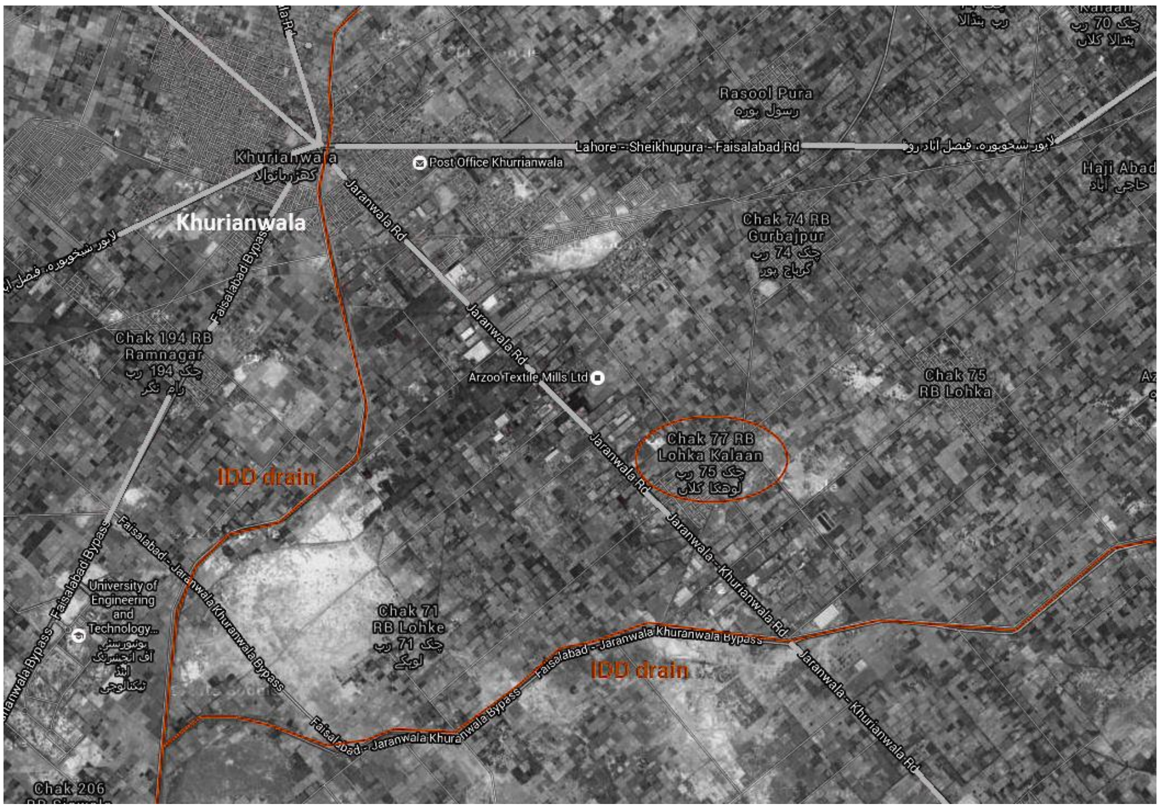

Figure 4.17:Location of the eastern site

The red lines in Figure 4.17 display the surface water drains and the white lines represent the main roads. Industrial units are established along the main roads, especially along Lahore-Sheikhupura-Faisalabad road and Jaranwala-Khurianwala road. Although a few big industrial units installed wastewater treatment plant, not a single plant functioned properly. (Extracts from focus group discussion with farmers in village Loukey, 17 June 2015)

Reasons of wastewater irrigation: The village area of *Loukey* consists of 100 *Murabba* (10.117 km^2) and receives canal irrigation water from Lower Chenab Canal (East). Industrial units along the main road occupy approximately 10-15% of the village area. Only 25% of the area receives canal water because of its location at the head of the water channel. Approximately 60% of the area—located at the tail of canal—was irrigating with untreated industrial wastewater due to insufficient supply of canal irrigation water. Farmers blamed the establishment of PIDA and FO for the reduction of canal water supply. After decentralization of the irrigation department, more than half of the village area faced the issue of canal water shortage. The farmers heavily criticized the local administration within FO and accused them of canal water theft. They went so far as to hold protests, against the influential farmers and PIDA personnel responsible for canal water theft. Even the IDD officials were aware of the poor performance of PIDA within this region. Previously, the irrigation department run by the centralized administration performed exceptionally well and did not face any issues with water theft before the establishment of PIDA. At that time, each farmer received adequate canal water as stated by his allocation. None of the influential local farmers was able to interfere with the centralized administration of canal water channels. (Focus group discussion with farmers in Loukey describing the effectiveness of PIDA, 17 June 2015)

In regards to agricultural production, the farmers cultivated cropping patterns like wheat and fodder. However, they could not grow any other crops during the summer because the untreated wastewater irrigation destroyed their crops during hot summer.

Average crop yield for wheat was about 20 (mound) mds per acre, which is half of the yield grown in canal-irrigated area. Even, the livestock mostly consume such grown crops, as these are not fit for human consumption. Irrigation with untreated industrial wastewater affected not only the yields of crops but also the quality of the crop. (Focus group discussion with farmers in Loukey, 17 June 2015)

Figure 4.18:Agricultural fields irrigated with untreated industrial effluents

Figure 4.18 illustrate the agricultural fields irrigated with untreated industrial effluents. Skin infection on the feet was common among farmers who were in direct contact with the wastewater. (Personal observation during focus group discussion, a person had skin infection on his both feet below the knee area. That person was directly involved with wastewater application process. However, he refused for a picture to be taken, as he was shy to show his feet)

Figure 4.19:Soil compactness due to untreated industrial wastewater irrigation

Another impact of untreated industrial effluents was soil compaction shown in Figure 4.19.

Groundwater was also not suitable for drinking purpose even for animals.Since 2005, drinking water supply was available to the villagers. Farmers paid 20% of the cost of the project. Currently, they are paying maintenance and operational charges on a monthly basis (Approx. Rs.200/month). Farmers are willing to pay same amount for treated irrigation water on monthly basis.

Farmers were well informed about the drawbacks of wastewater irrigation, as well as their rights and liabilities. However, when they tried to approach the authorities and even held protests through strikes and roadblocks, they received only rejections. After many unsuccessful attempts, they lost their trust in higher authorities and policymakers. In the next section, a brief overview of current or newly proposed projects targeting sustainable wastewater management in Faisalabad is presented.

4.3.3 Domestic wastewater (western)

Lower Chenab Canal (West) irrigates the main areas of Faisalabad city through its Rakh Branch Canal. The farmers of western areas are situated at the tail of canal water channel, which receives irrigation water through *Surwala*distributor from the Rakh Branch canal. This distributor passes through the centrally populated areas of Faisalabad city and supplies canal water to villages in the western site (including 217/RB, 218/RB, 219/RB, 220/RB, and 221/RB, RB represents the Rakh Branch canal).

The outlet at *Abdullahpur* for this distributor is designed to supply 45 cusecs of canal water to the villages mentioned above. Recently, the authorized head discharge from this outlet is 20 cusecs. The canal water supply has reduced because of a reduction in cultivated areas.Former agricultural lands have shifted into residential areas. (Extracts from in-depth interviews with IDD officials and IDD departmental reports, June 2015)

In the past, the distributor was poorly operating because of the dumping of garbage from urban residential areas. (A cleaning project launched in 2011—for about 20-30 million rupees—which effectively ensured a continuous supply of canal water until the farm gate.)

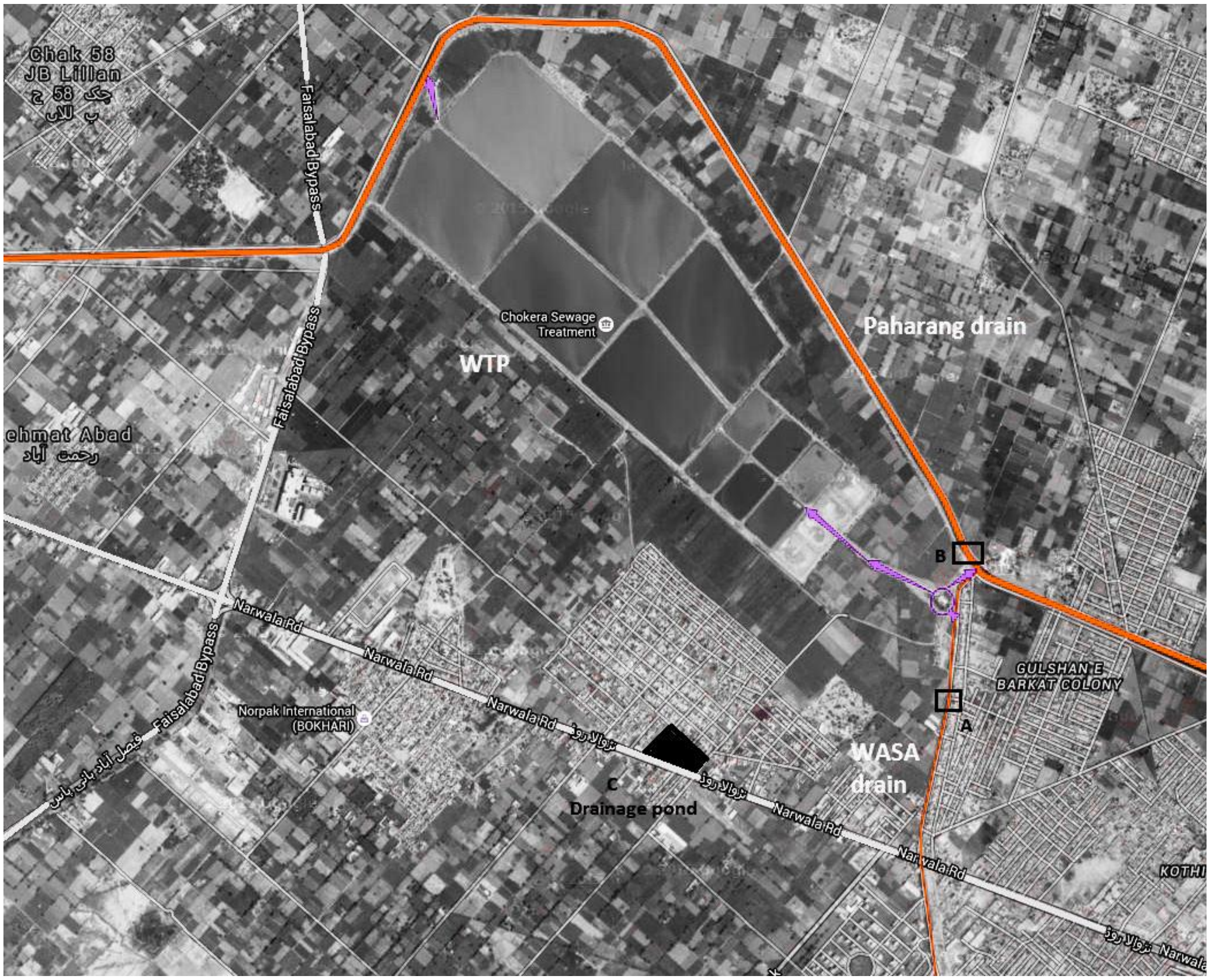

Figure 4.20:Location of the western site
Source: Google Map

In Figure 4.20, the thick red line represents the central Paharang drain and the thin red line represents the domestic drain (PS-4) that supplies domestic effluents to the treatment plant. The blue arrows depict the inflow and outflow from the treatment plant. The agricultural fields situated on the right and the left sides of WTP bought wastewater from WASA. The black boxes A and B represent the position of photos (shown in the following Figure 4.21). Site B shows the large scale of Paharang drain.

To the west of Faisalabad, WASA drains pump out water and dump into *Paharang* drain. Along with such drains, the farmers have practiced wastewater irrigation for more than 40 years. The focal person (resource person) from Chokera explained that canal water supply discontinued after the flood of 1972 and the area was seized due to land leveling issue. Later, WASA dug out a domestic drain from the western area of the city passing through this area to dump into the main Paharang drain. At that time, farmers began to irrigate their farmlands with available domestic wastewater from the WASA drain. For over 30 years in *Chokera* village, farmers have been purchasing such untreated wastewater from WASA for irrigation. It is, in fact, the most highlighted and red spotted area in the western part of Faisalabad City.

Domestic drain (PS-4), Site A **Paharang drain, Site B**

Figure 4.21:Snapshot of the domestic drain and Paharang drain

Figure 4.21 depicts the open drainage system of WASA Faisalabad. Site B shows the enormous big size of drain, which carries wastewater from western side of Faisalabad city.

During 2004-05, the wastewater treatment plant began to function (see subsection 4.2.4), but farmers were still using untreated wastewater through a trench from the main drain. According to these farmers, treated wastewater contains less organic matter and higher salinity level compared to untreated wastewater. Such practice has increased agricultural productivity but reduced crop diversity. Crops grown in this area are mainly sold in nearby vegetable markets (*Ghulam Muhammadabad* vegetable market) without any product differentiation.

For the past two decades, the western part of Faisalabadwas often the topic of discussion in regards to the formal sale of wastewater to farmers. Several studies conducted by national (UAF) and international (mainly by IWMI) researchers evaluated its impact on health and natural resources, especially for this area. (seeAbedullah, Kouser & Ali 2016;Ali, 2002;Amerasinghe et al., 2009;Anwar, Nosheen, Hussain, & Nawaz, 2010; Baig et al., 2011;Ensink, 2006; Ensink, Mahmood, & Dalsgaard, 2007; Ensink & Van der Hoek, 2009; Iqbal et al., 2013; Kahlown, Ashraf, Hussain, Salam, & Zeeshan, 2006; Kouser, Abedullah, & Samie, 2009; Raja et al., 2015;Sadiq Butt, Sharif, Ehsan Bajwa, & Aziz, 2005;Weckenbrock, 2010; Weckenbrock et al., 2010)

Farmers admitted that their health conditions were worse with hepatitis and abdominal diseases within the village. Due to such health concerns, irrigation with wastewater was rigorously objected during last decade, and the public government instructed WASA to cease the sale of untreated wastewater. Without an alternative source of irrigation, the farmers filed their case in court and won their right to use wastewater for irrigation purposes (Weckenbrock et al., 2011). IWMI researchers in this region worked to calculate the hidden cost of wastewater application, especially regarding health risks (Ensink, van der Hoek, Mara, & Cairncross, 2007; Clemett & Ensink, 2006).

Figure 4.22:Agricultural fields of Chokera village next to WSP

Figure 4.22 supports the farmers’ point of view in favor of wastewater irrigation. The fields were quite fit for crop production andthey could attain high yields. Besides wastewater irrigation, two other main causes of the vulnerable health condition of villager were mentioned. First was the absence of a local sewer system in thisvillage.

Figure 4.23:Sewage pond of Chokera Village, Site C

All villagers dumped their discharges into a drainage pond (Figure 4.23) and marked with C in Figure 4.20. The villagers pointed out that this drainage pond is the leading cause of the spread of water-borne diseases.

The other cause of worse health conditions in the village was the existence of poorly managed cattle farms (*Bhanscolony*). As the city administration of Faisalabad banned cattle farms (cows, buffaloes, goats) within the vicinity of city area, all cattle farms shifted to peri-urban areas. However, villagers did not want to remove their cattle farms, as it is their main source of income. Actually, the hygienic condition of the village due to poorly planned cattle farms is quite vulnerable. This area could not be included in the city district government even though it is adjacent to the urban boundary; thus, WASAdid not provide any drainage facility to the village.Notwithstanding, drinking water facility was available under a project funded by World Bank a few years ago.

The farming community raised some doubts and concerns about the researchers and their studies. They feared that the research could potentially ban their wastewater supply. Farmers also lost their trust in researchers even claiming that research teams come only to fulfill their agenda. Naturally, now they were reluctant to help or provide real data;they even intentionally misguided data about drawbacks. Our research team visited this area three times to meet with the chief, but he refused to provide any information. The focus group discussion was conducted in Chokera after the focal person made continued efforts.

4.4 Conclusion

The study area Faisalabad was selected because of its controversial aspects concerning wastewater management. Being the thirdhighest populated city of Pakistan with a vast industrial sector, Faisalabad is still heavily involved with agriculture (60% of Faisalabad is agricultural land). The drainage system at the district level mainly aims to reduce the effects of waterlogging and salinity, whereas the drainage system at the city level aims to pump out all the sewerage from the city to stormwater drains. In conclusion, the violation of laws from the industrial sector and poor management from responsible departments and agencies is worsening the situation day by day.

In short, the volume of wastewater has doubled over the last decade without any drastic changes in demographics and industrial units. Mostly, industrial units are not properly treating their effluents; instead, they are just diluting. Therefore, the current sustainable wastewater management is at the position where one can say, “Dilution is the solution for pollution”(Samad, Ahmed, & Gulzar, 2015b).As a result, pollutant residues remain mostly untreated; quality of wastewater became worse compared to ten years ago. In addition, treatment plant comparison could not be evaluated because of the unavailability of data.

The problem is not so newbut acute. Several regulations governing this issue exist but the regulations could not be enforcedadequately. At the individual level, industrialist prefers to dump without treatment to reduce their cost of production. At the institutional level, EPA and WASA officials could not enforce the laws because of limited available (human and financial) resources. The factual ground about the current state of wastewater management in Faisalabad has been documented with the most essential aspects of the preceding discussion. Within this study, the term ‘wastewater’ refers to untreated wastewater. A limited quantity of domestic wastewater is treated,but most of it is directly dumped into drains (see Figure 4.1).The local circumstances of wastewater management vary broadly depending on numerous factors. The overall trust of villagers on researchers and public policymakers has been lost during the last few decades.

5. WASTEWATER IRRIGATION, INTERTWINED THREATS, AND OPPORTUNITIES

The structure of this chapter is as follows: First, the study plan identifying the location of the site for the houshold survey is explained in section 5.1. Secondly, the socio-economic and land statuses of the respondents are assessed across different categories (section 5.2). The next section (5.3) elaborates the quality of soil, groundwater and irrigation water within the study area. The fourth section aims to explore the health and sanitation condition across the categories. Fifth, section 5.5 appraises the farm income for each farmer. Then, the total income and expenditures of each farm family are evaluated. Section 5.7 estimates the impacts of the quality of irrigation water on crop yield and farm income. Lastly, the overall conclusion from the analysis is briefed. The research questions and targeted inquiries are tabulated in Table 5.1 for explaining the chapter's structure.

Table 5.1:Research questions and targeted inquiries

Research questions	Section
1. What was the impact of wastewater irrigation on the socio-economic condition of farmers?	5.2
What were the socio-economic indicators (age, education, experience, family size) for different farm families? What was land tenure system within study area?	
2. What was the condition of natural resources (such as soil, groundwater) in the study area?	5.3
What kind of variation existed in the quality of irrigation water? Did physiochemical characteristics of groundwater vary due to the application of irrigation water of different qualities? What were the variations on the soil properties across the areas irrigated with water of different qualities?	
3. What was the health status of farm households who reside in the study area?	5.4
What was the general condition of safe drinking water availability in the study area? What was the sanitation and hygiene condition in the study area? What was the health status of farm families?	
4. What were the total costs and benefits during a farm year (land tenure system, crop diversity, net crop income, and farmincome)?	5.5
Did the cropping pattern vary with the quality of irrigation water? What was the variation of cropping systems across irrigation water of different qualities?	
5. What was the financial status (income and expenditure) of farm households across the categories applying different quality of irrigation water?	5.6
Did the role of non-farm income in family income vary across categories? How was the difference in the structure of farm household income caused by the quality of irrigation water?	

Research questions	Section
What was the share of household expenditure in family income?	
6. What was the impact of the quality of irrigation water on crop yield and farm income (Dose response analysis)?	5.7
What was the impact of irrigation water quality on crop yield (wheat) and farm income?	

Disposal of untreated wastewater affects natural ecosystem generally through three ways. First, it directly pollutes the freshwater reserves, such as lakes, rivers, and reservoirs through direct mixing (UN-Water, 2010). Secondly, it affects the quality of groundwater through seepage either by sewage ponds or by unpaved drains. Lastly, the application of wastewater irrigation also affects soil and groundwater resources at field level (Ashraf, Maah, Yusoff, & Mehmood, 2011; Friedel, Langer, Siebe, & Stahr, 2000). Likewise, the discharges of untreated wastewater affect public health through direct and indirect contact or both. People having direct contact with wastewater either living along the drains or working within wastewater-irrigated fields face the high risk of infection as compared to others. Through indirect contact, people may get sick through the food chain(Amerasinghe, Weckenbrock, Simmons, Acharya, & Drescher, 2009). Such environmental and human health threats largely depend on the contamination level of wastewater. Both microbial and chemical pollution cause a threat to public health and resources conservation. The microbial analysis could not conduct due to the limited availability of time and financial resources.

The primary emphasis in this part of the study was to evaluate the risks and opportunities of communities and the environment that are directly linked to untreated wastewater, which was quite tricky. Even in the case of slums, people mostly face health issues due to an unhygienic drainage system, but it does not affect their livelihood. Thus, there was a need to select such a study area where untreated wastewater is affecting the communities and natural resources. For that reason, the wastewater-irrigating communities around the peri-urban areas of Faisalabad were selected.

5.1 Study design and sampling

The peri-urban areas of Faisalabad were chosen around the central city area. A household’s perspective was evaluated using survey data. For that, the household head was interviewed using a structured questionnaire (attached in Appendix) to collect information regarding (*Kharif* of 2008 and *Rabi* of 2008-09) farm budgets, household expenditure, income, and health status for all members of the family for the whole year. Samples of irrigation water, groundwater, and soil were also collected and tested by AARI during the summer of 2009. The overall description of each village was explored initially through the ‘General’section in the questionnaire. Afterward, a detailed analysis was conducted through the household survey. (Questionnaire attached in Appendix I)

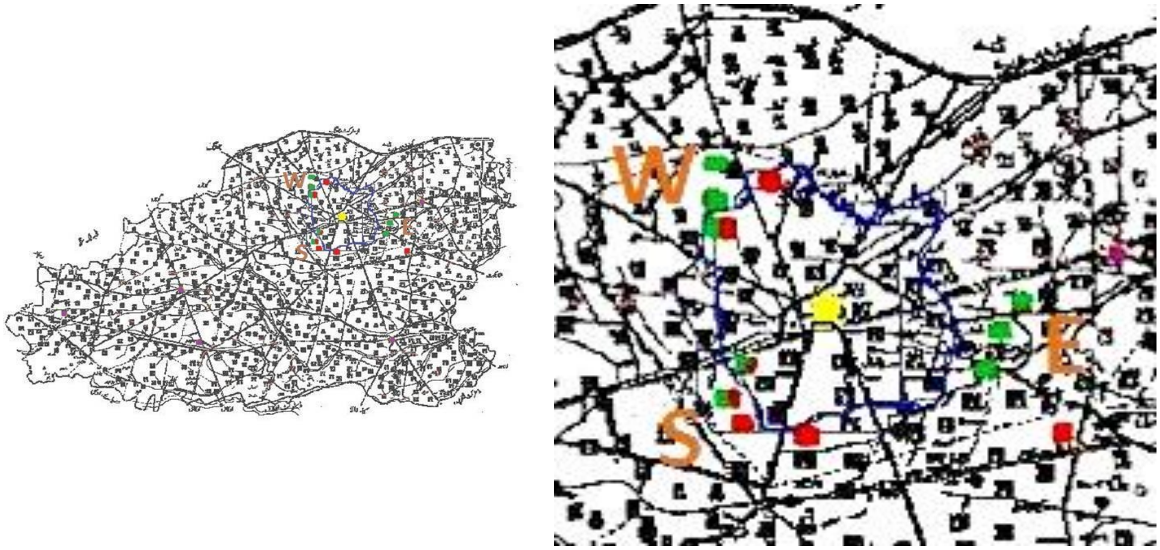

Figure 5.1:Location of study areas

The selection of each site (Figure 5.1) was based on previous studies (Clemett & Ensink, 2006; Ilyas, Gilani, & Bhatty, 2008; Kahlown, Ashraf, Hussain, Salam, & Zeeshan, 2006). The yellow shade refers to the center of Faisalabad; the blue line indicates the city administration; the green blocks display the canal irrigated area, whereas, red blocks represent the wastewater irrigated areas. W (western), S (southern), and E (eastern) represent the location of areas. The general hypothesis proposed was that wastewater irrigation would affect the socio-economic conditions (net farm income, cropping intensity, cropping pattern,and land tenure system) and natural resources' condition of wastewater users, compared to non-users in the peri-urban area of Faisalabad.

Small to medium-sized agricultural farms existed around the peri-urban area of Faisalabad city. Most of such farming communities were utterly dependent upon agriculture for their livelihood. Another source of farm income was livestock farming. Legally, livestock farming was restricted within the urban areas of Faisalabad city. Therefore, all cattle farms (*Bhans* Colony) shifted from city areas to peri-urban areas. These cattle farms mainly fulfilled local milk demands. Along with farm income,non-farm income was also an integral part of their income sources.These peri-urban communities supplied unskilled labor to urban areas forindustrial and commercial activities. However, other factors such as employment opportunities, education or skill level, and distance to the central city also affected the availability of non-farm income. Several variations across the villages were found such as geographical location, administrative setup, and socio-economic conditions. Each category or even each village inevitably led to lots of variations that cause the high values of standard deviation. First, Microsoft Excelspreadsheets were prepared and then the data was analyzed using data analysis software (SPSS statistics 24 and STATA).

5.2 Socio-economic analysis of farmfamilies

The socio-economic analysis involved factors affecting farm family's economic and social status. The economic analysis would be addressed in detail regarding each family's income status (section 5.5 and 5.6). Here, the general description of social variables is interpreted which affect farm families' social and health statuses. Therefore, social factors, such as family size, education status, the age structure of farm families, and the dependency ratio, are considered as essential variables for describing the social status. Farm labor also plays a vital factor infarm production.

Table 5.2:Household social status within the study area

Variables	Industrial wastewater (N=87)	Domestic wastewater (N=56)	Canal water (N=79)
Farm labor (m)	1.5 (1)	1.8 (1.2)	1.7 (1)
Non-farm labor (m)	1.8 (1.1)	1.4 (1.3)	1.9 (1.2)
Household labor (f)	1.4 [a] (1)	1.7 [b] (1)	1.5 [a] (1)
Dependency ratio	90 (80)	73 (62)	95 (75)
Family size	6.2 (2)	5.9 (2)	5.9 (2)
Farm household education index	4 [a] (2.5)	5.3 [b] (3)	4.7 [b] (3)
Education of household head	5.7 (4.6)	6 (4)	6 (4.6)
Age of household head	46 (10)	50 (12)	47 (13)
Experience (farming) of household head	20 [a] (12)	27 [b] (11)	26 [b] (14)

Note: The mean (and standard deviation in parentheses); letters in supper script represent the significant difference between the categories at 5% level of significance as a result of Mann-Whitney test (similar letters depict that there was no significant difference between both categories)
N: Number of observations

In Table 5.2, the main factors describing the social status of farm families are briefed. Family size (6 members) and family structure (dependency ratio) were mostly the same across the category (households using different types of irrigation water) Irrigators using domestic wastewater exhibited the highest averages such as the family education index and household head's education, age, and farming experience. The average farm labor was highest for farmers irrigating with domestic wastewater. This finding also supports highest cropping intensity in domestic irrigated area (see Table 5.3).

5.3 Natural resources

Nature supplies natural resources such as air, soil, water, animals, plants, and so on. Most of them are essential for sustaining life on this planet and also exist in a limited amount. Any alteration with the quality and quantity of shared resources would affect the balance of life in a broaderaspect (Figure 2.1). One can consider a resourceas physically scarcethat can be used to produce a new product.Therefore, all such resources should be considered thoroughly before utilizing them for producing any new product. Maybe whatever is going to be produced, it will affect the quantity and quality of natural resources in an adverse way permanently. Hence, the wastewater-irrigated agricultural system is of concern. (see Garcia & Pargament, 2015;Winpenny, Heinz, & Koo-Oshima, 2010).

The objective of the study was to estimate the quality of irrigation and groundwater resources (with and without wastewater irrigation) in the study areas. For this purpose, the study was required to analyze samples of irrigation water and groundwater for microorganism, organic matter, nutrients, chemicals, and heavy metals. A complete analysis can help understand how humans are exposed to the chemical, heavy metal and microbial substances from untreated wastewater (explained in second chapter, Figure 2.5).Untreated wastewater that is discharged is used for irrigation, which seeps into soil and groundwater (environmental). Then, human consumes the crops irrigated with untreated wastewater, and human health is affected. This is howhumans are exposed to risks from microbial, chemical, and heavy metal contaminants.Previous research findings support the hypothesis that untreated-wastewater irrigation alters the composition of soil and groundwater of farming areas (Foster, Garduño, Tuinhof, Kemper, & Nanni, 2005;Gallegos et al., 1999; Ju, Kou, Zhang, & Christie, 2006; WWAP, 2015a).

5.3.1 Water

Land, labor, farm machinery, and irrigation water are consideredas essential factors of production in irrigation agriculture(I. Hussain & Hanjra, 2004). Within our context, irrigation water is the mostcrucial factor of production for agriculture. Rainfall, canal water, and groundwater were the main water resources for crop production. Faisalabad is situated in the semi-arid region. During 2008-09, the average annual rainfall was approximately 337 mm in Faisalabad. Other possible sources of irrigation are saline groundwater and limited canal water.

Waterlogging and saline watermade groundwater unfit for irrigation for the entire Faisalabad city(Wolters& Bhutta1997). AARI provided afacility for farmers to check the salinity level of irrigation water (at the time of digging of tubewell to check the salinity of groundwater) at a subsidized rate. These water samples were examined only for limited salinity parameters. These parameters could not fully explain the state of natural resources (groundwater and irrigation water). This facility was utilized for this research on the behalf of farmers due to technical (soil science) and financial constraints. And this whole exercise clearlyelucidated the effects of untreated wastewater on groundwater.

Irrigation water and soil samples were collected from each respondent at his farm and further submitted to laboratory of AARI. Up to that time, the goal of research was to explore the impact of the quality parameter (irrigation water) on crop production using cross-sectional data for each farmer. However, this idea later proved infeasible from a technical standpoint. Irrigation-water and groundwater samples at the village level showed the same values across all the respondents. The second constraint was that the quality parameters of irrigation water were not significantly correlated with other factors of production within the sampling frame of analysis.

5.3.1.1 Irrigation water

Based on the analysis presented in following Table 5.3, it is evident that only canal water was fit for irrigation, whereas all wastewater samples used for irrigation possessed high levels of salinity. As expected, all samples of wastewater (domestic and industrial) used for irrigation were unfit for irrigation purposes because of high values of salinity parameters.

Table 5.3:Results of analysis of physio-chemical parameters of irrigation water

Parameters	Industrial wastewater (N=30)	Domestic wastewater (N=56)	Canal water (N=26)	FAO Guidelines Moderate to severe
EC (d*S*/m)	0.5 [a] (0.7)	**3.1 [b] (0.5)**	0.3 [a] (0.6)	0.7 - 3.0
SAR	8.1 [a]	**19 [b] (10.9)**	3.7 [c] (2.4)	0 -15
RSC	2.4 [a]	**8.2 [b] (5.6)**	0.6 [c] (0.3)	1-2.5
Ca+ Mg(meq/l)	4 [a]	5.9 [a] (3.6)	2.9 [b] (2.6)	
Sodium (meq/l)	**11.4 [a]**	**25 [b] (6.6)**	5.2 [c] (4.7)	3 – 9
Carbonates (meq/l)	n.a.	**1.4 (3.7)**	0.2 (0.4)	0 - 0.1
Bi-Carbonates (meq/l)	6.4 [a]	**12.3 [b] (4)**	3.0 [c] (1.8)	1.5 - 8.5
Chlorides (meq/l)	5.4 [a]	**11.3 [b] (3.2)**	2.8 [c] (3.3)	4 – 10

Note: The mean (and standard deviation in parentheses); superscript letters represent parameters with significantdifference between the categories at 5% level of significance as a result of Mann-Whitney test (similar letters depict that there was no significant difference between both categories)
meq/l: Milliequivalents per liter
d*S*/m: deciSiemens per meter
N: Number of observations

The right column of Table 5.3 shows the limits for each parameter recommended by FAO/WHO for the quality of irrigation water (Ayers & Westcot, 1989; Pescod, 1992). The first three parameters, which are Electrical Conductivity (EC), Sodium Absorption Ratio (SAR), and Residual Sodium Carbonate (RSC), represent the salinity level of water samples. The statistical analysis (Mann-Whitney test) of these physio-chemical parameters showed significant differences in salinity level across the parameters.

Results interpreted that domestic wastewater group possessed the highest level of salinity. Underground water of Faisalabad is saline. Local residents pump out saline ground water to fulfill their domestic water requirement. Thus, all domestic drains possessthe saline water along with human wastes. On other side, industrialists pumped out saline groundwater to cover their industrial water requirements (boiler, washing, dying, cleaning, bleaching, and so on). Saline water was not suitable for industrial machinery. Therefore, industrialists must have a desalination plant (reverse osmosis process) to treat the saline groundwater for industrial purposes. This was the reason for the low salinity level of industrial wastewater compared to domestic wastewater.

5.3.1.2 Groundwater

The groundwater of Faisalabad region was already saline which is not suitable for agriculture (see section 3.1). Agriculture within study areas entirely depended upon canal irrigation water. The continual irrigationwith untreated (saline) wastewater badly influenced the salinity level of groundwater. It caused secondary salinity within this region (Table 5.4).

Table 5.4:Results of analysis of chemical parameters of irrigation water

Parameters	Industrial wastewater (N=30)	Domestic wastewater (N=56)	Canal water (N=12)	FAO Guidelines Moderate to severe
EC (d*S*/m)	1.7 [a] (2.4)	**4 [b] (0.8)**	0.3 [c] (0.9)	0.7 - 3.0
SAR	**25.3 [a]**	**22 [a] (7.4)**	7.1 [b] (3.1)	0 -15
RSC	**10 [a]**	**6.8 [a] (4)**	2.8 [b] (0.1)	1-2.5
Ca+ Mg (meq/l)	6 [a]	6.3 [ab] (3.9)	8 [b] (0.5)	
Sodium (meq/l)	**43.8 [a]**	**34.1 [b] (6.6)**	**14.5 [c] (6.7)**	3 – 9
Carbonates (meq/l)	n.a.	**0.3 (0.5)**	0.5 (0.8)	0 - 0.1
Bi-Carbonates (meq/l)	**16 [a]**	**12.8 [b] (1.3)**	**10.3 [c] (0.2)**	1.5 - 8.5
Chlorides (meq/l)	**16.4 [a]**	**13.2 [b] (1.7)**	7.3 [c] (3.4)	4 – 10

Note: The mean (and standard deviation in parentheses); superscript letters represent the significantdifference between the categories at 5% level of significance as a result of Mann-Whitney test (similar letters depict that there was no significant difference between both categories)
meq/l: Milliequivalents per liter
d*S*/m: deciSiemens per meter
N: Number of observations

Table 5.4 portrays that groundwater in canal-irritated areas was less saline compared to other areas. This effect was due to the continuous recharge from canal water through fields and canal. On the other side, groundwater of industrial and domestic wastewater irrigated areas showed a high level of salinity (secondary salinity). The finding demonstrated that chemicalcompounds present in irrigation water were seeping down into the groundwater. Other studies also support these findings of the harmful effect of irrigation with untreated wastewater on groundwater resources (see Gallegos et al., 1999; Matsuno, Ensink, Van der Hoek, & Simmons, 2003)

5.3.2 Soil analysis

The soil is a non-renewable resource at least within the human sphere of influence. The land quality generally is represented through the soil fertility in the production function. The soil of Faisalabad is considered fertile.No doubt, a complete assessment of physical, chemical and heavy metal of soil is required to check the status of the soil. Especially, heavy metal analysis (micro and trace elements) is necessary to check the contamination level of soils after application of untreated wastewater. A number of studies are available who clearlyadvocated the impacts of wastewater irrigation on soils and crops(Drechsel, Giordano, & Gyiele, 2004;Farahat & Linderholm, 2015; Friedel et al., 2000;Kordlaghari, Sisakht, & Saleh, 2013; Mapanda, Mangwayana, Nyamangara, & Giller, 2005). In Faisalabad, Kahlown et al. (2006) checked chemical and limited heavy metal parameters within the study area. The results were attached in Appendix E. The complete examination including physical, chemical, heavy metal, and microbial analysis require huge work (soil scientists) and enormous funding.

Hence, another facility provided by the AARI in Faisalabad on behalf of the farmers was utilized. AARI designed this facility for farmers who can check the fertility of their soil at subsidized rates. Such soil fertility analysis actually helpsthem to recommend the required dosage of chemical fertilizer specific to each field. For this purpose, few parameters (EC, pH, organic matter, available phosphorus, available potassium, and saturation) are analyzed. Organic matter (organic N), available phosphorus (P), and available potassium (K) guide towards the current status of soil, which consequently direct to the required amount of fertilizer (N:P:K). N, P, and K are the main components of chemical fertilizers.

These six chemical parameters were not enough to check the quality of soil; however, these parameters explained how chemicals from irrigation water were added to soils under the frame of this study. These parameters supported the hypothesis of the alteration in soil quality with irrigation using untreated wastewater. The soils samples were collected for each respondent at two depths levels under the guideline of AARI officials. The mean values of the parameter for each category were calculated to show the variations across the categories (see next Table 5.5).

Table 5.5:Chemical analysis of soil samples across the categories

Soil depth	Parameters	Industrial wastewater (N=69)	Domestic wastewater (N=43)	Canal water (N=43)	Permissible limits
0-6 inch	EC (d*S*/m)	0.8 [a] (0.4)	1.1 [b] (0.3)	0.6 [c] (0.3)	4
	Soil pH	8.8 [a] (0.3)	9.36 [a] (6.2)	8 [b] (2.51)	4-8.5
	Organic Matter (% w/w)	0.6 [ab] (0.1)	0.7 [a] (0.2)	0.6 [b] (0.1)	>0.85
	Available P (mg/kg)	13.9 [a] (7.7)	18.9 [b] (8)	10.2 [c] (6.9)	10-50
	Available K (mg/kg)	251 [a] (41)	272 [b] (65)	263 [a] (45)	150-800
	Saturation (%)	37 [a] (1.9)	36 [a] (8.5)	37 [a] (6.1)	
6-12 inch	EC (d*S*/m)	0.9 [a] (1.1)	1.0 [b] (2.1)	0.6 [c] (0.3)	4
	Soil pH	7.3 [a] (2.6)	8.3 [b] (1.7)	7.6 [c] (1.2)	4-8.5
	Organic Matter (% w/w)	0.6 [a] (0.4)	0.6 [a] (0.9)	0.5 [b] (0.1)	>0.85
	Available P (mg/kg)	12.4 [a] (10)	16.4 [b] (6.9)	8.7 [c] (6.5)	10-50
	Available K (mg/kg)	245 [a] (42)	250 [b] (61)	244 [a] (43)	150-800

	Saturation (%)	37^{a} (2.2)	33^{b} (7.8)	34^{b} (5.8)

Note: The mean (and standard deviation in parentheses); superscript letters represent the significantdifference between the categories at 5% level of significance as a result of Mann-Whitney test (similar letters depict that there was no significant difference between both categories)
N: Number of observations

Table 5.5 represents the findings of the chemical analysis of soil samples across the categories. The upper layer of soil was more contaminated with the substances present in irrigation water than the lower layer of soil (Amin, Hussain, Alamzeb, & Begum, 2013).

In the case of domestic wastewater irrigation, high level of nutrients (N:P:K) reduced the fertilizer cost for farmers (support the findings of Weckenbrock, 2010). Ijaz et al.(2019) also concluded that sewage water increased the total nitrogen, available phosphorus, and available potassium values in the soil of *Layyah* (Pakistan). The soil of industrial wastewater irrigated areas was less fertile as compared to soil of irrigated areas with domestic wastewater (see Arif Saeed et al., 2018). The soils irrigated with domestic wastewater were more saline as compared to soil of canal-irrigated area.The continuous supply of saline domestic wastewater with organic matter pushes the farmers to maximum utilization of their agricultural land. Such excessive irrigation to land enhances the salinity level of soil. Muyen, Moore, & Wrigley(2011) also argued that irrigation with untreated wastewater enhanced soil salinity and sodicity.

Moreover, AARI further conducted another research in Faisalabad and four other cities. Total three hundred thirty eight soil samples were analyzedin Faisalabad and the surrounding areas. All samples had higher values of Zinc than WHO's standards and 64 percent of the samples showed higher levels of Pb than WHOs (Correspondent of the Express Tribune, 2015).

5.3.3 Discussion

Analysis of limited parameters restrict to visualize the entiredepiction of affected natural resources. However, one of the clear finding was that saline wastewater caused secondary salinity. Moreover, the salinity of groundwater had a positive correlation with the distance from freshwater reservoirs (canals or rivers) and it declines with depth. The farmers irrigated their fields with salinewater thoroughly, but not all of the water was available to plant roots due to high electrical conductivity. Therefore, farmers did not grow salinity-sensitive crops (cotton) and preferred to grow salinity-resistant crops such as sugarcane, fodder etc. Irrigation with highly saline water adversely affected farm productivity (Muyen et al., 2011).

As regards irrigation with domestic wastewater, the soil fertility (N:P:K) also required a complete examination of other quality parameters.No doubt, domestic wastewater contained organic matter and other nutrients; however, crops required a proper ratio of these nutrient contents. An excessive amount of one nutrient would not be beneficial.

Moreover, heavy metal accumulation can transfer from untreated wastewater irrigation to soil, groundwater, and crops.In case of crops, higher values than recommended limits were a risk to human health (see Appendix E). Each microorganism, chemical, and the element must be within the recommended range. Results of a few studies conducted in Faisalabad are mentioned below who examined the heavy metal accumulation in soils and crops.Siddique et al.(2014) and Umar Hayat et al. (2015) found that Pb, Mn, and Fe in soils and crops irrigated with municipal effluents exceeded WHO limits; also, high concentration of Zn, Cd, Ni, and Pb was detected in Faisalabad (Ashraf et al., 2015). Jabeen, Aslam, & Salman(2018) identified a higher concentration of Cu, Fe, and Pb in soil and vegetable (leafy parts) in Faisalabad. Only one study in Pakistan was conducted regarding potentially harmful elements (Pb, Ni, Cr, Co, and Cd) and dietary minerals (Mg, Ca, Mn, Cu, and Fe) in sewage wastewaters and vegetables across five cities including Faisalabad. It was concluded that all potentially harmful elements were within limits in Faisalabad (Zia, Watts, Niaz, Middleton, & Kim, 2017). However, this study only considered irrigation with sewage wastewater.

Some other studies showing the effects of biological, chemical, and heavy metal contamination of untreated wastewater on human health through crops (all around Pakistan) are as follows: higher concentration of heavy metal in Multan (Muhmood et al., 2015); Pb, Fe, and Mn accumulation in soil and leafy parts of crops (Hayat et al., 2015); Pb toxicity in pea plant (Khan, 2015);Pb accumulation in vegetables (Khalid et al., 2017); Pb accumulation in spinach (Khan, Iqbal, Ashraf, Ashraf, & Ali, 2016); Cr and citric acid's impacts on sunflower plant's body (M. Farid et al., 2017); Cr impact on cauliflower (Ahmad et al., 2017);Cr stress in maize plant (Islam et al., 2016); Cd toxicity in wheat (Saifullah, Sarwar, Bibi, Ahmad, & Ok, 2014); reduced yield of alfalfa under Cd stress (Perveen et al., 2016); Cd uptake in wheat and maize (Ahmad, Akhtar, Zahir, & Mitter, 2015);and Azo dyes contamination in wastewater (Waqas, 2014)

Whereas, Khalid et al.(2017) conducted a study in *Vahari* (Pakistan) detecting the Pb in wastewater used for irrigation and growing vegetables. Even the Pb concentration detected was within range (WHO limits) in soils irrigated with wastewater; however, the Pb concentration in plants exceeds WHO limits for the vegetable crops (spinach, radish, and cauliflower).

In the next segment, a brief review of the health and hygienic condition of farming communities (producer) around Faisalabad is addressed. Consumer health after the consumption of contaminated food could not be analyzed due to data limitation. It was supposed to assess the health of farmers who also consume their own produce to some extent.

5.4 Health and sanitation status of farm-families

The neglected sector of wastewater management can cause farm households to be vulnerable to poor health and productivity loss. Provision of drinking water and sanitation facilities is the foremost responsibility of public administration. Unsafe management of wastewater imposes a significant effect on health and environmental risks. (SDG 6 and sustainable wastewater management already discussed in section 2.4)

In Faisalabad, Ensink(2006) studied the risk of hookworm and quality of irrigation water. The study concluded that the risk of hookworm infection within the farming community applying wastewater irrigation was 20 times higher than a community's risk irrigating with regular water.

Approximately, 40 percent of deaths in Pakistan are caused by contaminated water (Hassan, 2001). Another study stated that water-borne diseases are responsible for 30% of deaths in Pakistan (Daud et al., 2017). The use of toilets and overall hygiene condition of farm families were linked to hookworm infection (Feenstra, Hussain, & van der Hoek, 2000; Ensink, 2006).

5.4.1 Drinking water condition

In this section, the main emphasis was to elaborate the direct and indirect impact of poor wastewater managemnt on public health. The groundwater in Faisalabad district was undrinkable due to salinity. Private companies supply drinking water in water bottles from door to door. The WASA covered limited areas to supply drinking water. Even the epidemics of gastro spread because of the unhygienic infrastructure of supply lines of WASA across the city (Sahi, 2007). A number of studies are available who evaluated the quality of variouse sources of drinking water in Faisalabd and declared sources of drinking water as a risk to public health. (see, Ali and Akhtar, 2015; Farid et.al., 2012; Nasir et. al., 2016; Yamin et. al., 2015; Zia, Khail-ur-Reham & Latif, 2005)

Another hurdle was found with the national quality standard and WHO standards for drinking water. Values of the national standard of drinking waster varied from WHO standards for Arcenic, Cd, Pb, and Zn. For Arsenic, Pakistan's NEQS is ≤ 0.05 mg/l, whereas, WHO is 0.01mg/l. Similarly, NEQS limits for Cd is 0.01, while WHO limit is 0.003. NEQs for Pb is ≤ 0.05, as WHO is 0.01. For Zn, NAQS is 5.0 as comapred to WHO which is 3.0 (Daud et al., 2017).

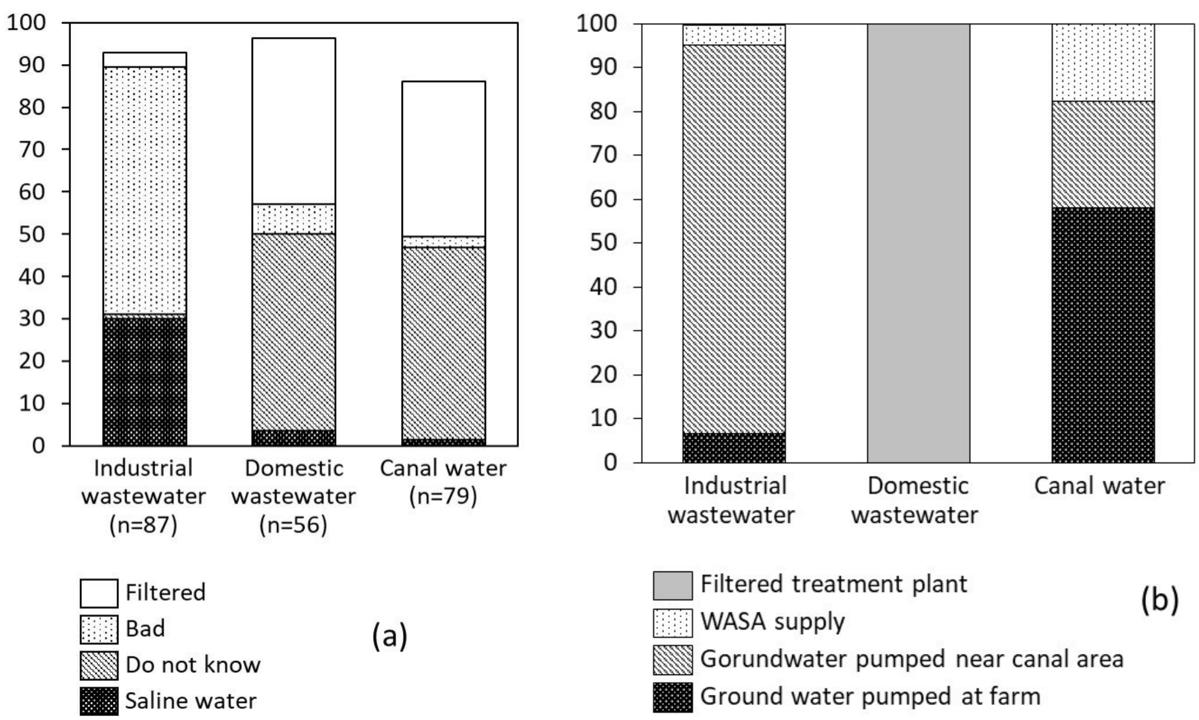

Figure 5.2:Quality (a) and sources (b) of drinking water across categories

Note: Bar represents the percentage of responses in each category.

Figure 5.2 depicts the quality and sources of drinking water. It was evident that the canal irrigators (control group) mostly utilized the privately filtered groundwater for drinking. As groundwater in canal-irrigated areas was not saline, the overall health condition was well within these areas (except for hepatitis E).

In the case of areas irrigating with domestic wastewater, a treatment plant for drinking water was installed through the funding of the World Bank a few years ago. This treatment plant was planned and established after discovering the vulnerable health conditions of the villagers. Now, the water quality was confirmed well. However, the treated drinking water was only available to one village.

The worst situation was found in areas irrigated with industrial wastewater (Figure 5.2). The villagers had to fetch drinking water from far distant areas (near the canal). Actually, these motor pumps along the canal banks have been the common source of drinking water supply for residents of Faisalabad. There were no quality checks (treatment or filtration) for these pumps.

5.4.2 Sanitation and hygienic condition of farm-families

Along with drinking water, the toilet and hygiene (hand wash) condition affect the public health status. Ensink (2006) found that good hygienic condition and proper defecation reduce the infection risk among wastewater irrigating families.

Sanitation condition refers to sewerage system of the house and the village. Moreover, hygienic condition was bound with hand washing and other hygiene activities of farm families. In addition, the toilet availability at home and its condition also counted as health conditions of a family. Only 83 percent of the respondents confirmed that a toiled it available at their houses.

Table 5.6:Sanitation and hygienic condition of farm families (percentages)

Variables	Industrial wastewater (N=87)	Domestic wastewater (N=56)	Canal water (N=79)
	Standard of house		
Good	40.2	67.9	50.6
Marginal	57.5	32.1	49.4
	Sanitation condition		
Good	23	26.8	34.2
Marginal	72.4	73.2	65.8
	Hygienic condition		
Good	29.9	60.7	44.3
Marginal	66.7	39.3	55.7
	Latrine		
Good	86.2	75.0	59.5
Marginal/bad	8.0	10.7	7.6

N: Number of observations

According to Table 5.6, irrigators using domestic wastewater and canal water had a mostly good standard of living as compared to those using industrial wastewater (the reason was a privileged level of education and family income). However, the sanitation situation (local drainage system) in areas irrigating with domestic wastewater was worse due to the dumping of village effluents into local ponds. Overall, hygienic habits were also better in areas irrigating with domestic wastewater and canal water areas than areas irrigating with industrial wastewater. Conversely, in the case of the availability and condition of a latrine, the situation was reversed; the absence of basic hygiene knowledge may be the reason for this trend.

5.4.3 Health condition

Generally, number of factors affected the health and sanitation conditions of villagers. Hence, the prime objective was to explore the effect of inadequate wastewater management on the health of farming communities. For this purpose, the health and sanitation status of farm families was examined through verbal investigation. Questions related to symptoms of diseases (microbial and heavy metal syndromes) were asked for the entire family including the household head (farmer).Accordingly, the frequency of sickness fromwater-borne diseases and days of sickness in 2008-2009 were counted. One importantfindingwas the productivity loss among irrigators using domestic wastewater.It was the remarkably highwith average days of sickness (6 days). Whereas, irrigators using industrial wastewater had fouraverage days of sickness and canal irrigators had only twoaverage days of sickness.

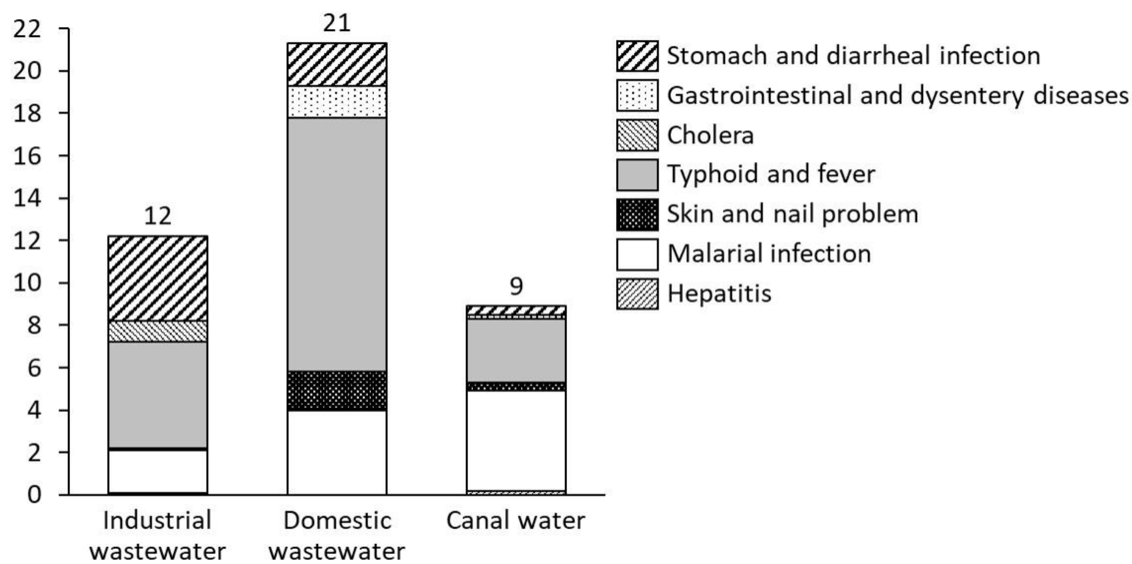

Figure 5.3:Illness prevalence (prevalence rate) among farming communities

After a deep look at the results (see Figure 5.3), it was evident that areas irrigated with domestic wastewater had the highest prevalence rate of illness. However, there was no significant difference found among farmers. The farmers considered that such kind of research could use to cease the supply of wastewater. Therefore, they disagreed about the prevalence of such diseases among themselves.

In contrast, when comparing the farm families, the results indicated a significant difference in incidence in diarrhea across the categories. Malaria and fever also had significant differences across the sites. Ali and Akhtar (2015) conducted a study in *Samundri* (Tehsil of Faisalabad), which determined that the most common water-borne diseases among family members wereGastroenteritis (53.6%), viral hepatitis (40%), Diarrhea (37.38%), and cholera (26.7%).

Irrigation with untreated wastewater may cause chronic health problems and loss of labor productivity among farm families (Feenstra et al., 2000; WHO, 2000c).Such findings have indicated that the microbial contamination of domestic sewerages is a health risk (Cifuentes et al., 2000; Ensink, 2006; Feenstra, Hussain, & van der Hoek, 2000; Murphy, 2017; Scott et al., 2003; Weldesilassie, Boelee, Drechsel, & Dabbert, 2010). Such poor health status mightalsobe the casedue to direct contact with untreated domestic wastewater in farm fields; the absence of a proper local drainage system may possibly be another reason.

5.4.4 Discussion

It was found that drinking water, hygiene, sanitation,and drainage systemsvaried from village to village. However, a strong connection between the incidence of water-borne diseases and proximity to irrigated areas using wastewater water was found. Other linked factors, such as poor water sourcesand poor hygiene and sanitation status made the situation worse. Overall, farm households irrigating with domestic wastewater suffered vulnerable health conditions. In contrast, canal irrigators had the lowest incidence of water-borne diseases by keeping the other factors favorable (hygiene, sanitation).

No doubt, a number of factors such as the source of drinking water, local drainage system, and overall hygiene condition of the area can affect the public health of farm households. The situation of waste borne diseases found quite complicated in the study area. Untreated domestic wastewater irrigation is not the only reason for the poor health of villagers. There are number of other intertwined factors such as local hygiene and drainage system, existing health care facilities, precautionary measures, and drinking water quality.

One of aspect was people ignorance towards diseases and causes of illness. There was no a single case (data set) who spent money as prevention cost. Most of respondent received treatment by using household remedies or some of them bought tablets from local pharmacy. Severe illness or even death caused by some curable disease has just accepted, as it is the‘will of God’. Death of two women during childbirth was found within one year in limited number of data set.A comprehensive study for health (particularly waterborne diseases) with the vision of SDGs is further required.

The other argument of an indirect connection between the quality of irrigation water andthe hygiene condition of farm families can be evaluated through the income effect.The next section gives an overview of farm income appraisal.Farm appraisal also assesses the comparison of the opportunities and risks involved with wastewater irrigation within the study areas.

5.5 Farm incomeappraisal

The complete farm budget analysis, including livestock, was evaluated to explore the consequences of wastewater irrigation on farm income. The hypothesis for this appraisal was that wastewater irrigation would influence the socio-economic conditions (farm income, cropping intensity, cropping pattern, and the land tenure system) of wastewater users compared to non-users in the peri-urban area of Faisalabad. The complete crop budget for all crops grown during one year (2008 to 2009) for each farmer, including *Kharif*2008 (summer season) and *Rabi* 2008-09 (winter season), was considered.

First, the most important factor of production for a farmer is land. The land status ensures the farm income. The structure of land tenure is actually an indicator of an economic and social status of farmers.

5.5.1 Land tenure system

Certainly, in irrigation agriculture, land size determines the socio-economic position of the farmer. It influences all other production-related decisions of farmers. Mostly, peri-urban farmers (from data) within Faisalabad possessed small (0-2 ha) to medium size (2-5 ha) farmland. From the data, it was estimated that about 60 percent of respondents owned farmland less than two ha. Around 28 percent of the farmers possessed farmland ranging from two to five ha. Only ten percent of the farmers owned land more than five ha. The trend of leasing agricultural land was highest in areas irrigated with canal waters. About 22 percent of irrigators using canal water rented agricultural land between two to 52 ha. In irrigated areas with domestic wastewater, 30 percent of farmers also rented farmland (2 to 5 ha). Conversely, only six percent of farmers rented farmland (0 to 2 ha) in areas irrigated with industrial wastewater.The average farm size within the study area was about two ha. Such average farm size is less than the average farm size (5.6 ha) in Punjab, Pakistan (Government of Pakistan, 2010, Table 1).

Table 5.7:Land tenure system across the categories

Land variables	Industrial wastewater (N=87)	Domestic wastewater (N=56)	Canal water (N=79)
Owned area (ha)	2.6 ^{a} (2.7)	1.5 ^{b} (1.8)	2.1 ^{ab} (2.2)
Leased-in area (ha)	0.2 ^{a} (1.2)	0.7 ^{b} (1.3)	1.9 ^{b} (6.6)
Cultivated area (ha)	3.1 ^{a} (2.7)	2.2 ^{b} (2.3)	4.2 ^{a} (6.4)
Net area sown (ha)	3.2 ^{a} (2.5)	2.4 ^{b} (2.2)	4.9 ^{a} (9.9)
Cropping intensity	113 ^{a} (42)	144 ^{a} (230)	118 ^{a} (76)
Rent (Rs /ha)	**22,769 ^{a} (3,940)**	**26,001 ^{b} (2,406)**	**33,110 ^{c} (10,370)**

Note: The mean (and standard deviation in parentheses); superscript letters represent the significantdifference between the categories at 5% level of significance as a result of Mann-Whitney test (similar letters depict that there was no significant difference between both categories)
N: Number of observations

The findings from the Mann-Whitney test and descriptive analysis are depicted in Table 5.7. Average farm size was quite less in domestic wastewater group, but they enjoyed the intensive farming (highest cropping intensity). This was feasible due to a continuous supply of water throughout the year. However, there was no statistically significant difference in cropping intensity among the categories. The variation within data might be the cause.

The second important finding was that the leased-in farm area was highest in the canal-water-irrigated area with the highest value of the rent. These farmers (control group) practiced urban agriculture (commercial vegetable farms). They rented in the land due to the availability of ample amount of canal water and good quality of groundwater (low salinity). The trend of land rent prices clearly supported the farm income across these categories (see table 5.11)

5.5.2 Cropping Pattern

The term ‘cropping pattern’ generally describes the different types of crop grown during a specific period within a particular region. Wheat is the essential crop (as a staple food) within the Punjab province. Every farmer grows wheat during Rabi season. Besides wheat, the second crucial crop is fodder, grown as feed for livestock. Irrigators using wastewater (domestic wastewater) prefer to grow sugarcane crops(as a cash crop) because of the continuous availability of irrigation water as shown in Appendix H 1. A small number of farmers within this category cultivate other crops like rice, cotton,and canola.Among vegetable crops, apple gourd has been the most commonly grown vegetable within these areas. For areas using canal water for irrigation (control group), farmersgrow a wide range of crop including cash crops and vegetables to fulfill the local urban demands. Few of them—who own the largest farms in the area—grow vegetables on a commercial scale.

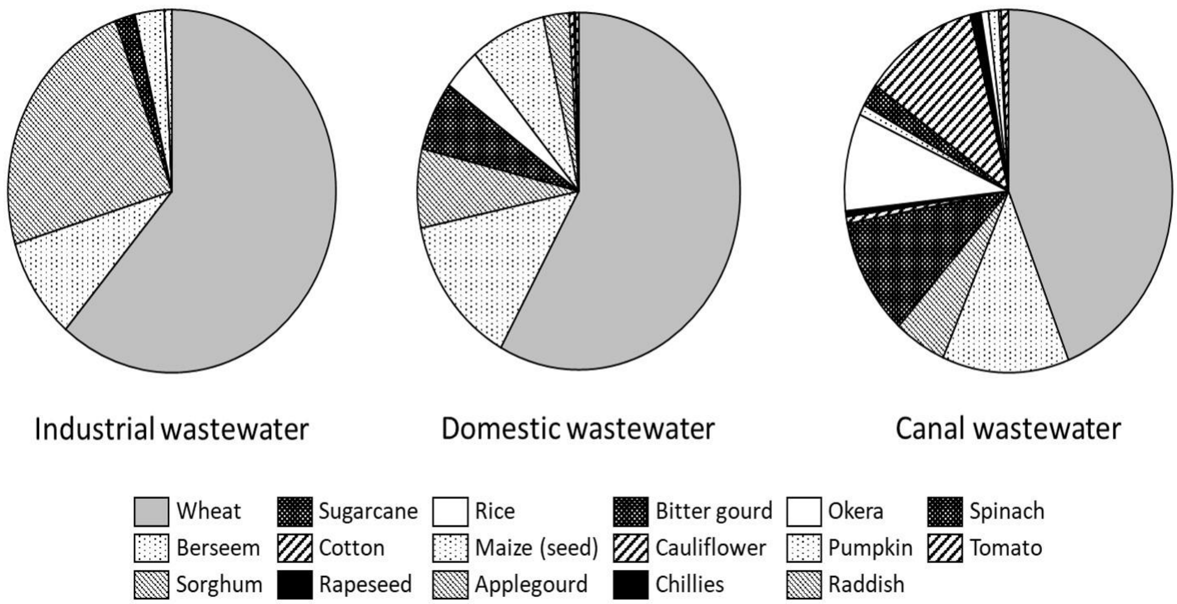

Figure 5.4:Percentage of the cropped area under each crop across categories

The croppingpattern for each category is portrayed in Figure 5.4. After comparing the cropped areas under different crops, one can conclude that crop diversification variedwith the type of irrigation. Under irrigation using industrial wastewater, farmers mostly grew wheat, *berseem* (as *Rabi* fodder), *sorghum* (as *Kharif* fodder), sugarcane, and maize (sugarcane and maize just on small proportion of area, only for fodder purpose). About 90 percent of the farmers grew wheat and fodder (berseem and sorghum) crops.Irrigators using domestic wastewater enjoyed additional alternatives for crop production. In addition to wheat, *berseem*, and *sorghum*, they produced cash crops such as sugarcane, rice, and maize (for fodder and seed) (Weckenbrock & Jacobi, 2008). During the study period, apple gourd was a valuable vegetable crop among them. Recently, growing all vegetable crops has been banned in these areas. Farmers irrigating with canal water (control group) grew a wide range of crops including wheat, *berseem*, *sorghum*, sugarcane (on vast areas), cotton, rapeseed, rice (as a cash crop), and maize (Hoek et al., 2002). Cauliflower wasthefirst preference among vegetables because ofthe highest crops returns. Other vegetable crops included bitter gourd, chilies, okra, pumpkin, spinach, and radish.

In conclusion, the quality of irrigation water directly influenced cropping diversity; results were in agreement with the previous work done by Rehman et al.(2013).

5.5.3 Crop Income

The term ‘total value of product’ (TVP) represents the total financial return received from a specific crop over a unit area. TVP is the product of yield and the per-unit price (received by the farmer). As price varies, variable TVP is used for standardizing the comparison. The ‘gross margin’ reveals the profit for cultivating a particular crop, and it is calculated by deducting the total variable cost from TVP.

5.5.3.1 Wheat

Wheat isthemost important crop for each farmer in Punjab as a staple food. Regardless of farm size or type of irrigation, almost every farmer grows wheat to fulfill at least his household consumption (There was only a single respondent in the industrial wastewater irrigated areas who did not grow wheat during 2008-09).The total value of the product (TVP) for the wheat crop was highest in areas irrigated with domestic wastewater because of higher yields compared to other areas.Average wheat production in Faisalabad was approximately 98 mounds per ha (Imran, A., Ayaz, M., &Noureen, K., 2015).

Table 5.8:Gross margin of wheat across categories

Variables	Industrial wastewater (N=86)	Domestic wastewater (N=56)	Canal water (N=79)
Area sown (ha)	1.99 ^{a} (1.70)	1.32 ^{b} (1.00)	2.23 ^{a} (3.08)
Total value of product (Rs/ha)	69,191 ^{a} (21,185)	10,6269 ^{b} (22,424)	95,880 ^{c} (20,403)
Total variable cost (Rs/ha)	30,819 ^{a} (10,747)	30,863 ^{a} (12,789)	37,524 ^{b} (15,406)
Gross margin (Rs/ha)	38,372 ^{a} (21,789)	75,406 ^{b} (29,702)	58,356 ^{c} (23,273)
Net returns per unit of rupee	1.24	2.44	1.55

Note: The mean (and standard deviation in parentheses); superscript letters represent the significant difference between the categories at 5% level of significance as a result of Mann-Whitney test (similar letters depict that there was no significant difference between both categories)
N= Number of observations
1US Dollar = 80 PK Rupee (2008-09), therefore 1PK Rupee = 0.0125 US Dollar

Findings of the Mann-Whitney test (Table 5.8) show that there was a significant difference in gross margins of wheat across the categories. The TVP was highest in areas irrigated with domestic wastewater because these areas had the highest yields. Ijaz et al. (2019) support the findings of improved yields of wheat irrigated with sewage wastewater. The price of wheat was the same throughout the area (support price of wheat). The other significant finding perceived from the data was the lowest average TVP (representing low yield) in areas irrigated with industrial wastewater. The farmers in the eastern site who irrigated their fields with untreated industrial effluents complained about the quality of wheat grain. They usually used their wheat crops to feed animals. The untreated industrial effluents and the salinity of irrigation water adversely affected the crop yields.

The reason for highest gross margin in irrigated areas with domestic wastewater was due to low variable cost compared to that of irrigated areas with canal water. The cost of production in the canal-water-irrigated areas was exceptional high due to excessive application of fertilizer, both organic and inorganic.

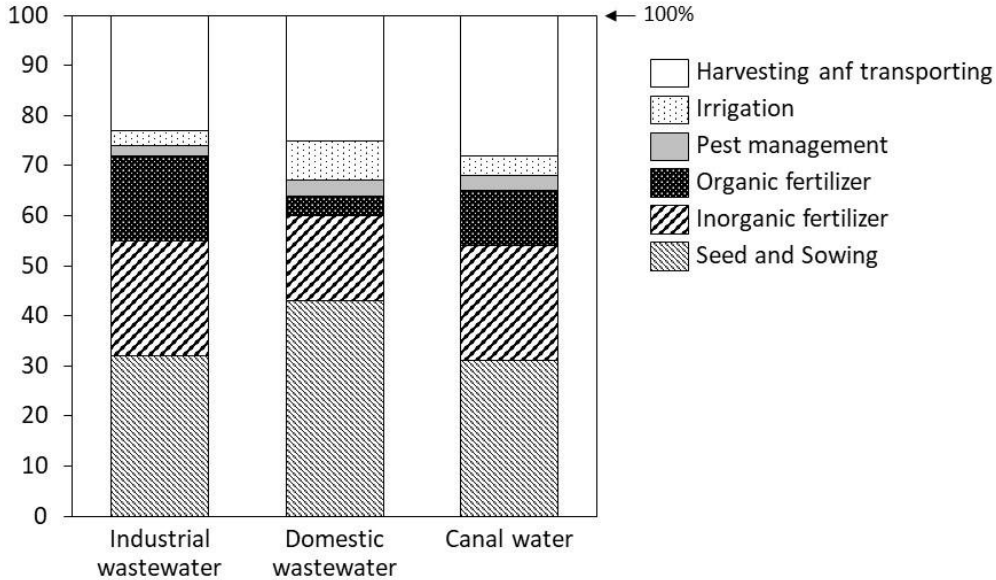

Figure 5.5: Variable cost of wheat (percentages) within the study area

Figure 5.5 elaborates the percentage share of variable cost to produce wheat. Irrigators using domestic wastewater applied the minimum amount of organic and inorganic fertilizer, and this in line with the findings of Mojid, Biswas, & Wyseure (2012). Conversely, irrigation cost was highest for irrigators using domestic wastewater, who paid about 9,000,000 rupees per year for irrigating approximately 10 ha of land (26 *marabba*) along with *Abiana*. For other areas, farmers just paid*Abiana* or in some cases diesel charges for pumping the water (either from tube well or drain). The *Abiana* fees varies from 60 to 150 Rs. per hadepending upon grown crop during 2008-09.

On the other hand, for irrigators using industrial wastewater and canal water, the cost of organic and inorganic fertilizer comprised more than thirty percent of their total cost of production. The application of inorganic fertilizer in canal-water-irrigated areas in excessive amounts was consistent with the findings of Rehman et al.(2013). However, industrial-wastewater-irrigated areas did not achieve higher yields like canal-water-irrigated areas. It was also evident from Figure 5.5 that there was nearly limitedvariation among pesticide usage across the categories, in case of the wheat crop.

5.5.3.2 Fodder crops

Wheat-fodder is most common cropping pattern within the study area due to salinity. Fodder crops are essential throughout the year (Rabi and Kharif) to feed livestock. Almost every respondent from the study sample owned livestock as a compulsory part of his farm.

Fodder crops group included *berseem*(Trifolium alexandrinum L.),*sorghum/jowar*(Sorghum bicolor), and maize during 2008-09. *Berseem*was mostly grown as *Rabi* fodder while *sorghum* was grown as *Kharif* fodder. Maize was grown for both fodder and seed production. For seed production, maize crop was considered as a cashcrop. The production of maize crop as fodder was limited in the study area (Tahir, Tanveer, Ali, Abbas, & Wasaya, 2008). Therefore, berseem and sorghum were the main fodder crops. Both crops possessed different cropping requirements. It was hard to combine the cropping budget of both crops. Finally, the weighted average gross margins per unit of land (ha) was estimated for each farmer.

The other difficulty was found in the estimation of fodder crops' total value of produce (TVP). Mostly, farmers grew fodder crops on small plots i.e. few *kanals* (one *kanal* =0.0505857 ha) according to their domestic livestock feed requirements. Normally, fodder crops were cut four to five times during one season (6 months). Usually, it is being cut few inches above from the ground. Then, it regenerate after each cut. Crop is again ready for next cutting after 3-4 weeks of cut. Farmers cut in the required portions from the field andfed their animals on a daily basis. The process of cutting afterward took place in the next adjacent area of the field. Usually, Farmers grow fodderonly for feeding their own livestock. Rarely, farmers have to purchase it from the market. In the absence of required fodder from their own fields, farmers cut from neighboring farms (with neighbor‘s consent) as a reciprocal activity. During this study, no one exactly knew about the amount of fodder (yield) utilized. Another common practice was the sale of the fodder field on an area basis (1000 Rs. per *kanal* per cut for *berseem* during 2008-09). This practice also hindered estimating the real price of fodder within the study area. Different areas hada different value system.

Lastly, a uniformed system of yield and value estimation was conducted to compare the value of fodder production across categories. The average yield was assessed from the data collected by farmers. Afterward, the weighted averages were estimated for a combined group of fodder crops.As a result, the average gross margins (fodder crops) were estimated using these weighted averages for each farmer.

Table 5.9:Gross margin of fodder crops across categories

Variables	Industrial wastewater (N=69)	Domestic wastewater (N=48)	Canal water (N=56)
Area sown (ha)	1.10 [a]	0.48 [b]	0.87 [b]
Total value of produce (Rs/ha)	69,453 [a]	10,5612 [b]	70,543 [a]
Total variable cost (Rs/ha)	14,600 [a]	12,140 [b]	14,854 [a]
Gross margin (Rs/ha)	54,853 [a]	93,472 [b]	55,689 [a]

Note: The mean values;superscript lettersrepresent the significant difference between the categories at 5% level of significance as a result of Mann-Whitney test (similar letters depict that there was no significant difference between both categories)
N = Number of observations
1US Dollar = 80 PK Rupee (2008-09), therefore 1PK Rupee = 0.0125 US Dollar

As shown in Table 5.9, returns were highest in areas irrigated with domestic wastewater.The lowestcost of fertilizer and an unlimited supply of irrigation water doubled their returns. Overall, irrigators using domestic wastewater benefited from crops like wheat and fodder. There was no significant difference between gross margin across areas irrigating with industrial wastewater and canal water even with the difference in the cultivated area. The reason lied behind the yield difference and the importance of the crop from the farmer's perspective. Indeed, fodder was the second most important crop (after wheat) for the farmers of industrial wastewater category.Some even grew fodder for commercial purpose. On the other side, the farmers in canal-water-irrigated areas grew fodder just to fulfill their domestic livestock feed requirements.

5.5.3.3 Cash crops

Cash crop was also a pooled group including sugarcane, cotton, rapeseed, rice, and maize (for seed production). Sugarcane, being the most significant cash crop, was analyzed separately, whereas remaining crops were pooled as 'other cash crop.'

Table 5.10:Gross margin of sugarcane across categories

Variables	Industrial wastewater (N=14)	Domestic wastewater (N=17)	Canal water (N=30)
Area sown (ha)	0.06 [a]	0.14 [b]	0.52 [b]
Total value of produce (Rs/ha)	11,782 [a]	28,415 [b]	46,068 [b]
Total variable cost (Rs/ha)	4,367 [a]	11,326 [b]	24,929 [b]
Gross margin (Rs/ha)	7,416 [a]	17,090 [ab]	21,139 [b]

Note: The mean values; superscript lettersrepresent the significant difference between the categories at 5% level of significance as a result of Mann-Whitney test (similar letters depict that there was no significant difference between both categories)
N = Number of observations
1US Dollar = 80 PK Rupee (2008-09), therefore 1PK Rupee = 0.0125 US Dollar

Sugarcane has been the most important cash crop in a peri-urban area of Faisalabad (Naeem, Bashir, Hussain, & Abbas, 2007), even under the salinity conditions. However, a number of variationswere found among the respondents. Results of the analysis are represented in Table 5.10.

Irrigators using canal water grew sugarcane on a commercial basis. Hence, the total variable cost (including irrigation, fertilizer, and pesticide costs) was the highest compared to other categories. Tube well used for irrigation raised their cost of operation due to costly energy consumption (Ali, 2011). Likewise, irrigators using domestic wastewater also irrigated their sugarcane fields with saline groundwater (through tube well) along with wastewater. However, the fertilizer cost was less, which reduced the total variable cost for them. On the other side, farmers irrigating with industrial wastewater faced various problems in sugarcane production. Few of them had a total crop loss due to the inferior quality of wastewater. Some of these farmers just sold their crop as fodder. Moreover, few of them found quite a low sale price (about half of the sale price as compared to other areas) for their produce. As a result, enormous variation was found among sugarcane farmers.

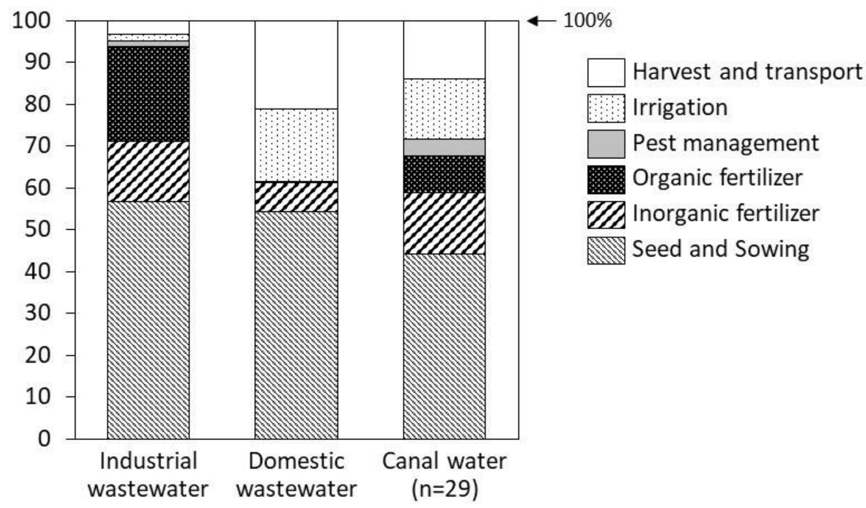

Figure 5.6:Variable cost of sugarcane (percentages) within the study area

The comparison of the average cost of production for sugarcane among categories discloses a significant difference in the source of irrigation (see Figure 5.6). A closer look at the data indicates that non-domestic wastewater (industrial wastewater and canal) irrigators had higher fertilizer cost. The findings are consistent with Naeem et al. (2007) who estimated the cost of production for sugarcane with small and medium-size farms in Faisalabad. All sugarcane produced within these areas directly supplied to eight sugar mills located within the Faisalabadregion without any product differentiation.

Table 5.11:Gross margin of the 'other cash crops' across categories

Variables	Industrial wastewater (N=2)	Domestic wastewater (N=4)	Canal water (N=14)
Area sown (ha)	0.10 [a]	0.26 [ab]	0.53 [b]
Total value of produce (Rs/ha)	1,136 [a]	4,274 [ab]	28,018 [b]
Total variable cost (Rs/ha)	673 [a]	3,039 [ab]	10,645 [b]
Gross margin (Rs/ha)	463 [a]	1,235 [ab]	17,373 [b]

Note: The mean values; superscript lettersrepresent the significant difference between the categories at 5% level of significance as a result of Mann-Whitney test (similar letters depict that there was no significant difference between both categories)
N = Number of observations
1US Dollar = 80 PK Rupee (2008-09), therefore 1PK Rupee = 0.0125 US Dollar

The 'other cash crops' in Table 5.11 is a pooled group which includes cotton, rapeseed, rice, and maize (for seed production) crops. The primary purpose of presenting such findings was to explain the significance of diverse cropping system with different sources of irrigation water within the study area. The weighted average was estimated for the pooled group across the categories.

Table 5.11 clearly indicates the multi-cropping status of canal-water-irrigated farms (14 farmers out of 79). These farmers grew different combinations of crops (for instance rapeseed, rice, and maize seed) to enhance their farm budget. The outliers (exceptional farmers different from the general farming community) were found in canal-water-irrigated areas, and they caused variation to the data set. Irrigators using domestic wastewater showed the highest net returns (gross margins) for wheat and fodder crops. Even for sugarcane, the net returns were the second highest. Nevertheless, the situation was bad for them, especially because they had a limited choice of alternative crops. Untreated wastewater was not suitable for each crop and sometimes these farmers faced complete crop failure. With these conditions, they faced similar situations as the farmers irrigating with industrial wastewater.

5.5.3.4 Vegetable crops

Vegetables play a vital role in urban agriculture. Vegetable gardens in peri-urban areas demonstrate a form of commercial farming. Hence, vegetable crops arealso a combined group comprising all grown vegetables within the study area. The respondents grew a variety of vegetablessuch asapple gourd(*tendi*), bitter gourd, cauliflower(*phool gobhi*), chilies, okra(*bhindi*), pumpkin, radish, spinach, and tomatoes during 2008-09.

Table 5.12:Gross margin of vegetables across categories

Variable	Industrial wastewater (N=2)	Domestic wastewater (N=11)	Canal water (N=18)
Area sown (ha)	0.02 [a]	0.08 [b]	0.85 [b]
Total value of produce (Rs/ha)	4,088 [a]	22,842 [b]	38,475 [b]
Total variable cost (Rs/ha)	379 [a]	6,363 [b]	13,880 [b]
Gross margin (Rs/ha)	3,709 [a]	16,479 [b]	24,594 [b]

Note: The mean values; superscript lettersrepresent the significant difference between the categories at 5% level of significance as a result of Mann-Whitney test (similar letters depict that there was no significant difference between both categories)
N = Number of observations
1US Dollar = 80 PK Rupee (2008-09), therefore 1PK Rupee = 0.0125 US Dollar

As shown in Table 5.12, farmers irrigating with canal water were mainly vegetable growers with the highest area under vegetable cultivation. Among them, the control group farmers (with ample amount of canal water) were involved in vegetable farming on a commercial scale. Some of them leased-in the large farm areas (for example, 52 ha, 18 ha, 14 ha, and so on) for vegetable cultivation using modern farming technologies. Such farms were exceptional cases whogenerated million of revenues from their farmland(Adil, Waqas, Chattha, Bakhsh, & Hassan, 2007).Farmers grew bitter gourd, cauliflower, chilies, pumpkins, okra, tomato, radish, and spinach. Cauliflower, pumpkins, and chilies crops generatedthe highest returns (millions of Rs.) per unit of land. Such crops and large farms wereexceptional cases, which created a variation while estimating weighted averages for the pooled group.

However, irrigators using domestic wastewater also grew vegetables (apple gourd, cauliflower, tomato, and spinach). Apple gourd and pumpkin were themost profitable vegetable in thedomestic-wastewater-irrigated area. The comparison of gross margins in domestic-wastewater-irrigated areas and canal-water-irrigated areas showed no significant difference (Mann-Whitney Test). Vegetable farming was profitable across both categories. Currently, there has been a ban on growing vegetables that are irrigated with domestic wastewater in Faisalabad. In the case of irrigation using industrial wastewater, only two respondents grew pumpkin and earned limited returns.

5.5.4 Livestock Income

Livestock is equally important across all peri-urban areas of Faisalabad. After the restriction of livestock farm within city areas, these peri-urban villages commercially maintained Bhans (cattle) colonies. The link between livestock and crop production was crucial. Farmers covered their daily dairy food consumptions by themselves. Also, livestock was found as a vital source of family income either on a monthly or daily basis. Hence, livestock is also considered as assets for the farming community.

Almost every farmer within the study sample had livestock at the farm. However, the size of livestock varied. Tropical livestock unit (TLU) was estimated to cover the variation among the type of livestock. There was no significant difference in livestock number (TLU) and livestock income across the categories.

5.5.5 Farm Income

Income from each crop grown on farmland and income from livestock are summed up for each respondent during the crop year. Income for a specific crop is the product of gross margin and area under cultivation for that crop.

Table 5.13:Farm income per family in study areas

Income (Rs/family/year)	Industrial wastewater (N=87)	Domestic wastewater (N=56)	Canal water (N=79)
Cultivated area (ha)	3.06 [a]	2.23 [b]	4.17 [a]
Wheat income	72,133 [a]	89,100 [b]	123,209 [b]
Fodder crops income	58,266	45,884	66,627
Sugarcane income	1,734 [a]	7,542 [a]	31,407 [b]
Other cash crops income	1,375 [a]	2,673 [ab]	25,901 [b]
Vegetables income	3,647 [a]	6,428 [b]	116,499 [b]
Tropical livestock unit	4.5	4.3	5.3
Livestock income	72,783	66,224	116,422
Farm income	**209,938 [a]**	**217,850 [b]**	**480,066 [c]**
Farm income per ha	75,432 [a]	121,833 [b]	109,586 [b]

Note:The mean value; superscript lettersrepresent the significant difference between the categories at 5% level of significance as a result of Mann-Whitney test (similar letters depict that there was no significant difference between both categories)
N = Number of observations
1US Dollar = 80 PK Rupee (2008-09), therefore 1PK Rupee = 0.0125 US Dollar

Table 5.13 clearly shows that the quality of irrigation water directly affected the crop returns (type of crops and yields). Farms irrigating with canal water had the highest farm income because they also had the largest cultivated land. There was no significant difference in farm income per unit of land between farms irrigating with domestic wastewater and canal water. This finding fully supports the using wastewater as an alternative source of irrigation water. The situation was shocking in industrial-wastewater-irrigated areas. Findings show that there was a significant difference in net returns between farms irrigating with industrial wastewater and canal water for all crops except for fodder crops (shown in Table 5.13). Industrial-wastewater-irrigated areas had higher returns from fodder because they had the highest share of area under fodder cultivation (Table 5.9).

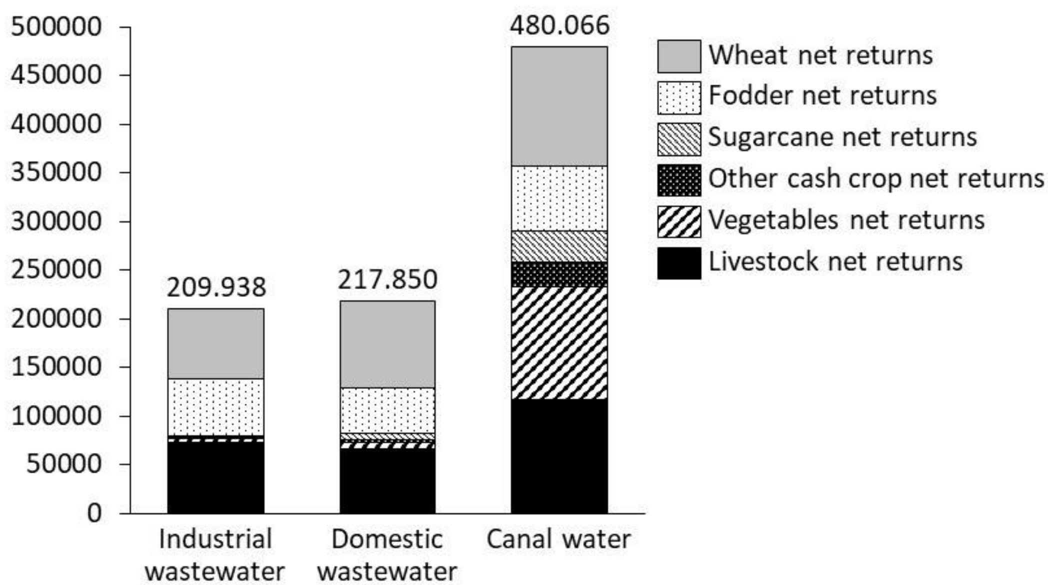

Figure 5.7: Contribution of different sources of farm income by categories
1US Dollar = 80 PK Rupee (2008-09), therefore 1PK Rupee = 0.0125 US Dollar

In Figure 5.7, the percentage share of different sources of farm income is mapped. Income of farmers irrigating with industrial wastewater mainly came from wheat (34%) and livestock (35%). The share of income from fodder (28%)was less than that of the commercial farms (see table 5.7). These farmers owned the largest farm area compared to other categories, but they had to grow cheap fodder crops due to poor quality of irrigation water (industrial effluents). Ultimately, the poor quality of irrigation water affected their farm income. These farm households farm at a subsistence level depending on the wheat-fodder cropping pattern.

It is clear from Figure 5.7 that40% of the income of farmers irrigating with domestic wastewater came from growing wheat (high yield). Returns from livestock (30%) and fodder (21%) were ranked second and third. For farmers irrigating with canal water, prominent sources of farm income were wheat (25%), vegetable (24%), and livestock (24%).These farmers enjoyed a secure financial status because they had a number of cropping options available.

5.6 Farm household's financial status

Farm income cannot describe the complete socio-economic status of a farm household. Farm household income appraisal is the assessment of income received by all family members. Farm and non-farm incomes are both reviewed for each household.

5.6.1 Non-farm income

Non-farm income is characterized as salaried work (including social security) or other non-farm sources like entrepreneurship.

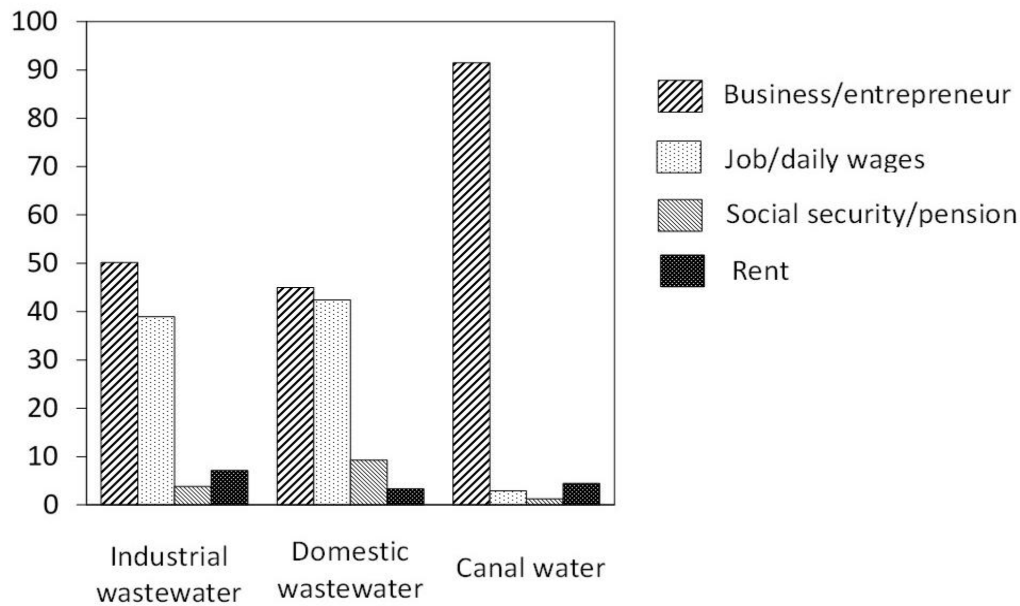

Figure 5.8:Contribution of different sources of non-farm income by categories

Note: Bar represents the percentage share of each source of non-farm income

Figure 5.8 explains the percentage share of different sources of non-farm income across the categories. Farmers irrigating with industrial wastewater ran a small-scale business such as transportation services. They mostly received daily wages as unskilled labor in city areas or in bricks kiln (nearby the village); income from renting out agricultural land for the establishment of bricks kiln was relatively high because there was a lot of bricks kiln found in southern, industrial-wastewater-irrigated areas.For farmers irrigating with domestic wastewater, sources ofnon-farm income included owning a business (retail shops), jobs (factory worker as semi-skilled labor), social security, and pension. In canal-water-irrigated areas, most farmers owned tube well or other farming machinery. They rented out to other farmers and earned income (Figure 5.8).

5.6.2 Farm Household income

Farm income was already calculated and presented in previous 5.13. The farm household income is appraised after adding non-farm income and farm income for each respondent. The results of the Mann-Whitney test are elaborated in next Table 5.14. Farm household income contains both farm income and non-farm income per household on a yearly basis. The results of family income are consistent with the findings of Rehman et al. (2013).

Table 5.14:Structure of farm household income in study areas

Income (Rs/family/year)	Industrial wastewater (N=87)	Domestic wastewater (N=56)	Canal water (N=79)
Cultivated area (ha)	3.06 [a]	2.23 [b]	4.17 [a]
Farm income	**209,938 [a]**	**217,850 [b]**	**480,066 [c]**
Farm income per ha	75,432 [a]	121,833 [b]	109,586 [b]
Farm income per family member	37,685 [a]	41,075 [a]	80,956 [b]
In USD*	471 [a]	513 [a]	1,012 [b]
Farm income per family farm labor	70,230 [a]	73,059 [a]	181,312 [b]
Non-farm income	87,324 [a]	48,471 [b]	68,476 [b]
Family income	297,262[ab]	266,321[b]	548,542[a]
Family income per family member	53,368	50,249	92,973
Family income per family member (Rs. per day)	146	137	254
Per capita income (USD* per day)	1.82	1.72	3.18

Note:The mean value; superscript lettersrepresent the significant difference between the categories at 5% level of significance as a result of Mann-Whitney test (similar letters depict that there was no significant difference between both categories)
N = Number of observations
***: - 1US Dollar = 80 PK Rupee (2008-09), therefore 1PK Rupee = 0.0125 US Dollar**

A closer look at findings in Table 5.14 indicates that farmers irrigating with canal water had the highest share of farm income. However, a variation of the share of farm income was also the highest among them. Progressive farmers rented agricultural land that supplied an ample amount of canal water. These farmers, supplying all required inputs on a commercial basis, grew crops and earned high returns. The farm income per family member and farm income per family farm labor were also highest for them.

The share of farm income was also high for farmers who irrigate using domestic wastewater, even the smaller farms. It supports findings that there is a positive impact of municipal wastewater on farm income (Weckenbrock et al., 2010). However, there was no significant difference in farm income per family member or farm income per farm family labor between farms irrigating with domestic wastewater and industrial wastewater. Irrigators using domestic wastewater intensively crop on small an agriculture land and most family members work as farm labor. Therefore, per person income was low even with the highest yields.

The irrigators using industrial wastewater had the largest average agricultural land but earned the lowest average farm income. In the absence of canal water, they irrigated with and their farm income, farm income per family member, and farm income per family farm labor were negatively affected by the poor quality of irrigation water.

It is evident from the data that poor quality of irrigation water affected the farm household's dependence on non-farm income as an income source. Regarding the share of non-farm income on farm household income, industrial-wastewater-irrigated farms (29%) had the highest among while domestic-wastewater-irrigated farms (18%) and canal-water-irrigated farms (12%) had lower shares. As it was already mentioned, the source of non-farm income for industrial-wastewater-irrigated farm households was daily wages as unskilled labor. The low farm income and the instability of non-farm jobs make their overall financial situation worse. These farmers complained that their financial condition was getting worse and worse over the last few decades. (Extracts from focus group discussion with farmers of Kajla and Loukey, June 2015)

The last rows of Table 5.14 estimated the per capita income of farm household across the categories. The calorie-based poverty line is estimated as 1,141.53 Rs. per day during 2007-08 (Federal Bureau of Statistics, 2014). The income per family member per day presented in Table 5.11 does not count the in-kind household food consumption (crops and dairy products). It just represents the net cash income that farmers earn from farm and non-farm activities. However, it favors the hypothesis that the quality of irrigation water directly affects the income of farm households.

5.6.3 Household expenditures

The overall farm householdincome and expenditure patterns across the categories express the variation within the socio-economic status of the household and the efficient usage of limited family resources.

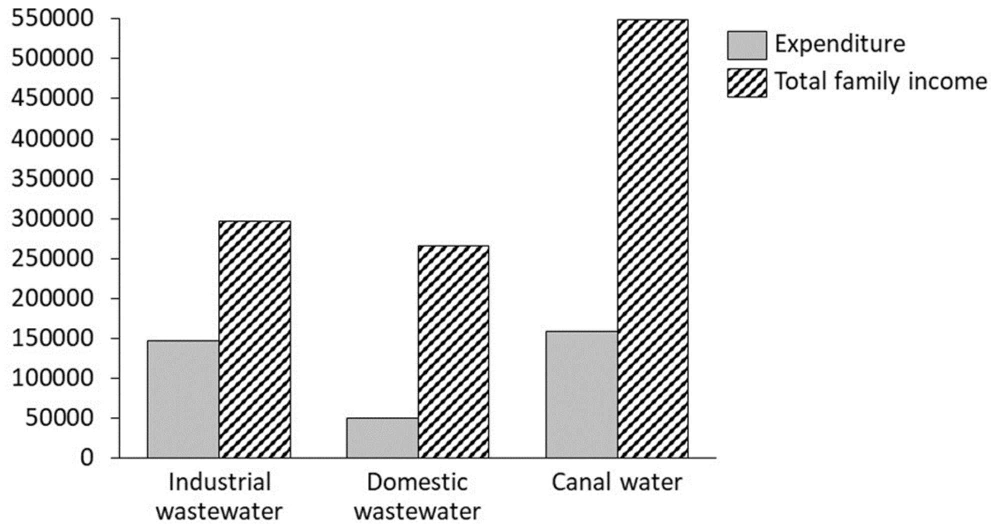

Figure 5.9:Family expenditure and farm household income analysis by categories

Figure 5.9 indicates that farmers using industrial wastewater saved only 50 percent of their income compared to farmers irrigating with domestic wastewater (81%) and canal water (71%). Actually, these savings are not true savings. Most of their savings went to unseen/unexpected risk factors (further crop requirements, marketing factors, price fluctuations, losses, health, accidents, and social incidents).

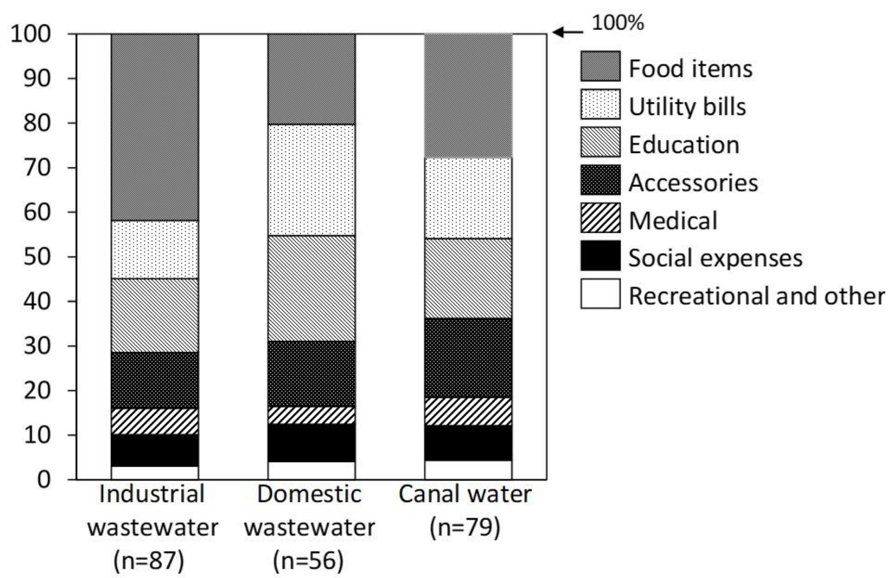

Figure 5.10:Expenditure share among different heads across the categories

Note: Bar represents the response of farm-families in percentages for each category.

Conventionally, farming communities fulfill a significant portion of their food consumption with their own crop production. The food items mentioned in Figure 5.10 includes buying food items. However, the situation was critical in industrial-wastewater-irrigated areas. These farmers spent a significant amount of their income to buy food items as they only grew a limited number of crops (wheat and fodder). This was because most farms in these areas were involved in subsistence agriculture.

Irrigators using domestic wastewater spent the main share of their income on education and other household utilities (electricity, gas, telephone, and energy) on regular monthly basis. Although they had the most days of sickness, the share of medical expenses was low. The data related to medical treatment showed that medication for their illness mostly came from nearby a pharmacy. Therefore, treatment cost was low.

Farmers irrigating with canal water spent more as their income level was the highest. They enjoyed the highest level of accessories (electrical appliances). Based on the above discussion, one can say that, overall, farmers irrigating with domestic wastewater managed their limited family resources well to get excellent opportunities and a better standard of life. However, farmers irrigating with canal water were actually earning well to maintain a good standard of life. Farmers irrigating with industrial wastewater, however, were barely managing their livelihood and they were not satisfied with their earnings.

Undoubtedly, farmers with more resources (inputs), such as land, irrigation water, and capital, have more tendencies to get ahigher level of farm income(C.T. de Wit, 1992). Therefore, the plentiful supply of wastewater for irrigation enhanced the yield, and ultimately, the farm income of farm households (Weckenbrock et al., 2010). In fact, irrigation water was the limiting factor of production within these areas, but the quality of irrigation water also mattered a lot. Precisely, the statistical description of resource availability could notfully justify the postulate mentioned above. Thus,further detailed consideration is required for determining the role of the quality of irrigation water for crop production and farm income.

5.7 Impact valuation (Dose response analysis)

A simple OLS method was applied to regress the yield of wheat crop (mds/ha) against the monetary values of inputs costs (sowing, fertilizer, pesticide, irrigation, and harvesting). Data were transformed by taking the natural log of all continuous variables to handle the non-linearity (Benoit, 2011). All regressions were done using an SPSS software. In this empirical research, several functional forms for the production function were estimated. The current model was selected after continued trials with different variables and with different functional forms. The final selection of the model was based on the expected signs of coefficients and statistical preferences. The significance of the overall regression, individual coefficients, and expected inferences of the outcomes were the criteria. Most importantly, the model was selected to detect the hypothesis of the impact of wastewater irrigation on the socio-economic condition of farm households.

After trying a number of specification (functional form and variable), a semi-log Cobb-Douglas function was selected to estimate the impact of the quality of irrigation water on farm yield. Factors of production such as land, labor, and fertilizer were included in the analysis. It was observed that the farmers applied a variety of farming activities. Therefore, the cost for each farming activity was incorporated after unitizing the inputs (value). Social factors such as education status, family size, and experience were also included in the analysis but such factors actually showed correlation with non-farm income and not with farm income. It is apparent from the Appendix H3 that all factors, except inorganic fertilizer and area, were correlated (either positively or negatively) with the wheat yields (mds/ha).

Table 5.15:Estimated production function for the yield of wheat

Variables	Coefficients (SE)	t-statistics (p-values)
Constant	2.265	9.55***
	(0.237)	(0.00)
ln_Sowing cost (Rs.)	0.224	8.65***
	(0.026)	(0.00)
ln_Inorganic fertilizer cost (Rs.)	0.008	0.954
	(0.008)	(0.34)
ln_Organic fertilizer cost (Rs.)	-0.018	-3.40***
	(0.005)	(0.00)
ln_Pesticide cost (Rs.)	0.022	3.30***
	(0.007)	(0.00)
ln_Irrigation cost (Rs.)	0.002	0.296
	(0.007)	(0.767)
ln_Harvesting cost (Rs.)	0.020	2.097**
	(0.009)	(0.03)
Industrial vs. Canal	-0.231	-4.40***
	(0.052)	(0.00)
Domestic vs. Canal	0.106	1.637
	(0.065)	(0.10)
Number of observations	222	
R Square	0.50	
F (009,212)	26.651***	

The *, **, and * represent significance at 10%, 5% and 1%, respectively. Figures in parenthesis are standard errors**
1US Dollar = 80 PK Rupee (2008-09), therefore 1PK Rupee = 0.0125 US Dollar

The results from the semi-log model (proposed in Section 4.2.6) are described in Table 5.15. The contribution of each farming activity to wheat production (dependent variable— natural log of wheat yield)is tabulated under the assumptions of the model. The coefficient of ‘organic fertilizer' indicates negative and significant values (see Table 5.15). It implies the exploitation of both resources. Regarding sowing cost, one percent increase in sowing cost would raise the yield by 0.22 percent[5]. Dummy variable 'industrial vs. canal' shows a negative coefficient. It represents that shifting from canal-water-irrigated area to industrial-wastewater-irrigated area reduced the yield by twenty-five percent[6]. This finding is also consistent with farmers' observations. The second dummy 'Domestic vs. Canal' showed no significant coefficient but the positive coefficient is consistent with other studies (Ahmad, Bakhsh, & Hassan, 2006, p. 242).

The second model suggested looking at the association between the quality of irrigation water and farm income of farm households. The correlation analysis provided information on the relationship between family income and available family resources, including irrigation water. The household size, dependency ratio, educationstatus and age of the household head, and available family labor influenced the overall family income.Farm household income was used as a proxy variable to represent the livelihood of the farm household. Resources such as family size, land tenure system, cropping intensity, TLU (Tropical Livestock Unit), family labor, education of household, and the dependency ratio represented independent variables. Farm income was reliant on crop income and livestock income. Appendix H4 indicates a positive correlation among diverse sources of farm income.

Table 5.16: Estimated production function for farm income

Variables	Coefficients(SE)	t-statistic(p-values)
Constant	7.889	9.512***
	(0.829)	(0.000)
ln_Wheat income	0.277	4.302***
	(0.064)	(0.000)
ln_Fodder income	0.110	4.239***
	(0.026)	(0.000)
ln_Sugarcane income	0.017	0.660
	(0.025)	(0.510)
ln_Cash crop income	0.053	1.413
	(0.038)	(0.159)

[5]Log-log model: Log Yi = α+βlog Xi + εi

[6]Log-linear model:logYi=α+βXi+εi

100·ˆβis the expected percentage changeinYfor a unit increase inX. For instance, forˆβ=.06,e.06≈1.06, so a 1-unit change inXcorresponds to (approximately) an expected increase inYof 6%

(EXP (0.231)–1) *100 = 25

ln_Vegetable income	0.034	1.207
	(0.028)	(0.229)
ln_Area sown	0.592	4.040***
	(0.147)	(0.000)
ln_Tropical livestock unit	0.055	0.404
	(0.135)	(0.686)
ln_Family farm labor	-0.257	-1.226
	(0.210)	(0.222)
Industrial vs. canal	-0.660	-2.480***
	(0.266)	(0.014)
Domestic vs. canal	-0.076	-0.273
	(0.279)	(0.785)
Number of observations	222	
R Square	0.364	
F (010,211)	12.096***	

***, **, and *** represent significance at 10%, 5% and 1%, respectively. Figures in parenthesis are standard errors**
1US Dollar = 80 PK Rupee (2008-09), therefore 1PK Rupee = 0.0125 US Dollar

The contribution of main sources of farm income is presented in Table 5.16. Where, the dependent variable is the natural log of farm income (Rs/farm household). From the results presented in Table 5.16, it is evident that wheat and fodder crops mainly contributed to farm income. Also, the sown area of each farm household contributed to generating farm income: a ten percent increase in the sown area may upsurge the farm income by five percent.

The coefficients for both dummy variables (Table 5.16) show that the shift from canal-water-irrigated areas to wastewater-irrigated areas (industrial or domestic) would lower the farm income.However, the coefficient of dummy 'domestic vs. canal' was not statistically significant. Nevertheless, the farm income supports the conclusion of lower farm income with wastewater irrigation.

For both regressions (Table 5.15 and 5.16), the coefficients for dummy 'industrial vs. canal' were both negative and statistically significant ($p<0.05$). Consequently, it is evident from the results that untreated industrial effluents adversely affected the yields and income of farmers.

5.8 Summary and Conclusions

This detailed impact study assistedto explore the diverse and comprehensive conditions farm households are in when there are different qualities of irrigation water (industrial, domestic, and canal). The impactof irrigation water on farm households varies from place to place, depending upon the quality and quantity of water, as well as the frequency of irrigation. Any proposed solution or policy first requires to observe such ground realities. The categories of 'industrial wastewater, domestic wastewater, and canal water' across the study area provided substantial evidence of the effects of the quality of irrigation water on farm households.

Industrial wastewater irrigation: there were two different localities (southern and eastern) irrigating with untreated industrial wastewater. Farmers of both areas were stressed with limited or no canal water supply. In eastern areas, the quality of industrial effluents was worse than southern areas. As a result, farm income reduced almost more than half. Farmers were facing subsistence farming due to quite poor quality of irrigation water. In the southern region, farmers were also facing adverse impacts such as decreased crop production, limited crop choice, and low farm income but the extent was not as severe as eastern areas. Collectively, all farmers in this category face limited crop choice with low cropping intensity compared to other categories. Low yields and even low quality of crops reduced their net returns. The pressure to shift jobs for non-farm income (daily wages jobs as unskilled labor) to fulfill their livelihood was evident.

Domestic wastewater irrigation: saline but highly nutritional (organic matter, available phosphorus, available potassium) domestic wastewater improved crop yields. The ample supply of domestic wastewater throughout the year also contributed to higher yields. Higher cropping intensity automatically increased farm income. Consequently, the farmers invested all family resources in the farming sector due to high return per unit investment. It further intensified farming activity by employing all available family labor. Overall, this farming community,even with limited family resources, enjoyed a better quality of life in terms of education, housing status, financial assets, and other standards (transport, electronics, and social status). The only drawback was the vulnerable health condition of villagers.The frequency of illness like diarrhea among these wastewater irrigating communities was also higherthan other categories (even they purposely veiled the real health information).

Limited canal water supply: neighboring villages or adjacent sites to wastewater irrigating sites faced the problem of a limited supply of canal water (farmers at the tail of watercourses) but did not have access to wastewater. These farmers grew a limited number of crops and remained as low-income farm households. Such farmers wished to receive canal water, and if not, at least have access to wastewater for irrigation.

Ample canal water supply: the control group at the head of the watercourses had access to sufficient amount of canal water. Highest crop diversity allowed them to achieve maximum farm returns; such farmers enjoyed commercial urban farming.

The study included different aspects such as natural resources, the health of farmers, and the socio-economic condition of the farmers. The statistical and econometric analysis supported the hypothesis, that the continuous application of untreated wastewater affects the soil condition (pH, EC, available phosphorus and potassium), the groundwater composition (EC, SAR, chlorides, and so on), and the health and socio-economic conditions (crop yields, farm income, crop diversity, family income) of farm households.

Health scenario found quite complicated in the study area. Untreated domestic wastewater irrigation is not the only reason for the poor health of villagers. There are number of other intertwined factors such as local hygiene and drainage system, existing health care facilities, precautionary measures, and drinking water quality.

Having a broad understanding of such reality is required before deciding the most suitable future policy options. The location of treatment plant, type of treatment plant, improvement of the drainage infrastructure (locationwise improvement), effects of wastewater (domestic or industrial), and the severity of issues (prefer the most stressed issue first through policy) can be decided after reviewing a comprehensive study about the area (feasibility report for further strategic and policy planning).

6. RREVIEW OF LEGAL FRAMEWORK

This chapter presents an overview of the current state of the legal context of the existing institutional framework to formalize the wastewater management. The review of the current legislative framework reveals the desired circumstances. For this concern, this chapter is organized in four main sections. The first section addresses the endorsement of formal laws and regulations over time. Secondly, the policies and process of policy formulation at national level are discussed. Thirdly, the role of the international community for shaping up the legal framework in Pakistan is reviewed. Finally, the gaps within the institutional and legislative frameworks that reflect the poor implementations of these laws are enlisted (Table 6.1).

Table 6.1:Research questions and targeted investigations

Research questions	Section
1-What kind of legislation existed to address the issues of water pollution, untreated wastewater irrigation, public health, sanitation and drainage system, and wastewater generation?	6.1
How did the various aspects of wastewater management regulate through regulations? How had this legal framework developed over time?	
2- How were the national policies addressing the sustainable wastewater management?	6.2
3-How had the international community influenced national policy formulation?	6.3
4-What kinds of gaps in legal framework existed responsible for the poor implementation of laws?	6.4

6.1 Review of existing legal framework

Needs assessment reviews the gaps between the current scenario and desired goals. The current scenario of wastewater management has elaborated in Chapter 3 and Chapter 5. The next objective is to know the desired goals (legal) of wastewater management in Pakistan. For this purpose, the existing legislation targeting the industrial development, urban settlement, agricultural practices and environmental pollution is reviewed. A list of responsible public agencies, departments and institutions arranged who are directly or indirectly accountable for specific duties (linked with wastewater management) prescribed by government rules of business (Government of Punjab, 2011: Second Schedule) is also included.

Table 6.2:Administrative organizations involved with wastewater management

Aspect	Provincial Department	Agenda
Freshwater pollution, Soil and groundwater pollution	EPD (provincial), EPAs, (Federal and provincial)	Natural resource conservation and pollution control
Wastewater generation, treatment, and safe disposal	Industries, Commerce & Investment Department	Industrial development and treatment of industrial effluents

Dumping of untreated wastewater into the river	Irrigation department IDD	Drainage infrastructure such as storm drains
Health impacts, Urban development plan, Drainage services and collective treatment	HUD&PHE Department	Public health, housing, urban development and land use
Untreated wastewater irrigation	Agriculture Department	Agriculture practices and food safety concerns
Domestic user and farmers	Local Govt. and Community Development	Responsibilities of public administrative organizations
Construction of drainage infrastructure and treatment plants	Planning and Develpoment (PND)	Planning and development for future policies

Table 6.2 details these related aspects of wastewater management, concerned departments, and their legal obligation. Prevalent legal framework across multifaceted disciplines is critically appraised regarding mentioned public organizations. The brief definitions of basic legal terminology (Appendix E)are included.The legal and institutional lapses are thoroughlyevaluated. Furthermore, a detailed chart of indicating department-specific legislation, offenses,and punishment, as well as concluding comments explore the laps in the legal framework (Appendix E1). (see also Government of Pakistan, 2002, p. 24-29)

The legal progression is distributed into three criticalphases chronologically. All important events and legal promulgation are arranged in a timeline(Camacho, 2013) based on their significance. The endorsement of environmental laws was a significant milestone in legal development in Pakistan. All legislation developed for the emergence of institutions responsible for the management of natural resources before the environmental legislationis discussed in phase I. The phase II presents the promulgation of environmental laws. The lastphase III explains the decentralized wastewater management. In the following subsubsections, all prominent incidents and legal promulgation are discussed under these three phases.

6.1.1 Phase I: Evolution of Institutions

The pre-date laws, the Constitution of Pakistan 1973mostly delegated the authorities, regarding the use and control of natural resources, to provincial governments. According to article 9 (page 7) of the Constitution of Pakistan 1973 (National Assembly of Pakistan, 2012), it addresses the human environment as:

> "No person shall be deprived of life or liberty saves in accordance with law."

This article could indirectly relate to the security of a person. The word "life" describes basic human needs, including physical and mental health. The focus of the constitutions (1956, 1965 and 1973) is towards administration, right of powers, prevention, and penalties. (see IUCN Pakistan, 2005; Cheema, 1998). Issues dealings with freshwater pollution, sustainable development, and agricultural practices cannot be found in any of the constitutions of Pakistan.

Consequently, what ended up taking place was the exploitation, instead of conservation, of natural resources such as freshwater resources.

Before 1997, there had never been any proper federal legislation to control freshwater pollution or industrial pollution(Naureen, 2009). Only scattered clauses in the Pakistan Penal Code (1860) were transcribed in regards to environmental protection, water quality, and resources, toxic and hazardous substances, public health and safety(IUCN Pakistan, 2005).

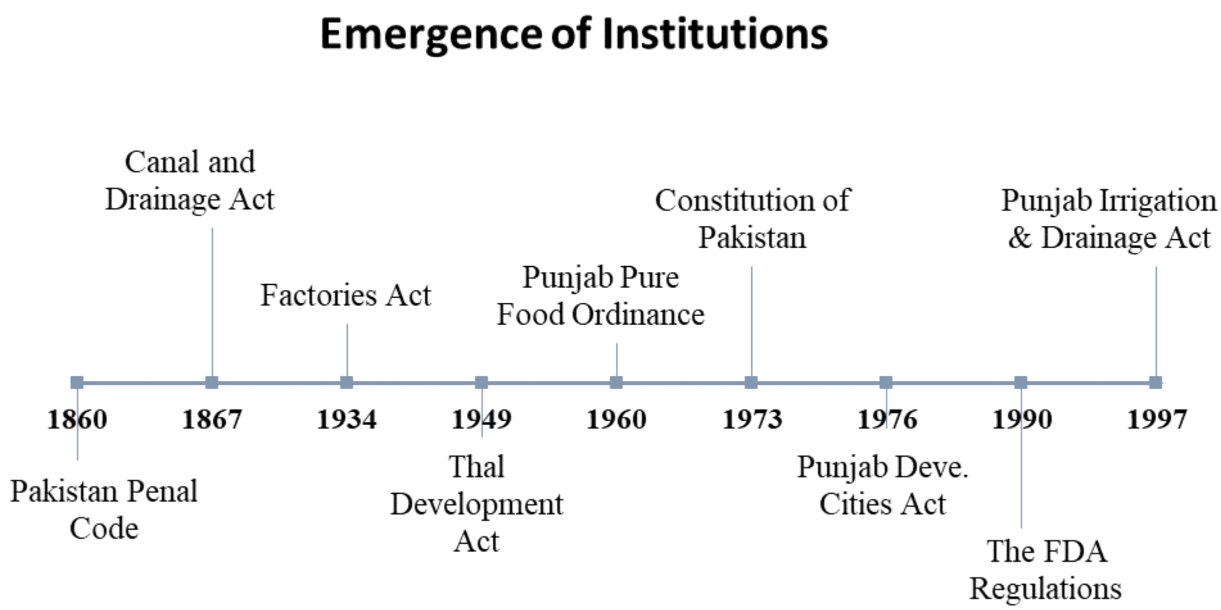

Figure 6.1:Phase I, the establishment of institutions

Figure 6.1 presents the timeline for major legislation regarding the emergence of public institutions enlisted in Table 6.1.

At best, the Canal and Drainage Act (1873) provided the guidelines on how to collect drainage charges from industries. However, the aim was just to cover the costs and had the least concerns about wastewater quality and the degradation of natural resources. This law was efficiently enforced until the formation of farmer's organizations during the 1980s(Memon&Scheumann, 2003). Later in 1997, all the powers of irrigation and drainage department were transferred to the Punjab irrigation and drainageauthority (PIDA) under the Punjab Irrigation and Drainage Authority Act. Under the Pakistan Environmental Protection Act (PEPA) 1997, the pollution charges on industries were imposed for discharging untreated discharge into public drains. The contradiction between minor penalties (imposed by Canal and drainage act 1870) and pollution charges(approximately hundred thousand rupees fees based on the industry's pollution load) proposed under PEPA 1997 was huge.

Likewise, the Factories Act (1934) primarily addressed the provincial government to arrange how to dispose of the effluents from industrial units. There were no concerns were regarding the water quality, toxic/hazardous substances of effluents, and how to treat the wastewater. This law became almost inactive because of its insufficient penalties for offenses. Even that violators were not worried at all (Government of Punjab, 1940).

The legislationfor providing the facilities of the sewerage system to the communityconcedes under urban development and public health (HUD&PHE) department. At first, the Thal Development Act (1949) and The Greater Lahore Water Supply, Sewerage and Drainage Ordinance (1967) provided the legal guidance to establish an authority for providing proper drainage facilities in the cities. Later, the Lahore Developmental Authority Act (1975) provided a complete legal framework for the functioning of the Development Authority in Lahore City. Ultimately, The Punjab Cities Development Act (1976) approved the establishment of the Development Authorities in Punjab Cities (including Faisalabad), which focused on issues related to industrial development, water supply, sewerage, drainage, and housing environment. Such development authorities could further introduce agencies to execute the functions prescribed by the Act. Consequently, WASA was recognized to facilitate the 'provision of water supply, sewerage and drainage services. The Schedule (Part A) of this act prohibited the discharging of dangerous chemicals into drains, and further explained that proper disposal of industrial effluents is the responsibilities of producers. A violation of this act would lead to an imprisonment of seven years anda half-million rupees (Government of Punjab, 1976).

Unfortunately, this law could not uphold due to lack of a proper legal framework and authority who could take the necessary action against such offenses. WASA has no proper authority to prevent pollution generated by industries and waste disposal through the public sewage system. As a result, since the industrial development inthe early 1970s, untreated sewage has been either used for irrigation purposes or mixed with fresh water sources (rivers). This practice has affected groundwater quality through seepage and percolation. The contaminated rivershave been usedfor irrigation, drinking,and other purposes. All these factors have severely increased threats to the ecosystem and even more to human health(United Nation Environment Prrogramme, 2014: p. 187).

6.2.2 Phase II: Consideration of environment protection

An agenda for 'environmental protection' was brought up for the first time at the administrative level of Pakistan government after attending the Stockholm Declarationof 1972. The United Nations Conference on the human environmentwas held from 5-16 June 1972 for the preservation and enhancement of human environment.Later, Pakistan decided to establish the Ministry of Environment (MoE) at the federal level in 1975. The MoE passed its first legislation, the Environment Protection Ordinance of Pakistan (PEPO), on December 31, 1983.This ordinance did not provide any legislative ground for confronting environmental issues. It just provided the legislative groundto establish an institutional framework for environmentalprotection, i.e.,Environmental Protection Agencies (federal and provincial) and Environmental Protection Council(Abdul haleem Cheema, 1998).

The National Conservation Strategy (NCS) was the next significant step in addressingthe environmental concerns of Pakistan. With combined efforts from the International Union for Conservation of Nature (IUCN) andthe federal government of Pakistan over a period of nine years (1983-1992), it was officially formulated in 1992 (Naureen, 2009; Sohail, Delin, Talib, Xiaoqing, & Akhtar, 2014). The primary targets were protection, sustainable development,and improvement in resource utilization. The NCS had explored 14 areas for future courses of action including maintaining soils, increasing water efficiency, protecting water bodies, and managing urban waste.The collection and treatment of wastes from industries were included in the list of the Regulatory Instruments, as well as in the Economic Instruments.The report emphasized the collaboration of the irrigation department and the agriculture department at the provincial level to increase irrigation efficiency. The cooperation of environmental protection agencies and local authorities would be helpful when dealing with the issues of industrial waste collection and centralized treatment plants (IUCN—The World Conservation Union, 2000).

The NCS came up with a resolution to preserve aclean environment. However, it failed to explain the procedure in regards to how it could achieve the goal in a continuing system (Faruqee & Colema, 1996, p. 2). A reliablesystem of feedback that was neededto learn from the successes and mistakes of strategies were missing. The preparation of a 'master plan' to keep sustainable development as the top agenda proved to be inadequate to reach the goal. The institutional change, whichconsidered as a key to accomplishing the goals, continues to face challengesin the transitional stage. (also see Banuri, 1993;Hanson, Bass, Bouzaher, Samdani, & Zehra, 2000;Runnalls, 1995; IUCN 2000;Naureen, 2009; United Nation Environment Programme, 2014)

The federal government promulgated the first legislation for environmental protection in 1997 by withdrawing the existing PEPO of 1983 and declaring the Pakistan Environmental Protection Act (PEPA). The Act provided the legal groundsto implement and monitor the goals of NCS and to conserve renewable resources. The PEPA provided the legal framework to establish the Environmental Protection Council and environmental protection agencies like PEPO. Administratively, the federal Environmental Protection Agency (Pak-EPA)transferred the authority to the provincial governments under the constitution. Moreover, eachprovincial government further delegated such authorities to the provincial environmental protection agencies. In addition, the provincial government also sub-delegated particular powers to the local governments. Certainly, the provincial EPA is responsible for implementingPEPA, propose and enforce the quality standards, and certify the laboratories. Assisting other government agencies for the implementation of the strategiesof an efficient disposal system is also included in the list of duties for provincial EPAs. The provincial agency also had the authority to collect information. The inspectors could enter and inspect any property with a search warrant. They can collect samples of discharged effluents and wastes.Additionally, nobody was allowed todischarge effluents or waste in an amount or concentration that exceeds NEQS(Ahsan & Khawaja, 2013; IUCN Pakistan, 2005; Mian, 2012).

The Director-General of EPA could also impose an administrative penalty, pollution charges, as well as collect the fines. Under the environmental protection order (EPO), the agency could direct the responsible person (even with the involvement of any governing agency or local authority) to remove the polluting effluents.Although EPAs usually issue the EPOs against the violators, they did not directly enforce any penalty.Instead, theyfiled cases to environmental tribunals against the person who violated laws(Mian, n.p.; Naureen, 2009).Appendix E3presents the trial-and-appeal options for violators over their convictions.

Another main feature of PEPA 1997 is the organization and implementation of the‘Provincial Environmental Tribunal’.Such tribunalshad the power to give directions, override other laws, and to make regulations particularlyconcerning violations of national environmental quality standards and environmental impact assessments (Anwar 2014).Mainly, the tribunals proposed to reduce the pressure for environmental-related trails on existing administrative infrastructure.Proper implementation of this law is still in progress. Environmental tribunal originated in Lahore (for Punjab Province). This Act also provided the legal ground for the establishment of Provincial Sustainable Development Funds, which provides funds for projects that aimto prevent and minimize pollution. These funds would cover its financial outlays to chargeentities responsible for pollution.

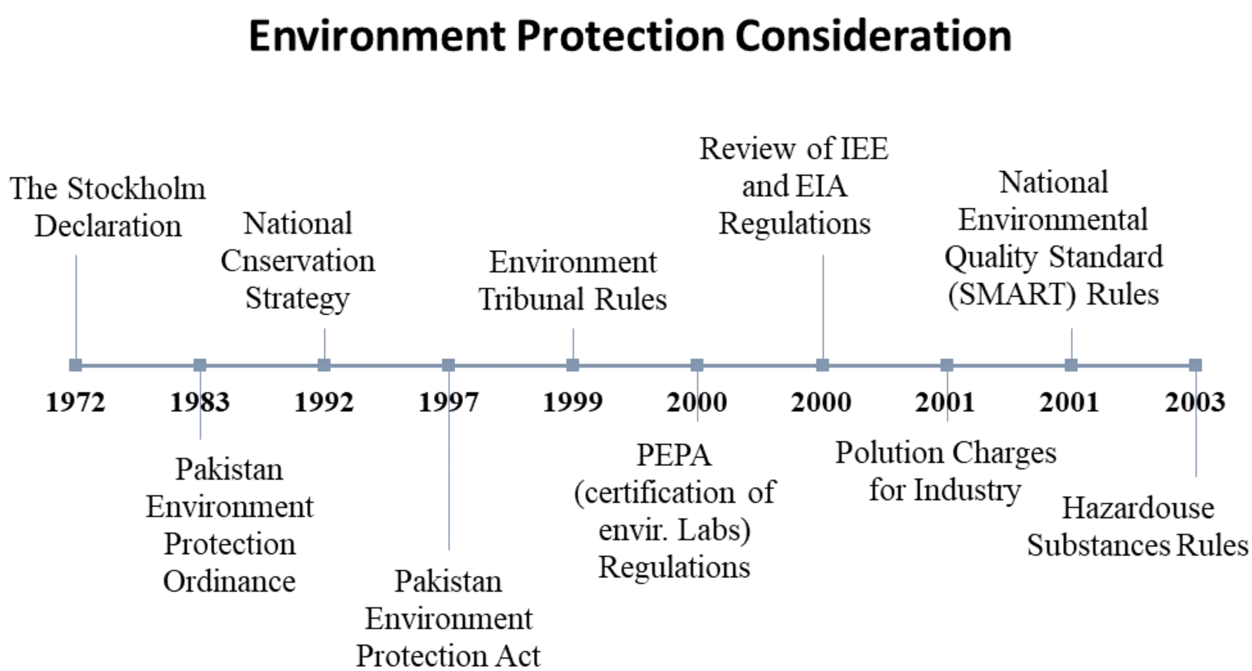

Figure 6.2: Phase II, significant events and endorsement of environmental protection laws

The Pak-EPA amended the existing National Quality Standards in 1993 for municipal and industrial liquid under section 6 of PEPA in 2000. The existing standards for 32 parameters were further revised under three different circumstances. Moreover, the National Environmental Quality Standards (self-monitoring and reporting by Industries) came into effect in 2001.It clarified the procedures and requirements for the submission of environmental monitoring reports to Pak-EPA.

The Pollution Charge for Industry (Calculation and Collection) Rules (2001) delivered the guidelines and procedures for the collection of pollution charges from industries that had established before 1994 (according to sub-section(2) and (4) of section 11, Prohibition of certain discharges or emissions, of PEPA 1997). Industries are responsible for calculating, reporting, and paying for pollution charges to the provincial government on a biannual basis. The pollution charges increased for three years with a rate of 20% (1st year), 40 % (2nd year), and 60% (3rd year). (The approximate calculated value of charges for polluted effluents are Rs.1, 831,680 (year 1), Rs. 3,663,360 (year 2) and Rs 5,495,040 (year 3), under Part 1 of Schedule IV of the 'Pollution Charge for Industry (Calculation and Collection) Rules, 2001').

TheEnvironmental Samples Rules (2001) defined the conditions and limitations for collecting samples(WWF-Pakistan, 2007, p. 18). For new projects, the submission of the Initial Environmental Examination (IEE) and the Environmental Impact Assessment (EIA) to the Pak-EPA became compulsory(Government of Punjab, 1997). The Pak-EPA is responsible for providing the guidelines for IEE or EIA and to review and approve new projects based on the guidelines (Aslam, 2006).

Evident from the above discussion, each industrial unit is legally required to treat its wastewater effluent before discharging into public drains. Every unit should submit a report about the quantity and quality of waste effluents on abiannual basis. The EPA officials can check and monitor anytime and can compare the quality and quantity of effluents according to report submitted by the industry at the time of disposal. Both the federal and provincial agencies have the authority to take samples under certain circumstances for inspection.

The evaluation showed that EPAs failed to apply and execute environmental laws(Azizullah, Khattak, Richter, & Häder, 2011; SPDC, 2012, p. 16).United nation Environment Programme (2013) briefed comprehensively the laps and challenges in environmental legal management in Pakistan (pp. 201-204). Some reasons were brought up after discussing with EPA officials.

> The lengthy process of effluent testing proved to be a significant factor in the failure of laws enforcement. The entire procedure for analyzing the samples, especially for the inspection of liquid effluents,usually takes months to complete. During this inspection process, the industrial units could operate under the same condition (discharging untreated effluents). It causes a primary flaw in defining such rules. (Extracts from personal verbal communication with EPA officials, July 2015)

Moreover, thelimited information stated within laws. For instance, only a few parameters are listed in the NEQS.Enforcement of NEQS lacks because of limited resources, proper equipment, technical staff and absence of training and monitoring programs. The pollution limits stated in the NEQS are too strict for industries toactually comply. Consequently, violators not only noticed but also took advantage of the increasing gap between the environmental laws and the lack of enforcement(Extracts from the in-depth interviews with industrialists and WASA officials, July 2015).

The laws were ineffective because the cost and consequence of violation were significantly lower than the total cost of building a wastewater treatment plant. Eventhe punishment and risk to be caught is less than the average daily operational cost of the wastewater treatment plan. As the jurisdiction of drainage water, groundwater and freshwater resources (Rivers)were not identified,the laws proved to be futile.(Cheema, 1998; OECD, 1997; Sohail et al., 2014; World Bank, 2006)

6.2.3 Phase III: Wastewater management under devolution plan

The government of Pakistan implemented these environmental laws after 2000, which coincided with the decentralization process. The devolution plan 2000, proposed by the National Reconstruction Bureau (NRB), aimed to reconstruct institutions as a decentralized government in Pakistan.Institutions involved with the governance of wastewater management sector faced transitional phases of an institutional change; during this time, the performance of governing institutions associated with wastewater management was affected.

After the decentralization of the government under PLGO 2001, few departments such as EPD, Agriculture and HUD&PHEDwere decentralized (Government of Punjab, 2001). Consequently, the PHED merged with the provincial local government. At the district level, Development Authorities and WASAs were liable to provide the servicesfor the expansion and maintenance of water and sanitation services in urban areas. Additionally, district-level governmentsalso had the authority to set up municipal offices to provide services like sewage networks, treatment plants,effluent disposal. At the Tehsil level (the second lowest level of public administration in local government), Tehsil Municipal Administrations (TMA) would be in charge of supplying these services.For this reason, the PHED staff, which was responsible for water and sanitation services in rural areas, was believed to delegate the responsibilities at the Tehsil level.

An interesting point about the chaos of authorities in consequence of devolution is that the PHED was responsible for the development of new schemes of sewage systembut the operation and maintenance of all these schemes were the responsibilities ofTMA staff(Saleem & Ahmed, 2013). The PHEDs continuedto supply water and sanitation services in rural areas. Beside it, water boards formed in the public sector of urban areas. PHEDs were still working actively in water and sanitation development projects when more than one Tehsil got involved (The World Bank, 2013: pp.10-11). In this respect, all development schemes were proposed from the supplyside with little involvement from the TMA side. In large cities, WASAs established city-district-level agencies to supply water and sanitation servicesin urban areas. In summary, the devolution plan was not uniformly implemented across all area; decentralization varied from area to area.

Later, the provincial government separated WASAs as autonomous bodies after the enactment of 'Punjab Local Government Act 2013'. Consequently, the provincial government was directly in control of WASAs, which were responsible for maintaining all water-related concerns (Yasin, 2015). Subsequently, 'Water Supply, Sewerage and Drainage Regulations 2015' was authorized and implemented by WASA Faisalabad. The FDA proposed these regulations during its 91st meeting on May 21, 2015 (FDA, 2015). The number of parameters for checking the quality of effluents was reduced, and their limits were relaxed compared to NEQS. One main achievement of these regulations is specifying pollution parameters and their range for industrial wastewater discharge. However, the penalties against discharging untreated industrial effluents into public drains were lesscomprehensive and detailed compared to penalties prescribed under PEPA 1997.

Apart from the chaos caused by the devolution plan in public sector administration, a key point of PLGO 2001 was to delegate the authority (District Municipal Officer) regarding controlling the violations againstunsafe disposal of industrial effluents. The Executive District Officer (EDO) is responsible for the enforcement at the district level, otherwise at Tehsil-level Town Officer (Municipal Regulations, Part-C of the First Schedule ofPLGO 2001).The EDOs at the city-district level and district level werealso responsiblefor prosecuting violators irrigating with untreated wastewater.

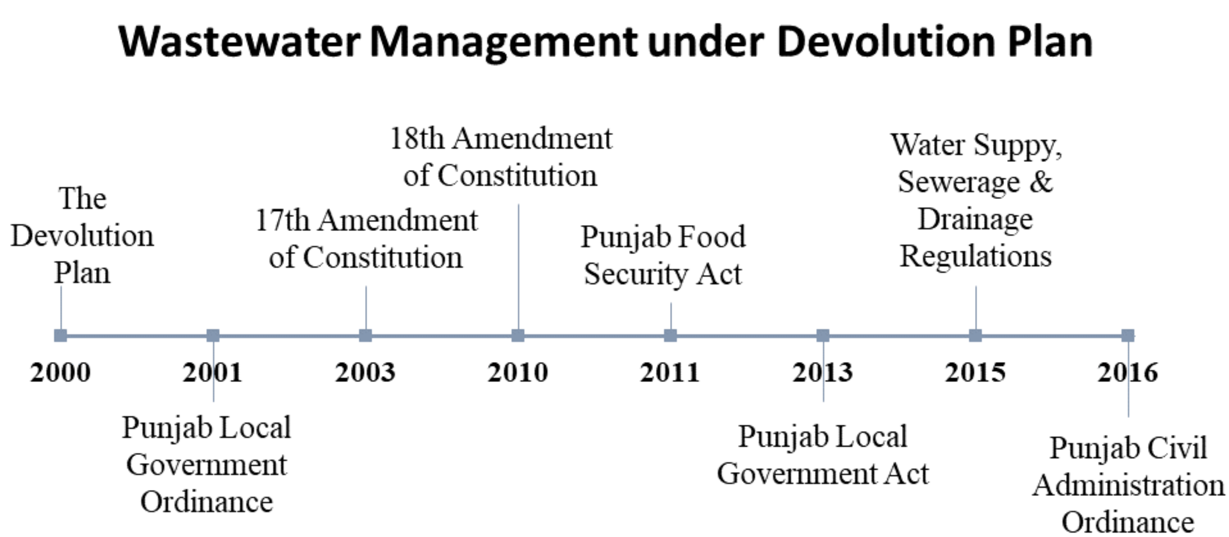

Figure 6.3: Phase III, wastewater management under institutional change

In Figure 6.3, the leading legal endorsements are shown for Phase III. With the 18th amendment in the Pakistanconstitution in effect, the agenda of 'environment protection' shifted from a federal to provincial jurisdiction (details presented in Box 1). As a result, the Ministry of Environment (MoE) devolved and Pak-EPA (previously a part of MoE) became a branch of the Ministry of Climate Change (MoCC) (See Appendix G1). The aftereffects of this transformation limited the financial and legal abilities of environmental protection agencies (both federal and provincial). After an audit in 2013, the Pak-EPA was limited with federal resources. However, the clauses regarding EIA and IEE from PEPA 1997 were still consideredunder the authority ofPak-EPA. The other responsibilities and powers shifted to provincial agencies. As a result, the IEE and EIA for each new project arestill subjected to Pak-EPA. (Correspondent-The Express tribune, 2013)

Box 2: Decentralization in Pakistan: Context, implication, and consequences

The Pakistan Local Government Ordinance (LGO) in 2001 was the first step towards the enforcement of devolution plan in Pakistan. In 2003, the 17th amendment approved to provide six years to implement the devolution plan (2003-2009) in the constitution of Pakistan 1973 (Government of Pakistan, 2003; National Assembly of Pakistan, 2012). Before it, constitution of Pakistan could not provide a legislative ground for the local government as a separate tier within the government. The purpose of the devolution plan was to decentralize the authority and governance of local people by using their resources. Consequently, the local government of Pakistan comprises of three administrative levels such as district, Tehsil, and union council (Ali Cheema, Khwaji, & Qadir, 2005).

Furthermore, the 18th amendment in the constitution of Pakistan approved in 2010 for the permanent implementation of devolution plan. For that reason, the concurrent list of 47 items in the fourth schedule of the constitution abolished including pollution, ecology, industry and planning, and agriculture. These fields shifted to the only provincial governmental jurisdiction. Previously, both federal and provincial government could make rules and regulations for such 47 categories.

Complications occurred factually in regards to jurisdiction and management of natural resources. Such as, if any provincial government wanted to control their natural resources by approving an act or bill within their provincial assembly, the federal government easily superseded such law by passing a federal act. As the highly populated province reserves more seats in federal assembly as compared to other provinces (less populated). Thus, politicians in highly populated province held enormous influence over the administration of other provinces regarding their management and usage of resources. Through the 18th amendment was the step to achieve the provincial sovereignty. (Hussain & Kokab, 2012)

After federal legislation, provincial local government ordinance and acts were also passed and implemented. In Punjab, Local government established under PLGO (2001) and the district government was responsible for all administrative and financial matters at the district level. After the civilian government in 2009, the provincial government again wanted to control the administration of province especially financial matters. Therefore, under Punjab Local Government Act (PLGA) in 2013, the Punjab finance department recovers the right to prepare district government budgets. Later at the start of the fiscal year 2015-16, the power of District Coordination Officer DCO (Administrative head of District)was rolled back and they renamed as the deputy commissioner. New commissioners and deputy commissions directly answered to the provincial government. The local mayor and the chairman of the *Zila Council* had no right to interfere in district administration. The final step was the approval of the Punjab Civil Administration Ordinance of 2016 from the provincial assembly by 30 December 2016.

With this ordinance in place, the provincial government reclaimed its powers to administrate the district government. Recently, it has been said that the devolution plan has rolled back, or that decentralization has been "recentralized."

The devolution plan could not achieve the expected benefits and potentials. Pakistan has a robust civil service sector, which can resist against any institutional change. Hence, civil bureaucrats and major political parties both resisted. The formulation of the plan was set without the consultations of provinces, meaning there was no involvement of civil bureaucracy and major political parties. As a result, only a few provincial tasks—already limited in their scope— had been decentralized. Furthermore, the power and authority of the provincial government concerning administrative or financial issues also further restricted the authority of local government. The provincial government was reluctant to lose control over the local-level administration, and yet it showed no signs of active administrative control over local governments on any specific task. Civil services at district level were lacking; less qualified elected representatives held the bureaucracy accountable. For instance, the selection of DCO and other senior staff required a mandatory correspondence of *Zila Nazim* (political representative at district). The overall morale of officers was low due to the absence of capacity building of the bureaucratic staff.

Sources: (Hussain & Kokab, 2012; Mezzera, Aftab, & Yusuf, 2010;; Saleem & Ahmed, 2013; Shafqat, 2014; SPDC, 2012)

However, with the devolution, there has been substantial progress in the legal framework almost for each sector. For instance, the 'Punjab Public-Private Partnership for Infrastructure Act (2010)' has provided the legal grounds for private investment in development projects. PND has launched some development schemes in wastewater management and urban development sectors. In addition, the provincial government has the capability to control all foreign-funded development projects. To achieve this purpose, a company 'The Urban Unit' was established to satisfy the donor's requirements.

After reviewing the current legislation background associated with wastewater management (Appendix E2), it can be concluded that the legal framework has struggled with lapses in policy implementation. It is very challenging to impose laws entirely. No doubt, progress in a legal framework is a continuous process of amendments. The PEPA (1997) was an exceptional step towards environmental protection legislation. In reality, however, even after 18 years since its approval, PEPA could not adequately monitor nor enforce.

With continuous changes in political scenario, not a single policy could uphold for so long. Each government selected its policies and strategies, most of which were heavily influenced and shaped by foreign consultants. Therefore, the consent of local masses either was absent or ignored. The role of the political representatives is controversial, depending on the region. Every so often, political representatives participated in lawmaking, but even then, they only participated for their own interests and benefits and not for the public. Confusion about the transitional stages of an institutional change also influenced the performance of public agencies. Far from delivering the expected benefits and potentials of devolution, the system ultimately collapsed. Devolution has had far-reaching implications for the implementation process.

During the devolution phase, policy formulation mainly highlighted the public welfare and interest. In the following section, such policies and their flaws are reviewed.

6.2 Policy overview

Policy formulation is a fundamental element for consistent decision making by any organizational personnel. Without any formally documented policy, staff members have no guidance on how to make a decision. At the national level, sustainable wastewater management needs proper coherent policies such as environmental policy, agricultural policy, sanitation policy, public health policy, and industrial policy.

For the first time in 2005, the National Environmental Policy was formulated to conserve, protect, and restore the environment of Pakistan. It incorporateda sustainable development agenda forfuture planning and policymakingplatforms whilesuggesting recommendations to the federal and provincial governments. At the same time, the provincial government could further formulate policies, plans, strategies,and programs using its grounds. Pakistan's international commitment, along with national environmental targets and awarenessrising of local community for environmental quality,was also included in the policy formulation. The primary emphasis was oncapacity building in the public sector and other stakeholders through aparticipatory approach. Sound institutions on legal, technical and administrative grounds performtheir role as crucialplayers for sustainable development. Environmental issues concerning Pakistan, including pollution of freshwater bodies, environmental degradation,and the cross-sectoral issues were also included in its framework of directions. (Ather , 2005; Ministry of Environment, 2005)

The next steps were to prepare the National Sanitation Policy (Government of Pakistan, 2006) and National Drinking Water Policy (Government of Pakistan, 2009)to meet the Millennium Development Goals (MDGs). The main goal of national water and sanitation policies was to meet the national targets set by MDGs. Improvement in water and sanitation condition is directly linked to public health. Preparingsanitation facilities, as well as making safe drinking water available, became the first agenda of civil administration at every level. The focus on the proper disposal of sewage was no longer a matter of urgency and was quickly pushed to the back burner (WWF - Pakistan, 2007). The poor harmonization between the ministries and the authorities led to a lapse of formal guidelines in drinking water and sanitation sector.

Under the constitution, the provincial government has the responsibility to formulate policies in these sectors.Nevertheless, due to heavy pressure from the international community/organizations, the federal government was involved in developing policies and setting guidelines through the MoE;a similar situation prevailed for formulating quality standards for drinking water. However, the ministry of health has the responsibility for setting and monitoring drinking water quality standards at the national level. The lack of coordination between ministries and other related authorities affected the progress of the policy formulation process. Eventually, 'Quality drinking water standards' was published in 2007 by the Ministry of Health. As stated by a report, these standards have not been enforced since 2008(Daud et al., 2007). Unfortunately, any autonomous regulatory organization was not there to execute these policies. For this, the MoE established a national drinking water committee in 2009.

Later, the National Industrial Policy was launched in 2011, which provided guidelines for industrial development (Government of Pakistan, 2011). The prime objective was to increase competition and add value to the industrial sector. The focus was to transform Pakistan into "A factory for the world rather than a shop." However, the problem was that industrial policies and environment policieswere always disconnected from one another. Environmental degradationdue to unplanned industrial development was not addressed at any strategic planning level (Aftab, Ali, Khan, Robinson, & Irshad, 2000; Hussain & Ahmed, 2012).

Sound national agriculture policy and national water policy that target food security, sustainable agriculture development, and environmental conservation, are still in progress. The guidelines for the natural resources extraction and criteria for appropriate input use are not available in Pakistan. (State Bank of Pakistan, 2009)

After discussing the policies and policy formulation process as mentioned in the previous sections, one can conclude that the whole policy-making or formulation procedures were mostly at the top management level. Top-level management decided the guidelines for subsequent decisions throughout the organization (vertical policy formulation). Therefore, there is a need for horizontal policy-making in sustainable wastewater management across sectors. As, 'horizontal policy formulation' can be referred to as coherent policymaking among two or more organizations that have the obligations to deal with some specific situation. Likewise, for sustainable wastewater management, many of the targeted objectives are complex and connected with different departments.

Another main lacking in the policy formulation process is the absence of local stakeholders' involvement. Farmers, industrialists, EPA officials, and other stakeholders want to participate in policy formulation, but there is no platform available. Industrialist organizations addressed their concerns about environmental enforcementto the DCO. Now, they also want to take part in policy formulation(personal communication with industrialist, July 2015). However, the problem is the absence of a local platform for policy formulation. As policies were only plannedat the top management level, they eventually failed during implementation.

6.3 Role of 'Foreign Hand'

After reviewing the legal progression in Pakistan, one can acknowledge the role of the international community over the local administration.As already mentioned, the Stockholm Declaration influenced the Pakistan government to examine the environment conservation in Pakistan. It was a prime instance ofinternational stimulus in the environment sector. As an outcome, the government of Pakistan focused towards the preservation of environment during the early 1980s. Likewise, it was also through international influence at the conferences and declarations that contributed to the development ofNCS (National Conservation Strategy) at the national level.

Afterwards, the Earth Summit (United Nations Conference on Environment and Development) declared 27 principles concerning the environment and development in 1992, and Pakistan ratified all of them. Pakistan also signed the Framework Convention on Climate Change (UNFCCC), which further transformed into the Kyoto Protocol.Accordingly, Pakistan has to prepare a sound institutional setup for formulating and implementing regulations, which can lead to sustainable development and a continued follow-up on international agreements.

Ratification of all these international agreements was not compulsory. Most of the time, any country signs or ratifies such multilateral agreements for its own sake of interest. In the case of Pakistan, ratification of all these MAEs became compulsory to get the GSP Plus status. The European Union offered 'Generalized Scheme of Preferences (GSP) Plus status' for developing nations who cannot compete for the international markets.

For this reason, in 2013, the government of Pakistan applied for GSP Plus with the European Union (Haque, 2014; Mustafa et al., 2014;Government of Punjab, 2015; Government of Pakistan, n.d.). The application process for GSP Plus required that the applicant country must sign,ratify and efficiently implement all the27 international conventions in regards to the environment, good governance, human rights and labor rights. Among them,15 Multilateral Agreements (MEAs) were about theenvironment, all of which Pakistan had to ratify to gain access to international trade.

Ultimately, the EU granted Pakistan the GSP Plus statusin January of 2014, which allowed zero duty access and preferential rates for the majority of Pakistan's exports. It would avail Pakistan to tariff concession opportunities offered by the European Union for the export of its products to European markets,which benefited the local industry.

> International export standards can affect the export volume, but industrialists export using the quota under GSP plus status. (In-depth interview with the owner of M.A. Textile Private Limited, on July 2015, describing the role of GSP plus)

After ratifying all the above-mentioned international agreements, it has been the responsibility of thestateto implement such sanctioned agreements. Therefore, a particular wing in the federal government, the Ministry of Climate Change (MoCC), has been specifically dedicated to carry out such implementations.

Furthermore, the EPD nominated a significant administrative department for the seven International Conventions and MEAs[7]that are relevant to the environment (MoCC website).

Implementing all the above-mentioned MEAs would require proper organizational setups. The institutional review showed such a real functional organizational setup is either missing or merely written on papers. Therefore, there is no mechanism to put MEAs into practice.For example, all the complaint files from the public about the environment are absent(self-assessment). Only one multilateral agreement, the Stockholm Convention on Persistent Organic Pollutants (POPs), to prohibit the use of certain pesticides such as dichloro-diphenyl-trichloroethane (DDT), had been strictly followed(Ministry of Environment, 2002). The other strict ban was on producing and using black plastic bags.

6.4 Gap analysis of existing legal and institutional framework

The discussion above revealed that regardless of all legislative and institutional promulgation, it could not be efficiently implemented (Government of Pakistan, 2002: p.16). Failure of enforcement was partially due to the flaws within alegalframework, which favored violators and their non-compliance. In-depth interviews and focus group discussions with implementing agencies and with other stakeholders also elaborated on the following gaps in the legal framework.

6.4.1 Flaws in thelegal framework and implementation process

The comparison between the legal proceedings regarding the offense of polluting natural resources could convey an outlook of gaps in implementation processes (Faruqee & Colema, 1996: p. 38-41). Nevertheless, gapsstill exist in the legal framework. Currently, three different penalties for the dumping of untreated wastewater into public drains have been authorized, such

7

1. 'Kyoto Protocol to the United Nations Framework Convention on Climate Change', Pakistan accepted on January 2005, (Fully compliance with the obligations and mandatory requirements of the Convention, No issues perceived by the relevant international organization/monitoring body on implementation of the convention on part of Pakistan, No report is pending at moment)
2. 'United Nations Framework Convention on Climate Change' (fully compliance, no issue, no pending report)
3. 'Montreal Protocol on Substances that deplete the Ozone Layer' (fully compliance, no issue, no pending report)
4. 'Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their disposal' (fully compliance, no issue, no pending report)
5. 'Stockholm Convention on Persistent Organic Pollutants Convention on Biological Diversity'(fully compliance, no issue, no pending report)
6. Convention on Biological Diversity (5th National Report is due by March, 2013)
7. Cartagena Protocol on Biosafety (Two Reports is due on part of Ministry of Climate Change)

as PEPA 1997, PLGO 2001, and WASA Sewerage and the Drainage Regulation of 2015 (for details see Appendix E). Unfortunately, all three legislations have gaps when being enforced.

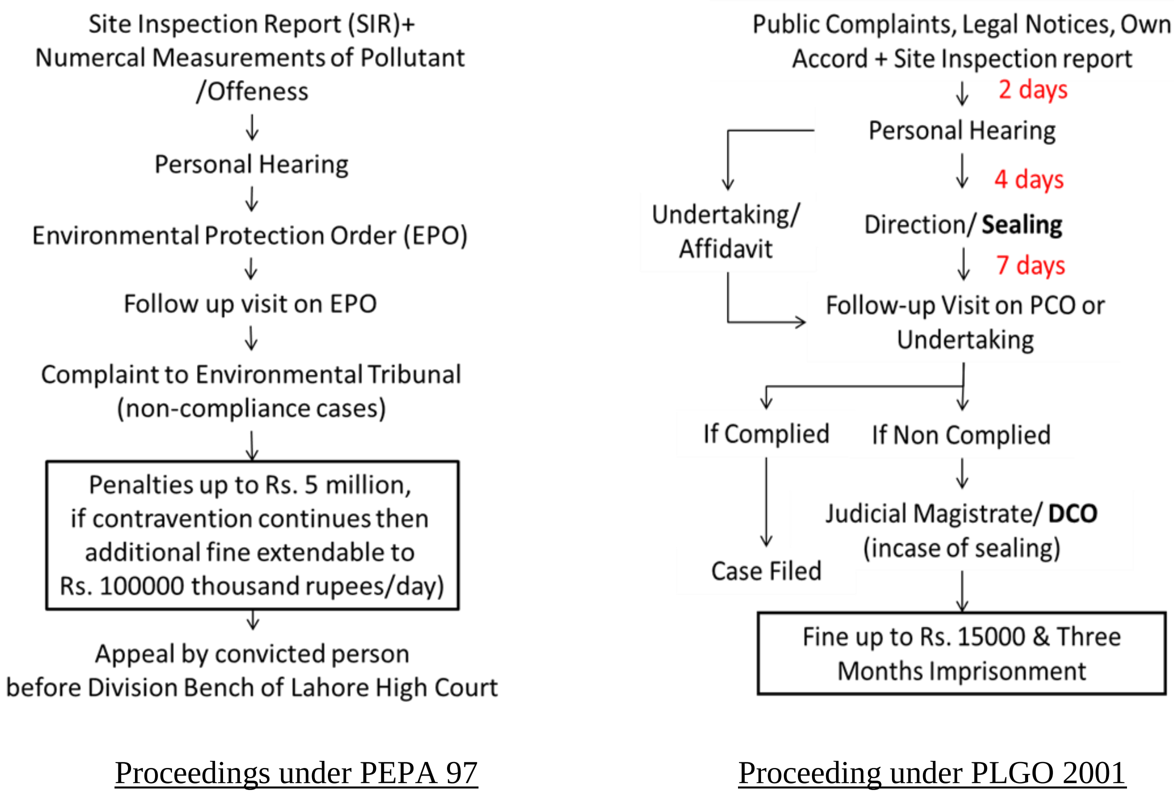

Figure 6.4: Comparison of legal proceedings
Data source: EPA, Faisalabad office

The comparison of legal proceeding between PEPA 1997 and PLGO 2001 is depicted in Figure 4.8. Under PEPA 1997, punishments (fine and imprisonment) are higher than those of PLGO 2001. PLGO 2001 is more efficient because of its capability for prompt action.

According to 146-D of PLGA 2013, an EPA inspector, with the help of the district government, the police department, or both, can effectively control the quantity of discharge and air pollution on the spot. However, both laws cannot address the quality issue efficiently because of the prolonged process of testing the effluents.

> By enforcing 146-Dof the ‘Punjab Local Government Act of 2013’, the EPA authority was able to control issues of discharged wastewater in quantity but not quality. In case of excessive discharge of wastewater, the city district government actively assists EPA officials. As District Coordination Officer (DCO), he possesses the authority to suspend industrial units for violating the rules. Such cooperation also proved useful in controlling air pollution. (In-depth interview with district director EPA describing the enforcement of the law, June 2015)

The NEQS (SMART) Rule,2001provides the list of parameters for a specific industry, although the permitted levels for these parameters were missing. On the other hand, 'WASA Sewerage and the Drainage Regulation of 2015' provides a limited list of parameters with permitted levels. However, compared to pollution charges suggested under'Pollution Charge for Industry (Calculation and Collection) Rules, 2001, the prescribed punishment (fine and imprisonment) for WASA Sewerage and the Drainage Regulation of 2015 is low and minimal (See critical assessment, p.6-7 and gap analysis, p.8 by OECD, 1997)

> Evidently, the penalty imposed on violators through a court judgment would be too small compared to the social cost paid by the environment and community.For instance, if the responsible party faced the tribunal hearing with the charge of violating the environmental law and found guilty, the tribunal could charge a maximum fine of 25,000 rupees. Nearly, it is equal to the daily operational cost of a wastewater treatment plant.Average daily operational cost of wastewater treatment plant could not provide from any industrialist. Whereas EPA official reported that it would be at least about 10,000 rupees. Not surprisingly, the party prefers to pay the fine as opposed to installing the treatment plant. (personal communication with EPA officials, July 2015)

6.4.2 Jurisdiction of natural resources

A legal framework review disclosed that the jurisdiction of drainage water (either treated or not), groundwater and freshwater (river) is not clear. A detailed study is briefed here about the legal authorities to control these resources legally.

Primary, the WAPDA (a federal agency) administrates the large hydropower structure at the national level. Then, Punjab IDD has the authority to control canal water supply within the entire province. IDD also maintains the infrastructure of stormwater drains and can take legal action against a party who damages the infrastructures. Based on the quantity of discharge (without any consideration of the quality of discharge), IDD allows individuals to discharge effluents by imposing a drainage fee. Moreover, IDD has the authority to control the groundwater extraction (whether or not the area is categorized as a 'problem area due to waterlogging and salinity'). At watercourse level, farmer's organizations (FOs) are responsible for maintaining irrigation and drainage issues.

Nevertheless, WASA has possession of the sewage infrastructure and legally owns the collected wastewater through its public drains. If anyone damages the public infrastructure and/or stormwater drains (WASA drains, not IDD drains), WASA possesses the right to file a lawsuit against the responsible party. WASA also claims the property right for treated water from the wastewater treatment plant.In brief, jurisdiction of water management is alienated chaotically.

Another issue is the absence of regulationsregarding water as a limited natural resource and as an economic good. As a consequence, canal irrigation water is still underpriced (highly subsidized) in Pakistan (Sahibzada, 2002). Sustainable wastewater management is also a part of water management. Considerable debate has taken placeon the controversial status of water (either priced or not). No doubt, water is a limited resource and becoming scarcer day-by-day. With this frame, wastewater is a negligent source that is increasing day by day. Ardent ignorance of such a problem would further worsen the extent of the problem in the future.

The above-stated jurisdictions of water resources cannot explain the environmental and public health threats from poor wastewater management. An industrialist or a polluter who is dumping untreated wastewater into surface water drains or river is destroying natural resources for his economic benefit at the cost of community and environment. Likewise, irrigating agricultural fields with untreated wastewater adversely affects soil, subsoil water, and public health. Moreover, extracting groundwater to dilute untreated industrial effluentsis a threatening concern. There was no consideration given for the exploitation of groundwater resources. Ultimately, natural resources like soil, subsoil water, andfreshwater resources face the tragedy of commons. Everyone considers his right to use and exploit the natural resources for personal interest.

Comprehensively, to address the tragedy of the commons, the most suitable solution states that the user or polluter has to pay the cost to the community. Identifying who is benefitting and who is adversely affected, estimating losses and benefits in monetary terms, imposing compensation by the polluter, and rehabilitating the natural ecosystem are main hurdles to implement the environmental regulations, especially in the absence of real markets for these resources. One can conclude that the entire legal framework should be as simple and as well defined as it can be to enforce the laws; otherwise, the polluter gets the benefit of ambiguity.

6.4.3 Formal rules andinformal (working) rules

Institutions are referred to as "a set of working rules" which explains the responsible authorities to take action within the specific arena, permitted action, the procedure to follow, available and prohibited information, and aggregated rules to utilize (Ostrom, 1990: p. 51). Rules described by laws and regulations are termed as 'formal rules.' Working rules and formal rules may or may not resemble each other(Cole, 2014: p. 27). In the ideal situation of good governance, both rules should closely ally with each other.(see details Ostrom, 1990; Ostrom, 1992)

In the wastewater management sector, differences existwithin the governing organizations based on their formal rules and working rules (Appendix E4). For example, WASA is legally responsible for the provision of sewage infrastructure—with pollution control measures—only as far as disposing municipals effluents away fromthe urban area. Accordingly, all untreated mixed municipal effluents are dischargedinto stormwater drains (managed by the IDD). IDD mainly directs the handling of drainage issues in canal-irrigated areas, especially during floods. The environmental concerns caused by mixing untreated industrial effluents with fresh water bodies and polluting the ecosystem are not included in the set of working rules for such administrative organizations. Conflicts of interest among public institutions responsible for wastewater management were found. These differences or conflicts create a situation when one can say that the law does not rule the system.

6.4.4 Failure of command and control approaches

The choice between economic development and environmental conservation from an industrialist's point of view is not hard to assess. Traditionally, the 'Command and Control Policy' was adopted to enforce environment conservation laws and to monitor the violators (Faruqee & Colema, 1996). As, "Command and control policy refers to an environmental policy that relies on regulation (permission, prohibition, standard setting, and enforcement) as opposed to financial incentives, that is, financial instruments of cost internalization." (Organization for Economic Co-operation and Development [OECD], 2008, p.83)

After a close examination of all available information regarding quality analysis reports of wastewater drainage in Faisalabad, it was concluded that the previous 'Command and Control Policy' failed to regulate and minimize pollution.

The main hurdle for an effective implementation of legal framework is establishing strict limits of national standards. The industrialist objected to the strict appliance of NEQSat once and further commented:

> These standards are the copy of international standards and are not feasible in the real circumstances. NEQS should reset with the consent of industrialists. A time frame should offer to industrialist for implementing the regulations. Application of schematic plan should be gradually adapted. Otherwise, the wheel of industrial production will cease to work. (In-depth interview with President of Faisalabad Chamber of Commerce, July 2015)

Likewise, a gradual restriction of NEQS could help the industrialists become accustomed to the restrictions. An alternative policy could implemented, in which there are economic incentives to self-monitoring industrial units.

6.4.5 Under-resourced laws enforcement agencies

The command-and-control approach requires a continuous check on the system. However, limited available resources (inspector, vehicles and scientific technology) of implementing agencies hinder enforcement process, if at all. For instance, the central EPA authority, in charge of regulation and enforcement, faced a lack of human resources (technical staff) and up-to-date technology(Government of Pakistan, 2005).

> At the district level, there were only four inspectors (each one provided with a motorbike) responsible for checking all 25,000 industrial units. The availability of mobile laboratories for testing the discharges effluents on the spot was lacking. Such advance level technology would requireexamining and accessing the water pollution level right away. (Personal communication with EPA respondent, July 2015)

At the district level, EPA does not work as an autonomous agency. It cannot propose or implement any reclamation project within the areas. The head office is under provincial management, including all financial matters. For its operational budget, EPA entirely depends on the provincial finance department and has to compete with other provincial-level development agencies for budget allocation. Since 2010, there is a continuous reduction in the developmental budget of environment protection department (Government of Punjab, 2014, p. 431-436). Moreover, there is no separate account for environmental penalties and pollution charges as Provincial Sustainable Development Funds, which was proposed in PEPA 1997. Preferably, PEPA 1997 recommended collecting penalties and pollution charges in a separate fund, which should further be utilized for rehabilitation services. Yet, this is not established. All penalties and pollution fees are deposited to the governmenttreasury without any categorization. It is possible that a new development scheme can propose from any department. However, the approval of each scheme or project has to follow the recommended lengthy procedure with PND.

A comparable condition also has prevailed in WASA, Faisalabad. WASA constantly faced budget deficit (financial instability) due to partial recovery of revenues. (see Fichtner, 2006; JICA, 2016; GHK, 2010& 2011). On one side, domestic consumers are reluctant to pay the water supply and drainage fees due to poor performance. On the other side, commercial and industrial users do not pay precisely according to their utilization. Theywant to pay minimal charges and justify their behavior by claiming that water is a God-gifted resource. The revenue directorate of WASA is still applying tariff rate according to ‘tariff 2007’, in which industries are paying on the timing basis.A flat tariff rate has been fixed for three different categories depending on the averagedischarge of an industry. Therefore, such drainage charges were not calculated based on precisely discharged quantity. Similarly, such drainage charges also did not consider the quality of discharge. (Khattak, 2011)

The recruitment qualification for officials in engineering and O&M wing is an expert in civil, mechanical, or electrical engineering (FDA, 1990). Generally, most of WASA officials are the civil engineering technical staff to supervise construction work and regulate the system. There continues to be a shortage of human resources like inspectors, data analysts, researchers, environmentalists, economists, managers, and planners who can sustainably address the issues of sewerage and drainage.Recently, the primary issue within WASA management has been the aging of permanent staff members while the newstaff members are appointed on a contract basis (Fichtner, 2006).

> The recent improvement of drainage infrastructure including technical equipment, previously missing due to little operational and maintenance expenditures, was a direct result of foreign investment (JICA assistance). Consequently, a check and balance system of WASA operations has drastically improved during the last few years.Misuse of funds is unfeasible;qualified technical staff members have been recruited to improve the efficiency of the entire system. (Extracts from in-depth interview with WASA officer, July 2015)

6.4.6 Confusion due to transitional stages of institutional change

Due to the transitional stages of a devolution plan,the liabilities and jurisdiction of the administrative organization were left in utter confusion. In fact, the administrative responsibilities between local and provincial governments were unclear, creating confusion among institutions about their liabilities(SPDC, 2012). Such poor coordination and lack of communication between provincial and local governments ultimately worsened the situation into chaos, for example, the coordination between EPA-Pak (Federal) and EPA (Punjab). There was no official link between them after the 18^{th} amendment. EPA-Pak is still responsible for IEE and EIA for each new project (owing to PEPA 1997), whereas the districtoffice of EPA is only concerned with other aspects.Confusion about the jurisdiction of responsibilities from a devolution plan also affected their performance(Khattak & Shahida, 2014).A similar situation between PHED and WASAs within different areas also exists.

6.4.7 Absence of a local pressure group in the laws makingprocess

The absence of local pressure groupsand the lack of public awareness in the lawmaking process proved to bethe main hurdle forenforcing existing laws. Mostly, people are unaware of their legal right to a clean environment. Many ofsuch legislation were formulated because of pressure and influence from the international community. These legislations, perhaps, would have been appropriately implementedif they reflected thepublic demand through a judiciary trial.

Local unawareness about thehuman environment can be addressed by appraising the judicial proceeding for the right to clean environment. Only two court cases were filed for the right of a clean environment. In the first case (a milestone), Shehla Zia complained in 1992 to the Supreme Court against the construction of a grid station in the residential locality without the consent of residents by WAPDA. The Supreme Court accepted her right tothe clean environment under article nine in the Constitution of Pakistan (Preston, 2005). The other court case was filed in Karachi by a social organization. The 'Karachi Administration Women's Welfare Society' complained to the Supreme Court concerning the use of storm water drains for industrial drainage and water pollution by industrial discharge. Correspondingly, the Supreme Court gave direction for mitigation measures.(IUCN Pakistan, 2005)

After discussing theright to clean environment with local masses in Faisalabad, it was observed that the local community was lacking in understanding its rights and responsibilities regarding the environment. Public knowledge on existing legal grounds was mostly based on some other's opinions, spread by word of mouth. Few of them—representatives of judicial actors—mentioned about hiring international legal consultancy firms. Such firms formulate laws after copying some other countries with minor changes. In due course, formulated laws will come into effect without real considerations. Ultimately, judicial actors including lawyers will take advantage of people's ignorance of their financial benefits.It is practically impossible for common people to exercise his right through the legal process.

6.5 Summary and conclusions

A critical overview of legislation revealed the loopholes in the legal framework that further weakens enforcement of previously mentioned laws.The jurisdiction of water should be legally comprehensible among industrial, agricultural, domestic, and mining sectors. Among them, ‘environment’ is also a legitimate user of limited freshwater resources, and its “rights” need to be considered too. A comprehensive policy by the state can only address the conservation and utilization of water resources (including groundwater) in a sustainable way. Any other use except for primary purposes would first need the approval by the state.

Formal laws for establishment and working of institutions exist, but proper coherent policies were missing. PEPA 1997 was the first milestone for the availability of environmental legal framework but could not correctly enforce, even 18 years after the promulgation, environmental laws. There should be a gradual restriction of NEQS specified for each industry; then, pollution tax based on the quantity and quality of wastewater effluent would be acceptable for industrialists. To conclude, the legal framework is lacking.For instance, the jurisdiction of drainage water, groundwater could not be clearly identified. Responsible agencies and organizations could not properly enforce regulations due to a lack of resources (both human and financial). Moreover, transitional stages of an institutional change (decentralization) confused departments regarding jurisdiction and responsibilities. The poor implementation of laws could be attributed to the absence of a local platform to advocate for people’s rights. Local unawareness about rights and responsibilities also influenced the poor implementation of laws and regulations. Transparency, trust, and reciprocity within the community are the keys toproper CPR management. However, the policymaking procedure never involved any local consent or demand, which jeopardized transparency as well as trust and reciprocity.After reviewing the entire policy formulation procedures in Pakistan, there is a persistent communication gap between the policy makers and local researchers.

7. CHALLENGES IN WASTEWATER MANAGEMENT

This chapter focuses on exploring the challenges faced by the wastewater management sector in Faisalabad. First, the main objectiveof sustainable wastewater management is explained in Section 7.1. It further clarifieshow wastewater management can be regarded as a social/governance dilemma in Faisalabad. Section 7.2 describes the external variables affecting the action arena (wastewater management) charted by the IAD framework. Third, Section 7.3 analyzes the action situation. Based on the information collected through qualitative techniques, participants, positions, and actions of stakeholders in the framework are identified (7.4). The last and most important section elaborates the overall challenges inthe wastewater management sector of Faisalabad (7.5). These challenges areidentified through evaluative criteria for analyzing institutions using qualitative data.

Table 7.1: The targeted research question following the IAD framework

Research questions	Section
1- Wasthe sustainable wastewater management a social/governance dilemma? (Define the sustainable wastewater management objective)	
What were the objectives of policy targeting sustainable wastewater management? How did observed outcomes (chapter 3)differ compare to policy objectives? Which outcomes were satisfactory? Which are not? Which outcomes were most important?	7.1
2- What was the nature of goods and services linked to wastewater management?(Analyze Physical and Material Conditions)	
What was the nature of the activity (wastewater generation, collection, treatment, irrigation, and dumping)? How was the good or service (drainage facility, pollution control, wastewater irrigation) provided/ produced? What physical and human resources were available to provide and produce this good or service? What was the scale and scope of provision and production activity?	7.2.1 7.4 3.2
3- What were the attributes of community in Faisalabad? (Analyze Community Attributes	
What knowledge and information did participants (stakeholders) had about the relationship among policy-oriented strategies, actions, and outcomes? What were participant's values, beliefs, and preferences towards achieving the strategic goal of others as well as themselves?	7.2.2
4- How did the working rules of institutions affect the desired outcomes?	
What were the working rules of institutions? (Analyze Rules-in-Use)	7.2.3 Appendix
5- What was happening within the action situation of wastewater management in Faisalabad?	7.3
(Integrate the Analysis) What were the positions/roles that actors play in wastewater management at different level of analysis?	7.4

Research questions	Section
Who were the participants, either individual, group of individuals or organization? What was the level of control (authority)of each participant? What were the actions of participants and how are these actions linked to outcomes? What information about the mismanagement in wastewater sector was available to participants? 6- What kind of interaction between institutions and individuals existed? (Analyze Patterns of Interactions)	
7- What were the challenges in sustainable wastewater management in Faisalabad? (Structured conceptualization) (Analyze Outcomes)	7.5

Table 7.1 explains the targeted research questions using the IAD framework for institutional analysis. These questions provide the guidelines for analysing the interactions among institutions and individual. (Hence, the specific terminology ‘appropriator,’ ‘provider,’ ‘rule in use,’ ‘action arena,’ ‘working rules’ and so on utilized in the text has postulated and defined by Ostrom, 1992).

The information was collected from stakeholders associated with wastewater management through qualitative data collection techniques.

7.1 Wastewater management as a social/governance dilemma

The sustainable wastewater management and theoreticalframeworkhave already been discussed in Chapter 2.3. Briefly, sustainability refers to the utilization of limited natural resources for production processes in such a way that future generation will not suffer from the availability of resources (Kuhlman & Farrington, 2010). In a broader spectrum, sustainable development considers economic, environmental, and social-cultural developmental aspects.Sustainable development means merely that zero or minimal level of adverse external effect on the environment, humanity, and wellbeing associated with any human activity (Dimitrov, 2010). A big debate in recent years has taken place against the environmental exploitation of resources just to achieve economic benefit. Narrowing down the context of sustainable development, the significance of wateris obvious. Undoubtedly, sustainable sanitation and wastewater management are ways to achieve sustainable development. Andersson et al. (2016) explained the term “sustainable sanitation and wastewater management” which already mentioned in Section 2.3.3. Concisely, sustainable wastewater management refers to less pollution and a more efficient system of wastewater management services.

Recently, the goal of all administrative organizations has focusedon good governance and sustainable development. The term ‘governance’ is defined as “the exercise of economic, political and administrative authority to manage a country’s affairs at all levels. It comprises the mechanisms, processes and institutions, through which citizens and groups articulate their interests, exercise their legal rights, meet their obligations and mediate their differences" by UNDP (1997) (Hill, 2013, p.17).

The policies were aimed to promote minimum pollution and maximum resource recovery (regarding water withdrawal and usage). The only option to achieve these targets is sustainable management (socio-economic, environmental, and institutional). Here, 'management through institutions' can be interpreted as 'governance.' An efficient system of governance is required to achieve sustainable development (Ahmed & Basit, 2012).

A failing administrative system regarding wastewater management in Faisalabad is a governance dilemma (Chapter 4). Industrialists exploiting natural resources came in the form of either production processes or waste disposal. Such industrial activities create positive (industrial products) and negative (pollution) externalities to the ecosystem including communities and natural resources. The domestic and commercial sectors are also releasing wastewater into the local sewage system. In the absence of proper treatment, such drainage causes water pollution. Considering a"fair" trade between industrialists and sewage services, with the suffering communities, it has been suggested that the social and environmental cost (cost of negative eternality) should be included in the price tag of any industrial products and provided services. However, it is hard to calculate this cost, not only for the industrialists but also for the public agencies. Another option is for the polluter to compensate the affectedparties (communities and the environment). This compensation can then be utilizedto rehabilitate communities (poor health) and the environment (exploited natural resources). This is the desired policy goal to achieve sustainability.

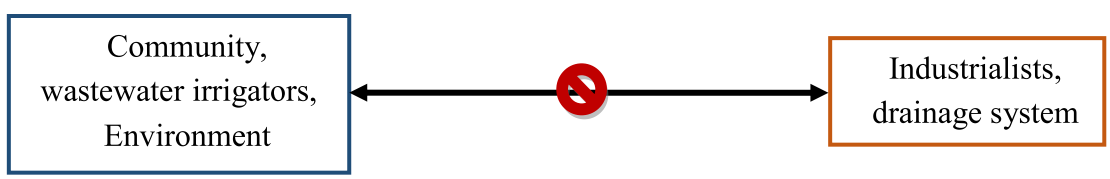

Figure 7.1:A deficient sustainable wastewater management

The direct link between both parties is not feasible due to obstacles such as theabsence of markets and platform for negotiation, time lag, and the estimation of hidden values (Figure 7.1).In the absence of such a platform for negotiation between polluter (benefited) and sufferer (current and future generations), the limited freshwater resources would go extinct.

Here, it is important to discuss the significance of institutions in the context of this study. Not all commonly used goods and services face the issues of crowding out or extinction. Institutions and public administrationsare involved inthe sustainable use of goods and services in case of pollution or extinction (Ostrom, 1998). The term 'institution' has been defined in numerous ways. Within our context of study, the most suitable definition is "Institutions are the prescriptions that humans use to organize all forms of repetitive and structured interactions including those within families, neighborhoods, markets, firms, sports leagues, churches, private associations, and governments at all scales" (Ostrom, 2005, p.3). Specifically, "Institutions promote positive outcomes by helping actors resolve 'social dilemmas' produced when individually rational actions aggregate to produce socially irrational out- comes" (Imperial & Yandle, 2005, p. 494). Dilemmas always exist even in the perfectly organized systems (Ostrom, 1998).

The analysis of the institutional framework of any region/country with regards to some specific aspect would guide the role of the state and existing institutional behaviors within its social circumstances(Ménard & Shirley, 2011). Specifically, the institutional framework is a composite of the rule, informal constraints (norms of behavior and conventions), and their enforcement characteristics (North, 1990).As institutional behavior are hidden and unseen, it is hard to overview and analyze them. The Institutional Analysis and Development (IAD) framework was developedinthe 1970s toinvestigate the common-poolresources (CPR). Such as, the IAD framework was conceptualized to look at the water supply and safety services in metropolitan cities. The IAD framework helped to analyze the interaction among society members and public organizations. Likewise, a number of case studies reviewed and conceptualized a general framework. It helps institutional (social or political scientists) analysts to understand the linkages between communities and outcomes across a diverse set of institutions (Ostrom, 2005a, 2010).

The IAD framework can be considered as "one of the most developed and sophisticated attempts to use institutional and stakeholder assessment in order to link theory and practice, analysis and policy"(Aligica, 2006, p. 89).

As, it was already mentioned, that the idea of the IAD framework was proposed to analyze the institutions and the governing issues withinthe commons. The IAD framework also has been applied to analyze different public administrations in metropolitan cities such as electric power company (Bäckman, 2011), forest land (Bravo, 2002), irrigation system (Ostrom, 1992), fisheries (Imperial & Yandle, 2005), soil and water conservation (Nigussie et al., 2018), public administration (Dimitrov, 2010), resource recovery in wastewater sector (Evans, 2016) and for policy analysis and design (Polski & Ostrom, 1999). Such institutional analysis is based on information collected using qualitative techniques such as focus group discussions and individual interviews with stakeholders. Conceptually, it is problem-driven research (a case study approach). The 'Framing Inquiry'allows one to explore a particular problem and, using theoretical predictions, to find a solution (Ostrom, 1990). In doing so, the theoretical way of explaining problems may affect the general understanding of the underlying mechanisms. The purpose of this study is to explore the reasons for wastewater sector mismanagement in Faisalabad. These reasons automatically provide grounds for future policy outline. In this study, the analytic approach was applied to identify gaps in the governance system of wastewater management that are actual reasons behind the unsustainability.

The following section elaborates the institutional analysis for wastewater management in Faisalabad. It is mainly concerned with interactions in the action area, where interactions between wastewater-related institutions and individuals produce outcomes. However, before investigating the action arena, there is a need to look at exogenous variables or the external world that can affect the action arena as already mentioned in Figure 2.9.

7.2 External/exogenous world

The external/exogenous variables of the IAD framework are comprised of biophysical conditions, attributes of society, and rule-in-use (see Figure 2.9, 3.8, and 3.9). These exogenous (external) variables include physical characteristics (resource unit), norms, cultural attributes, and working rules (Ostrom, Benjamin, & Shivakoti, 1994). In the following sub-sections, the external context for wastewater mangement in Faisalabad is discussed in details.

7.2.1 Biophysical conditions

Before focusing on the action arena for wastewater management, one should identify the nature of goods or services that are at issue. This process examines the convoluted context of the problem (Ostrom, 2005). The classification of goods or services depends on their nature and material status. According to the economic theory, goods and services are classified mainly by two attributes: excludability and subtractability/rivalry (McGinnis, 2011a).

		Subtractability/Rivalry	
		Low	High
Exclusion	Difficult	Public goods	Common pool resources (CPR)
		Wastewater irrigation, public health, drainage, community development	**Soil, ground water and surface water resources**
	Easy	Toll or club goods	Private goods
		Infrastructure of sewerage services	**Wastewater treatment plants**

Figure 7.2:Classification of goods and services associated with wastewater management

Source: Modified and adapted from Ostrom E.& OstromV., (1977, Figure 1, p.6); Ostrom (2010, p. 413); Hess & Ostrom, (2003, Figure 1, p.120)

Excludability refers to the difficulty of controlling the use of a good or service by a another group of users. In Figure 7.2, levels (easy and difficult) of excludability refer to the level of feasibility of exclusion. If the exclusion is feasible, the consumer may exchange goods or services for the agreed-upon price with suppliers. If the exclusion is infeasible, for a common good or service, anyone can use the good or service until the supply is available (free-rider) (Ostrom, 1998). Exclusion may be infeasible due to the nature of good or service such as homogenous units or an unlimited supply by nature. This characteristic is directly related to the CPR (See the red rectangle in Figure 7.2). Consumers are not exactly contributing to producing or developing such goods or services. Therefore, the marginal cost for each user is near to zero. Economically, it is not beneficial to invest in excluding other users.

The second attribute ‘subtractability’ refers to a condition in which consumption by one person can reduce the available amount of good and service for others. Subtractability has also been referred to other terms such as rivalry or competition. Both excludability and extractability differ from low to high instead of present or absent (see Figure 7.2). Low to high refers to relative characteristics (Ostrom, 2010). For instance, high subtractability expresses that only individual user is possible for one resource unit. Low subtractability refers to a situation where one shares goods or services with other consumers. Therefore, one’s use is not easily observable (Polski & Ostrom, 1999).

Figure 7.2 differentiates the nature of resources from the collective action problem. The term ‘wastewater’ used here refers to untreated wastewater. Such classification categorizes the diverse facets of wastewater management. Each category like private goods, club goods, public goods, and CPR indicates a particular administrative system or a commodity. The approximate classification of goods or resources based on the characteristics mentioned aboveclearly explains the exact governance dilemma in the wastewater management sector. No doubt, the classification of goods and services affects the problems faced by consumers (Ostrom E. & Ostrom V., 1977). Each category has its own inherent obstacles (Ostrom, 2005).Each group may have goods and services with different sub-attributes (Ostrom, 2010). The following sub-sections discuss such details.

7.2.1.1 Private goods

An individual with property rights and private goods has the right to exclude others from using the good as well as renting or selling the property. Individual treatment plant at the industry level or collective treatment plants are examples of private goods. WASA treatment plant is also a type of private ownership. Property rights of treatment plants depend on the type of project. If a single ownership exists, then the plant works as a private entity. If a group of people organizes the plant, it may works as tool good.The third type of ownership may occur under the public-private partnership (PPP). Contract regulations may define the limits and restrictions. Mostly, property regime is already decided among parties in a PPP. Even the option of exclusion to restrict free riders from public goods is available. Generally, the public sector allows private investment into public infrastructure due to limited government budget (detailed discussion in Chapter 8).

7.2.1.2 Toll or club goods

The goods with low rivalry/subtractability but easy excludability can be defined as club goods. These are also termed as ‘artificial scarce good’ or ‘natural monopolies’.All market inefficiencies for monopolies exist for such goods, either natural or manufactured. The infrastructure for the drainage including sewerage system (WASA services), surface-water drainage system, and wastewater irrigation (planned) possess the characteristics of toll or club goods (Figure 7.2). Governmental agencies or a group of people who own the property rights can regulate, exploit, or grant public access to resources. Areas irrigated with domestic wastewater in Faisalabad serve as an example.The government can also enforce, sanction, or subsidize the use for resource management (Burger & Gochfeld, 1998).

7.2.1.3 Common pool resource

Common-pool resource (CPR) goods have conditions that make it costly—though not impossible—to exclude potential beneficiaries from obtaining their benefits. Examples of CPR include soil, groundwater, andfresh surface water resources. The resource may be supplied by nature or produced by man (Ostrom, 1998). Due to the high subtractability, one's benefit directly affects the availability of resources for another. High subtractability as private goods and infeasible exclusion as public goods are the characteristics of CPR. For instance, one farmer's irrigation reduces the amount of water available for another farmer (Ostrom, 2005). People tend to view groundwater,and surface water (canals and rivers) as God-gifted resources, so they assume that these resources are free of cost. Same is the case with wastewater which is generated by using limited water resources (surface and ground). It is, however, difficult to estimate and set a price even if these resources have a monetary value. Water may be an exception to be considered as an economic good because of its importance to life. No doubt, if property rights remain unclearly defined with CPR, then there will be crowding out or depletion of that limited resource (Burger & Gochfeld, 1998).

7.2.1.4 Public goods

These goods also retain non-excludable characteristic but have low subtractability like tool goods. A free-rider situation occurs when it is costly to exclude others from gaining access to the resource. After that point, these public goods become 'commons' or CPR. Because of low subtractability/rivalry, the marginal cost for each new consumer is zero, or the price is zero in absolute condition (Ostrom, 2005, p. 23). That is the reason for the absence of private markets for such kind of public goods such as wastewater. Farmers gain access to wastewater for irrigation just because an open drain is located in nearby areas. It is hard and expensive to control this activity. Similarly, user community who can regulate the access to the resource by members or non-members could hold 'wastewater irrigation' as a resource.

7.2.1.5 Confusion among public goods, and CPR

It is somewhat complicated to classify the goods and services into above-mentioned categories. Even Ostrom firstly classified the goods and services based on infeasible exclusion and joint use (Ostrom E. & Ostrom V., 1977, Table 5.1, p. 115). Lately, the goods and services have been categorized according to their extent of exclusion and subtractability (Ostrom, 1998, 2005;McGinnis, 2011b). Hess & Ostrom(2003) explained and identified the concept of ‘commons’ in depth. The four kinds of confusion elaborated for identifying the commons are “differences between (1) the nature of the good (common-pool resources) and a property regime (common-property regimes), (2) resource systems and the flow of resource units, (3) common property and open-access regimes, and (4) the set of property rights involved in ownership.” This dicussion can exactly remove confusions regarding the undestanding the commons (Hess & Ostrom, 2003). In short, the IAD framework can be applied for CPR and public goods (Ostrom, 2007; Ostrom V.& Ostrom E., 1972; Polski & Ostrom, 1999).

Here, the concern is classifying goods and services,associated with wastewater management. Untreated wastewater produced by using limited water resources (commons) is considered as CPR. Property rights are not clear and untreated wastewater is a pollution and health problem. If nothing changes, limited freshwater resources may be depleted. Exactly, one can describe the wastewater possess the features as an ‘ongoing flow system that is jointly produced and utilized, publically organized, open-access, and limited in ownership’. However, wastewater irrigation (unplanned), in the eyes of the researcher, is considered as a public good not CPR. Ostrom studied irrigation system as CPR (Ostrom, 1992). The justification lies within the difference of nature of good. Irrigation water is once supplied by nature and each consumer is an absolute rival to other consumer for the resource unit. Although, in the case of wastewater, a group of people produce resource units continuously and these resource units cannot be generated at once. The drains for wastewater were constructed by government agencies for the purpose of proper drainage (WASA and IDD). From these drains, farmers irrigate their fields because wastewater nearby them is available. It is costly or even impossible to exclude these appropriators. Moreover, such farmers are sharing the resource unit without contributing to its cost of production. White (2015)categorized water markets, as well as wastewater and sanitation, into public goods (non-excludable and non-rival). Alternatively, planned wastewater irrigation organized by agencies can be categorized as toll goods (in *Chokera* Village). As, an annual bid for wastewater supply has been announced. Then,a representative for a group of farmers wins the bid, and that representative is further responsible for the collection of fees and the distribution of wastewater among the farmers according to their needs(White, 2015).

7.2.2 Attributes of community

This section describes attributes/characteristics of the study area communityin social, communal and cultural aspects in regards to wastewater irrigation. The most important aspect is ‘trust’ among the members of society. It refers to the belief that no one will havean advantage due to the weakness of others. The other aspect ‘reciprocity’refers to a practice in which everyone in the community cooperates sincerely and expects others to respond back in the same cooperative way. Members of society should have and share common knowledge and information regarding policy-oriented objectives. A strong social capital within a society will assistin achievingpolicy goals. Such practices can foresee the interactions and outcomes of implemented laws and policies (Bravo, 2002).

The information collected through qualitative techniques (focus group discussion, stakeholder analysis, departmental briefs) elaborated the societal attributes,and how they affect wastewater management in Faisalabad. The norms or valuescannot be instantly developed or built(Williamson, 2000). Actually, these immeasurablesocietal attributes develop from previous experiences of interactions between individuals and institutions. A few of them were observed andlisted in next Table 7.2.

Table 7.2:Problems with management of CPR within the society

Category	Sector	Collective action level	Collective action problems
Environment	Physical attributes	None	Depletion of natural resources (Open access)
Individuals	Internalized norms and values	None	Lack of trust
Society	Social relations	Low	Cheating the reciprocity norms
	Social environment	Medium	Eroding the general trust by cheating
	Institution	High	Violation of rules and ineffective monitoring/sanctioning
System	Physical Attributes	High	Free-riding in the provision of a public good

Source: Adapted and modified from Bravo (2002), p. 10

The first category 'environment' (in figurer 7.2) indicates theriver pollution and the depletion of groundwater and soil resources. At anindividual level, no one can understand his responsibility towards natural resources, and thus blames the institutions. Everyone thinks that if they did not utilize natural resources, then someone else would exploit and receive the benefits. So naturally, the question would be "why not me?" Such attitudesbecomesocietal behavior. Within such a society, where formal laws are not actually well enforced, the strongest group (mostly in monetary term) overrules the rights of vulnerable groups.Weak administrative organizations, in terms of implementing and enforcingthe laws,are under the instructions of influential groups. Ultimately, polluters (industrialists) violate the general trust for their economic gains.

7.2.3 Rules

The term 'rule' can be used under different perceptions. Simply, it refers to instructions for action. Formal rules (laws, regulations) are ones that are written and planned to be implemented. Informal rules refer to cultural norms and working rules. These are hidden but transferable through actions or verbal commands (Ostrom, 2005).

Institutions as working rules can be defined as such: "an institution is simply the set of rules actually used (the working rides or rules-in-use) by a set of individuals to organize repetitive activities that produce outcomes affecting those individuals and potentially affecting others" (Ostrom, 1992, p. 19).

The rules-in-use (working laws) for each institution, which are hidden, are hard to pinpoint. These working laws actually influence the interactions between individuals to produce outcomes. Little observable proxy information was collected through qualitative techniques (net-mapping, focus group discussion, in-depth interview and stakeholder analysis) and literature review (official departmental reports).

All types of rules affect the wastewater management. The implementation gaps in laws and regulations cause the mismanagement. After a massive industrial development since the 20th century,sustainable development has become a top priority target for governmental organizations. A large number of ministries and departments have shaped up to monitor economic development with environmental conservation.

7.3 An action situation as a focal point of analysis

This section intends to use the IAD framework to understand the role of diverse institutions associated with wastewater management.

This case study is not just highlighting the IAD framework as the best approach for searching reasons for mismanagement in the wastewater sector. Instead, it has found that the IAD framework can be quite useful for understanding the diverse institutional arrangements within Pakistan. "It has also proved the IAD framework as a useful approach for understanding the diverse variety of institutional arrangements in both developed and developing countries" (Imperial & Yandle, 2005, p. 502).

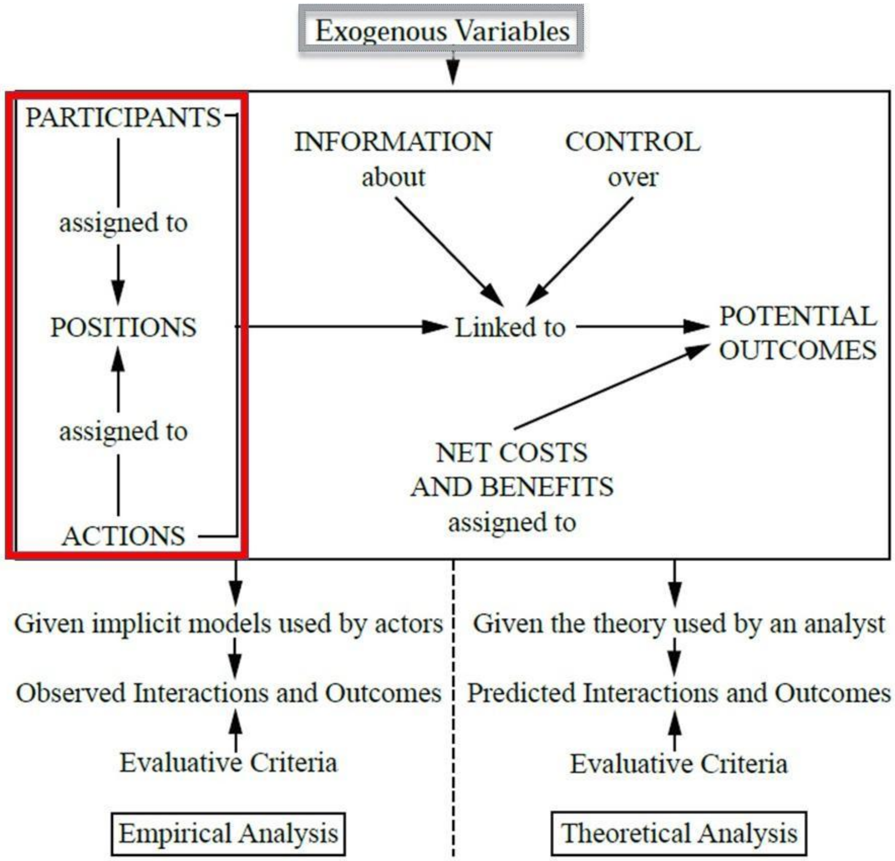

Figure 7.3:Internal structure of an action situation

Source : Adapted and modified from Ostrom E.(2005), Figure 2.1, p.33

In Figure 7.6, the action arena(black rectangle) comprises a set of variables.The right side of the rectangle shows the evaluation of outcomes.The left side (red rectangle)shows actors/participants, their positions, and their actions. These administrative organizations are a crucial part of the institutional analysis. All institutions, directly or indirectly involved (already mentioned in Table 6.1) with wastewater management, are critically analyzedin the following section.

After observing poor wastewater management from ground level (Chapter 4), it can be determined that sustainable wastewater management is a governance dilemma in Faisalabad. Governing agencies could not achieve the desired goals because of numerous reasons. Notably, due to the nature of product or service, wastewater management is a multifaceted problem with a notable situation. At a policy-formulation level, considering wastewater as a resource or an economic good is still out of the discussion. In Pakistan, canal water is still highly subsidized even in the midst of water scarcity. Commonly, water (groundwater and lakes) is considered a gift of nature. There was not even a single administrative institution responsible for controlling water pollution at any level. Different administrative organizations cover different aspects (mentioned in Table 6.1). The enforcement gaps exist with the legislative framework for each. To look at an inefficient system of wastewater management, one must investigate the action situation where actors interact to get incentives or outcomes.

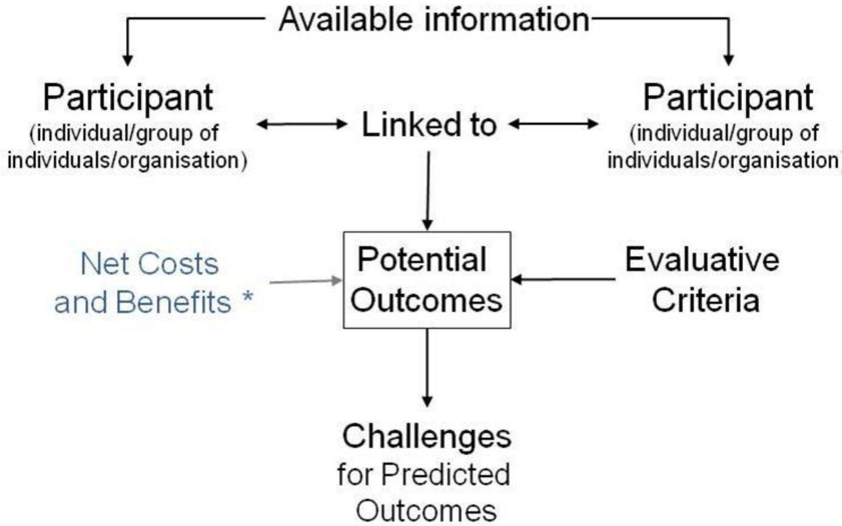

Figure 7.4:An action situation for institutional analysis in wastewater management sector

*Transformative and transaction cost (information cost, coordination cost and strategic cost) (Elinor Ostrom, 1992). Net costs and benefits estimation for the interactions could not evaluate due to lack of required information

Figure 7.4 simplifies the linkages among participants with repeated interactions for potential outcomes in the wastewater management sector. These participants may be service provider like WASA, and IDD or enabling agencies such as EPA. Not every participant retains perfect level of available information. The information level of actors, their power or authority to take decisions, their routine interactions with others, and the potential outcomes are inquired and documented. Likewise, the evaluation criterion could identify management problems (due to interactions) with respect to incentives and outcomes (governance arrangements and failures).

The next Section 7.4 comprehensively details the linkages between stakeholders (participants) and outcomes; these linkages and information are reviewed with evaluation criteria. The evaluative criteria for estimating outcomes are "economic efficiency, equity through fiscal equivalence, redistribution equity,accountability,conformance to values of local actors, and sustainability" (Ostrom, 2011).

7.4 Participants, positions, and actions

To evaluate potential outcomes, there is a need to review all participants/stakeholders involved in the action situation of wastewater management in Faisalabad. An actor cannot enter or leave the action situation on his own will. The analysis of available empirical evidence, which was conducted at different institutional levels, facilitate identifying stakeholders or actors in this specific situation (Bandaragoda, 2000: p. 12).

This section examines the primary stakeholdersin detail. These stakeholders hold quite diverse perspectives in regards to organizational goals, implementing procedures, environmental ethics, economic benefits, social gains, and good governance.

An analyst first has to look at all the factors affecting the situation of wastewater management. Second, one has to look at how the situation develops over time. Previous interactions and outcomes affect current perceptions and predicted outcomes. The historical development of each institution exactly shapes up the institutional setting and environment within that institution (institutional life history). The hierarchical orientation of institutions (stakeholders) is outlined under legal instructions (formal laws).

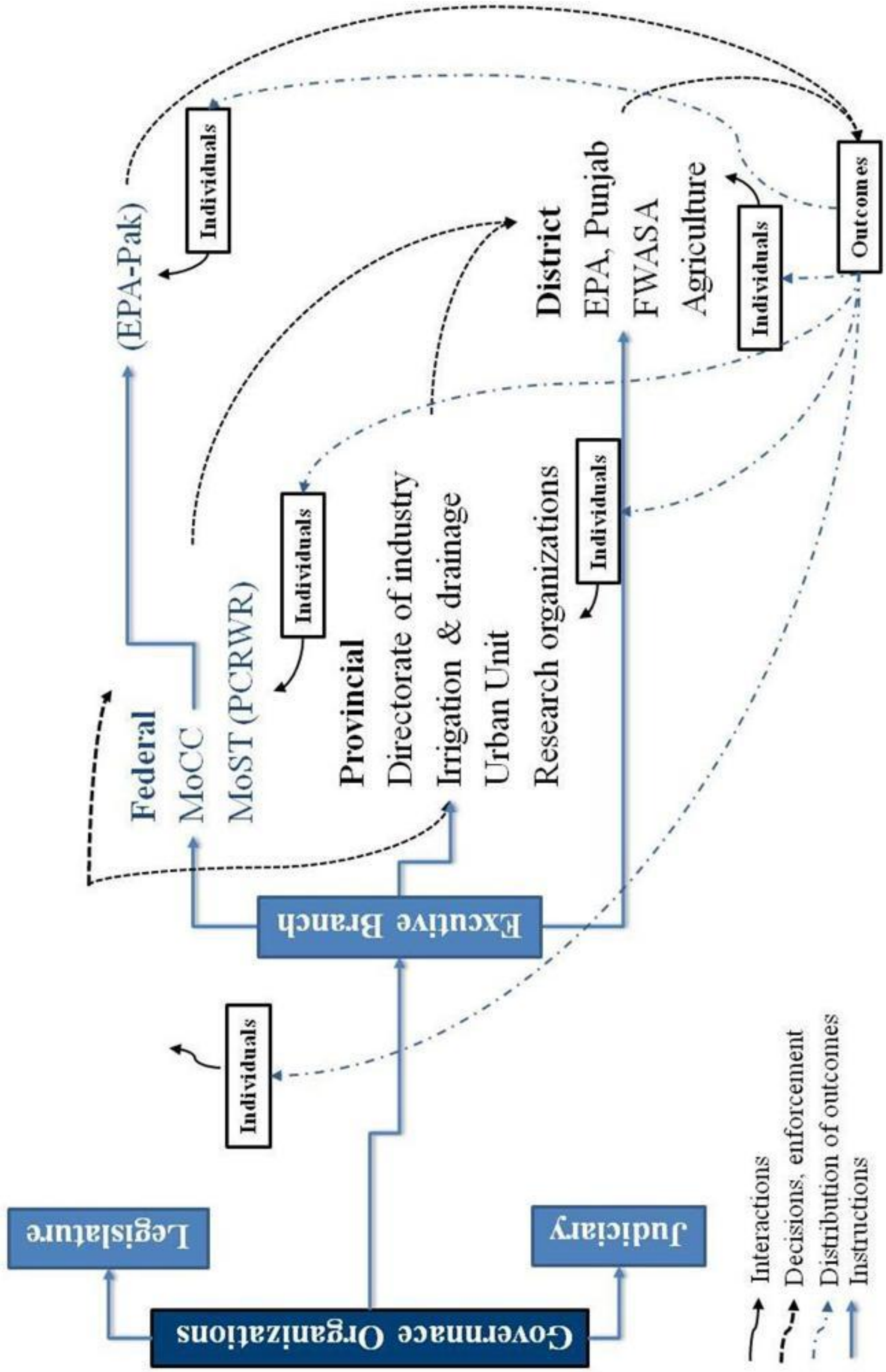

Figure 7.5: Institutional analysis (Multiple-level analysis and arenas of choice)

Figure 7.5 portrays the multi-level institutional analysis (a modified version of Figure 2.9 and 2.10). There is a need to look at the formal setup of institutions and their interactions with individuals. Their linkages portray the state of the government and the division of authorities among the district, provincial and federal government regarding wastewater management issues in different departments.

7.4.1 Individuals or Appropriators

Ostrom defined "appropriators" as those who consume resources from the resource system (Ostrom, 1990). Thus, the appropriators in our case study are wastewater irrigators, industrialists, and domestic consumers. Industrialistsare the foremost user of water resources for their economic benefit.

7.4.1.1 Industrial sector

Industrialists play a pivotal role in the whole wastewater management system. Faisalabad, commonly known as "Manchester of Pakistan," is widely recognized for its textile industrial sector. In fact, a quarter of the nation's entire export depends on it. The industrial sector dumps untreated industrial effluents into public and storms water drains, thereby using the sewage system developed by WASA at the city level and stormwater drains developed by IDD. Such industrial units are the main actors who are responsible for adverse externalities. Setting up a proper legal framework and a responsible administrative organization is required to regulate such activity (M. M. Aslam, Baig, Hassan, Qazi, & Saeed, 2004). The chairman of 'Faisalabad Chamber of Commerce (FCC)', who is also the owner of a textile unit, explained the industrialist's point of view in the following words:

> Only nine or ten industrial units are treating their effluents. The discharge of untreated industrial effluents is not the real threatening issue due to industrial development. The major problem is the terrible exploitation of groundwater resources. (In-depth interview with the owner of M.A. textile Private Limited, describing the exploitation of water resources due to industrial sector, on July 2015)

Industrialists suppose that their economic activity is beneficial for humanity by producing industrial goods. Thus, compared to benefits from industrialization, water pollution from industrial effluents is not big. According to them, there is a limited direct threat to human health and the environment.

7.4.1.2 Domestic Sector

Households and commercial users of urban area dump their effluents into public drains. Legally, it is mandatory for each household who possesses land greater than 15 *Marla* (One *Marla* = 25.2929 m^2) to construct a septic tank within the premises. To reduce the risk of bacterial infections and diseases, all sanitary discharge should be released into public drains after passing through a septic tank, (FDA, 2015, p. 2263). However, most of the population does not follow such instructions. Therefore, domestic wastewater is not considered safe for irrigation purpose due to biological contaminations. At the same time, these urban households suffer from water pollution from industrial units located within their areas.

7.4.1.3 Wastewater irrigators

Urban farmers who irrigate their agricultural fields with wastewater (either treated or not) are also appropriators by its very definition. On one site (Chokera village), farmers formally buy the sewage drainage and constructed the field channels from the central wastewater drains. At other sites, farmers pump out wastewater from open drains through a motor. The expenses for energy consumption are collectively paid.

7.4.2 Management through institutions

In this section, administrative organizations concerned with wastewater management and their prescribed roles are identified.

In Pakistan, a parliamentary system of governance is prevalent through democracy. The main pillars of this system are the legislative (a group of elected people), the executive (government authorities) and the judicial branches. The elected representatives (legislature) derive the executive branch (civil authorities) to enforce the rules and regulations. These rules and laws are created by the legislature within the parliament. The role of the judiciary is to interpret these laws and keeping the other branches accountable (Chapter 6). In the following section, the roles of the politicians (legislature) and the executive branch (governing organizations) for achieving the goal of sustainable wastewater management are thoroughly evaluated.

7.4.2.1 Constitutional level (legislature)

The main functions performed by legislatures at the constitutional level are "formulation, adjudication, and modification" of laws (Ostrom, 1990, p.53). The 'Constitution of Pakistan (1972)' with amendments has authorized the legislative body to provide boundary rules for authorities at different levels such as federal, provincial, and local governments. Thus, the parliamentary system in Pakistan consists of the Senate (upper house) and National Assembly (lower house). The political representatives are considering the issue at all forums including the provincial assembly, national assembly, and the Senate.

i. Senate

One report found how industrial water pollution was discussed during a Senate meeting (Pakistan Senate, 2011, p. 34-50). The report described a debate in the Senate meeting regarding the governance problems of wastewater management. When asked about what steps the government has taken to control the wastewater pollution, the Minister of Climate Change explained that import duties for treatment plans have relaxed (from 35% to 5%). He also informed about the tax reductions for industrial units that have complied with environmental standards. Regarding lawsuits against polluters, he provided the following information:

> "From 2005 to date, more than 2,500 EPOs have issued to different polluters and violators. So far, more than 880 cases have filed in the Tribunal. Currently, there are 766 cases pending adjudication in the Tribunal. Seventy-seven units closed down their operation after conviction". (Pakistan Senate, 2011, p. 37)

Regarding the state's obligation to environmental conservation, the report shows that the Minister of Climate Change could not reply to any questions asked by Senate members regarding environmental pollution. To most questions, he replied that such questions should be referred to the provincial government because according to the 18th amendment, the provincial government is responsible for the environment.

ii. Provincial (Punjab)Assembly

The main governance challenge at political platform is the involvement of political representatives (Members of National Assembly [MNAs], Members of Provincial Assembly [MPAs]) in the favor of industrialist's community. The reason of such involvement is either they are industrialists or possess close contacts with them. Such political agents remain either silent or indifferent towards environmental concerns during session of constitutional procedure. However, politicians who do not belong to an industrialist's community protest in the favor of local communities.

The failure of proper wastewater treatment and sustainable management was addressed in the Punjab Assembly, and a resolutionabout the industrial wastewater pollution passed on 2013, December 3. A political representative from *Samundri* (Tehsil of Faisalabad) submitted the below mentioned resolution to Punjab provincial assembly. The resolution states as follows:

> "The opinion of Punjab Assembly is that there are 144 industrial units in District Faisalabad which are discharging their toxic wastewater into *Laundry* drain, due to which thousands of peoples are suffering from different diseases and dying every year. Ask them to stop the discharging of toxic wastewater; otherwise, install the Treatment Plants for the treatment of Toxic Waste Water within 3 Months." (Government of Punjab, 2013, p. 272-273)

As a result of this resolution, approximately ten big industrial units in Faisalabad installed treatment plants. However, such state of affairs is quite site-specific.Largely,such politicians are few in number particularly in the case of Punjab province.

7.4.2.2 Collective level (executive branch)

Organizational and institutional arrangements are important for a proper policy implementation about sustainable agriculture and industrial development. The processes of management and adjudication are performed at the collective level. Before studying the executive branch, it is essential to understand the institutional terrain among these organizations. The general top-down administration runs the wastewater management at three different administrative levels (federal, provincial, and district government, Figure 7.3 and 7.7). At each level, the decision makers try to set specific goals, protocols, and limitations.

The executive branch (federal and provincial government) executes its powers over subordinate departments. In accordance with the recent decentralization, the provincial government retains the responsibility to administer the use or exploitation of natural resources. The responsibilities of providing irrigation and drainage infrastructure, regulating the establishment process of industries, and adequately planning future reforms are also subject to the provincial government's authority. The evaluation of organizational setup and their hierarchal arrangements (see Appendix G) show the formal linkages among institutions.

Each governing organizations and agencies linked with wastewater management (see Table 6.1) are addressed in the following sub-sections. Theoretically, a historical institutionalism approach is applied to analyze organizational development over time. Such study helps to explore the inherited/in-built issues within the organization. The information concerning the staff member's qualification, age structure, experience, promotion criterion, hierarchal arrangements, financial liabilities, and verbal working communication are proxy variables for estimating working rules. All these variables influence the action situation. The main criteria for the study of institutional framework are comprised of four components: historical development, objective and function, human and financial resource base, and present performance problems. Such relative analysis details the weaknesses and strengths of each organization.

An institutional analyst can take two additional steps after making an effort tounderstand the initial structure of an action situation:

> One is to dig deeper into the factors that affect the structure of the situation (Kiser & Ostrom, 1982). A second step explores how an action situation changes over time in light of how previous outcomes affect perceptions and strategies over time (Cox & Ostrom, 2010).

First, the Directorate of Industries (DOI), that administrates at the provincial leveland linked directly with industrial water pollution.

iii. Directorate of Industries

The DOI manages adepartment that is in charge of registering every industrial unit and fulfilling all legal responsibilities. The Directorate is under the administration of Ministry of Industries, Commerce, and Investment (see Appendix G3).

The DOI is responsible for legislating, formulating policies, and planning for industries including industrial estates, small industries and handicrafts enterprises. In addition, it regulates industrial location policies, collects data for survey, and registers industrial firms

In 1948, the Industrial Planning Committee was established after independence. This committee made efforts to bring industrial development to the Punjab province. The government introduced five rounds of a five-year development plan. During the first four rounds, approximately 6,236 industrial units were established in Punjab province. After nationalization policies rolled out in the early 1970s, the industrial sector was adversely affected. However, the textile industry continued to prosper because it was excluded from nationalization. During this era, Faisalabad became the hub of industrial textile units. Later on, the government introduced a clear and de-regulated policy to improve the investment climate. After 1985, a liberal industrial policy was introduced to facilitate entrepreneurs and to promote industries in the province. Under this policy, the role of the Directorate altered from regulating to facilitating; many functions were assigned to other departments(Khan, 2013).

The Industrial Profile of Faisalabad (Attached in Appendix D1) was prepared using the Census of Manufacturing Industries (CMI) 2006 (Directorate of Industries, 2006). About 18,006 industrial units in Punjabare covered in this. However, the Punjab Small Industries Corporation only covered small-scale and cottage-level industrial units. In 2010, this number decreased to 17,857, as several industrial units reported closure. Overall, textile and food industries are the significantly capitalized sectors in Punjab.

A private company called Faisalabad Industrial Estate Development and Management Company (FIEDMC) initiated the shifting of industries out from urban areas in Faisalabad. It was responsible for developing industrial estates and managing industrial effluents. The public administration was not involved in any way. Local industrialists pulled together their financial resources to purchase lots and to develop an industrial estate.

After reviewing information provided by departmental officers and news articles addressing the role of the organization, it can be said that the DOI showed poor performance in its fundamental duties. The motto of the organization is to accelerate industrial development while environment conservation is considered as a separate theme.

One of the main objectives of the DOI is to conduct CMI periodically within Punjab. Collaborating with the provincial Directorate of Industries and the Bureau of Statistics, the latest CMI was conducted between 2005 and 2006. However, the current status of industrial units could not be found due to the lack of human and financial resources. Even the latest CMI 2006 was only published after receiving updated data from a few districts. Since official staff members did not conduct the survey, data reliability was compromised. Reliable and precise strategies can only be formulated in the presence of consistent and updated information regarding the industry's status (number of industries, type of industries, location, capacity, type of pollution and extent).

A news report mentioned that an anonymous interview with one of the directors at the DOI revealed an unfortunate situation. He shared that any shopkeeper of industrial cities like Lahore and Faisalabad could install equipment and start production without registering to the department. He went further and asked

> "Having a total staff of only 400 including secretaries, directors, and peons, how can the department conduct survey on annual and monthly bases?" (Staff Reporter, 2016)

In fact, any small and medium-sized manufacturing units can open and close without notifying the DOI in big cities like Faisalabad. There is actually no official requirement. Only large industrial units officially inform the department and provide the required information (size, boiler size, working quality, and the quality of discharge) to get subsidies and tax exemption (in the case of exports).The industrialists commonly hide, distort, or underreport their real data because of the fear of taxation and competition against rival industries (Staff Reporter, 2016). In the absence of reliable information regarding the industries, it is impossible to enforce regulations and to suggest reliable plans.

Another challenge was in the recruitment process within the department. The audit report (2016-17) of 'Job and Competitiveness (J&C) Program' funded by World Bank and the Government of Punjab assessed the efficiency and competitiveness among the 15 implementing agencies and organization under the Industries department. The recruitment within implementing agencies could not follow the rules as follows:

> "It is emphasized that the recruitment process of J&C and its implementing agencies is notas per relevant rules and regulations and notable violations have been found during an audit of selected implementing agencies which requires special attention of the management." (Auditor General of Pakistan, 2017, p. 6)

However, the report indicated that fair disbursement of financial expenditure was as prescribed.

iv. Irrigation and Drainage Department

Irrigation and Drainage Department (IDD) department is legally responsible for regulating water supply in canals and looking after the storm drains. The untreated wastewater dumping into the river through storm drains was the aspect to include this department under investigation. According to the Constitution of Pakistan of 1973, irrigation and drainage are under the provincial government's responsibilities.

The IDDformulates policies and takes measures regarding irrigation and drainage infrastructure as well as construct and maintain barrages, rivers, canals, tube-wells, and reservoirs. It also strategizes drainage and flood protection schemes. (See Government of Punjab, 2011b, II Schedule, p. 58)

The history of the Irrigation and Drainage Department dates to the colonial era in the 19th century. Under the Public Works Department, the Directorate of Canal was formed in 1854. At the time of participation (1947), the Provincial Irrigation Department (PID) was established(Asrar-ul-Haq, 1998). Later, the next institutional change in the irrigation department was the establishment of PIDA. The Punjab Irrigation and Drainage Authority Act 1997 was passed, where a new organization named Punjab Irrigation, and Drainage Authority (PIDA) was established. Under this act, PIDA assumed all rights as mentioned by the Canal and Drainage Act of 1873. The PIDA further developed under a project funded by a Japanese donor agency (JICA).

This organization is an example of participatory irrigation management (PIM) (Hassan, Memon, & Hamid, 1999).

In terms of financial and human resources, IDD is a sizable organization. However, their working rules mainly revolve around maintaining canal water supply and constructing canal and drainage infrastructure. The environmental consideration within drainage services is mainly missing from their duties (Government of Punjab, 2011b). The departmental duties only considered the operational and maintenance cost of drains, not environment-related costs. The working staff has professional skills in civil engineering. Although IDD is a massive organization in all aspects, it lacks interactions among departments (Bandaragoda &Firdousi, 1992, p. 27). No updated information was available. Although, one can predict that there was probably no reduction in the workforce after an institutional change.

The farmers in Faisalabad raised objections on the function of PIDA. PIDA works efficiently in the western zone (LCC west) of Faisalabad. On the contrary, it is not efficient in the eastern zone because of local influential groups. Farmers also informed that before the establishment of PIDA, stealing or exploiting canal water was not possible in these areas.Another common complaint raised by the farmers was the ‘reduced allocation of canal water’ over the years. Additionally, the canal water supply was limited to farmers who live near the tail end of the canal, which influences the farmer to look for alternate irrigation sources such as wastewater. (Extracts from focus group discussion with farmers (*Khurianwala*), June 2015)

v. The Urban Unit

At a collective level, The Urban Unit plays a spirited role in the planning of future development projects for the urban area. It is a multi-disciplinary organization focused on the systematic development of urban areas through shared data repository and international and local collaboration with research centers and international donor agencies.

The Urban Unit is a self-governing company working under PND Department. As a Project Management Unit (PMU), it has been functioning since 2006. In 2012, the company underwent significant transformations. It converted into an independent private sector company, registering with the Securities and Exchange Commission of Pakistan (SECP).

The Urban Unit provides government-run agencies, private entities, and donor agencies with reliable and legitimate technical advisory services.

The main objective of the Urban Unit is to facilitate and fulfill the agenda of its donors and partners. The motto of the company is to achieve socio-economic goals in public servicing, as cities become engines of growth. The main emphasis is towards project implementation and management. It is a profit-seeking company by providing services in the urban planning sector. This means that a public administration for town planning/management is missing. About 1,049 employees have been hired at the provincial level, including 704 hired on a temporary basis under specific projects (Chaudhary, 2015, p. 21). It lowers the morale of workers and safe grounds for long-term development. Ideally, development authorities at the regional level should plan such kinds of services. The Urban Unit office is located at the DCO complex in Faisalabad, but there is no direct organizational link between the two organizations.

vi. Research Organizations

At the national level,the Pakistan Council of Research in Water Resources (PCRWR) conducts, organizes, and sets up national research centers wherever necessary. Also, it promotes research on all aspects of water resources, including irrigation, drainage, reclamation, navigation, drinking water, industrial water, and sewerage management. According to the law, the Council is responsible for developing and maintaining a database of national water resources and making it available for agencies and the public. It also may advise the government and submit policy recommendations regarding water quality and the development, management, conservation and utilization of water resources. Also, it publishes scientific papers, reports, and periodicals, as well as arranges seminars, workshops and conferences on water-related issues.

In 1964, the PCRWRwasestablished under the name of Irrigation, Drainage, and Flood Control Research Council (IDFCRC) within the Ministry of Natural Resources. Later, it was brought under the administrative control of the Ministry of Science and Technology (MoST)[8]in 1970. After another resolution in 1985, the Council was renamed to what it is today. Established by Act No. 1 in 2001, PCRWR is now an autonomous body. (Year Book 2013-2014 PCRWR, Ministry of Science and Technology, Government of Pakistan, Islamabad)

During 2004-05, PCRWR launched a project titled "Impact Assessment of Sewerage and Industrial Effluents on Water Resources, Soil Crops and Human Health in Faisalabad." The collected information about the wastewater drains provided the grounds for selecting the current study area (Kahlown et al., 2006). Under this project, the impact assessment of sewerage and industrial effluents addressed water resources, soil, crops, and human health in Faisalabad (Data attached in Appendix).

Another vital research institution under the MoST is the Pakistan Council of Scientific and Industrial Research (PCSIR), which has a nationwide network targeting the development of industrial technologies without the exploitation of indigenous resources. Research on

[8] The Scientific and Technical Research Division initially established in 1964 under the Ministry of Education for the promotion of research, utilization of research results, and implementation of national science and technology policy. In 1972, the division developed as the Ministry of Science and Technology to perform the diverse functions as mention in the article 28 of second schedule of the Federal Rule of Business 1973. The sanctioned strength of staff is 193 including 17 candidates for development. 16 institutions/organization/universities administrated through 7 different wings of this ministry. During 2010-11, the ministry received 925109 million rupees. 66 percent of sanctioned amount was allocated for developmental budget.

environmental and ecological pollution stemming from industrial activities is also included within their scope of work.

In reality, the MoST has a limited budget, which mainly focuses on development. That is the reason why the Ministry provides consulting services to the private sector.

Provincially, several departments run by different universities have contributed to exploring environmental threats caused by industrial development. In Faisalabad, the University of Agriculture (UAF) and the Ayub Agricultural Research Institute (AARI)generouslyprovide the platform for this research. The AARI lab performs soil, groundwater,and irrigation water analysis while providing services to farmers at very cheap rates.

Figure 7.6:Floating wet lands
Source: WASA

Another institute that made a notable contribution is the National Institute of Biotechnology and Genetic Engineering (NIBGE). It is a semi-government institute specialized in nuclear technology. The Institute launched a project called "Floating Wet Lands,"in 2015. Under which the floating wet land were constructed in the Anaerobic Pond of Chokera wastewater treatment plant (Figure 7.6). The primary objective was to improve the efficiency of the treatment plant.

The International Water Management Institute (IWMI) has researched on the irrigation water sector in Pakistan. Mainly, the IWMI researchers have been involved in irrigation reforms in Punjab. In regards to Faisalabad, the Institute had extensively targeted research on wastewater irrigation (*Chokera* village).

There are some other national or international institutes, who provided funding for research projects working on water pollution in Faisalabad such as SANDEE, AARI**.** However, the overall scope of the work was limited.

There was no local organization or NGO, who focused on the rights of the community and environment. Few international NGOs such as WWF and **S**DPI worked on water-related environmental issues in the affected communities, but their scale of work extended nationwide with limited institutional capacity.

Within Faisalabad, only a single operational NGO could be found within the wastewater management sector. "*Anjuman Samaji behbood"* (ASB)is a local NGO, which helps low-income communities and installs underground pipes to channel sewage to the main municipal sewage line (Zaidi, 2001, p. 15).

7.4.2.3 Operational level

'Appropriation, Provision, Monitoring, and Enforcement' are the practices tangled with operation choices (Elinor Ostrom, 1990). The constraints and relaxations at the operational level are only possible because of the changes in a collective-choice decision. Likewise, the change in the pattern of collective decisions is only possible due to changes at the constitutional level. Decentralization is a practical illustration of such direction. Because of the decentralization in Pakistan, power/authority has devolved to local representatives. Under this institutional change, agriculture, environment, water and sanitation, and public health became subject to the authority of the local government (Government of Punjab, 2001, schedule I, part A). At the beginning of 2017, the influential executive post of district coordination officer (DCO) at district level has eliminated under the act passed by Punjab provincial assembly. Former Deputy Commissioner regime has established. New organizational setup of the district was under transformation.

The exact concern of the analysis at the operation level is to find the day-to-day enforcement of regulation concerned with environmental protection, drainage, and wastewater irrigation.

vii. Environment Protection Department

Under legal instructions of the Pakistan Environment Protection Act (PEPA), organizations for environment protection include the Pakistan Environmental Protection Council (PEPC), the Environmental Tribunal, and Environmental Protection Agencies (EPAs). (Environmental tribunal and their role has already discussed in chapter 5)

PEPC is the prime authority to formulate environmental policies (constitutional level). Under the Pakistan Environment Protection Ordinance (PEPO) in 1983, PEPC was first recognized in 1984. At that time, the President of Pakistan acted as its chairperson (Martial law era). With a democratic regime in 1994, the Prime Minister of Pakistan headed it under the amendment of PEPO. Other members of PEPC are representatives from industry and trade, consultants (experts), educators, NGOs, agencies, mass media, and related departments (Ahsan & Khawaja, 2013; Faruqee & Colema, 1996).

According to the PEPA, PEPC meeting should take place at least twice a year. Nevertheless, the meetings are rarely held. Virtually, everything was just on papers and from 1984 to 1994, only a single meeting took place;this indicated an absence of responsibility towards the environment (Faruqee & Colema, 1996).

Under the PEPA guidelines, EPAs organized and performed their duties at the federal and provincial level.With the decentralization, the federal government delegated its powers to the provincial government (provincial EPD and EPAs). First, there is a need to explain the role of the federal EPA (Pak-EPA), which is also responsible for operational level processes for environment protection.

Pakistan Environmental Protection Agency (Pak-EPA)

Pakistan Environmental Protection Agency (Pak-EPA) is a federal agency and recently started working under the MoCC. The organizational map is elaborated in Appendix G1. Legally, this organization has operational-level duties for environment conservation. However, being the wing of MoCC, it also serves at the policy-recommendation level.

As the agency responsible for implementing the PEPA of 1997, Pak-EPA is also responsible for establishingenvironmental standards and labs, enforcingthe Punjab quality standards, coordinating policy framework, promoting public awareness regarding environmental issues,andassisting local authorities, government agencies and local councils(Government of Pakistan, 1997, section 6)

As mentioned before, the Federal Ministry of Environment (MoE) was established in 1975a result of the Stockholm Declaration (1972). MoE prepared the Pakistan Environment Protection Ordinance (PEPO) in December 1983. The ordinance provided legislative ground to establish an institutional framework, such as the Environmental Protection Council and environmental protection agencies, both at the federal and provincial level.Under this ordinance, the Pak-EPA was organized in 1983 at the national level. Later, the Pak-EPA designed the NEQS in 1993 for municipal and liquid industrial effluents. As the technical arm of the Ministry of Environment, it has prepared reports on different environmental issues and national environmental policies for the Pakistan Environmental Protection Council to consider and approve. It has also dealt with public complaints as well as carrying out research conducting investigations in different environmental issues.

As an institution, the Pak-EPA has faced many challenges. Since the decentralization, environmental protection went under the provincial jurisdiction and the MoE has been abolished. That led Pak-EPA to reorganize and become a part of the Ministry of Climate Change (MoCC) as a separate wing. Currently, the Pak-EPA performs duties to ensure the international environmental laws ratified by Pakistan are implemented (Ministry of Climate Change, 2012). Responsible for state-level environmental concerns, the agency has mainly been responsible for environment conservation (operational level) within Islamabad,the capital of Pakistan However, the Pak-EPA, the largest environmental protection agency in Pakistan, could not even address the full range of environmental concerns within Islamabad (Sahi, 2015).

Although there is limited or no collaboration between federal and provincial EPAs, the federal agency still has authority to approve EIA for each new project nationwide.

At the provincial level, the Environment Protection Department (EPD) administrates the functioning of the provincial EPA, laboratories, and their district offices.

Environment Protection Agency (EPA), Punjab

Legally, EPA Punjab has the responsibility to protect the environment (natural resources) within its administrative areas. EPA Faisalabad district office subsequently looks after the environmental complaints.

For the first time, the Environmental Pollution Control Organization (EPCO) was recognized provincially under the Public Health Engineering Department (PHED) in 1975. This organization dealt with environmental issues at that time. The primaryfunctions of this organization were to look after the matters relating to development authorities, agencies and companies, drinking water, drainage & sanitation facilities. However, the EPCO's scope of work was limited, and detailed follow-ups were missing entirely.

In 1985, the federal government requested to delegate powers of this organization to the Housing Physical and Environmental Planning (HP&EP) Department. Consequently, the Environmental Protection Agency (EPA) in Punjab was established on July 1, 1987. Punjab was the first province where an EPA was created in the best interest of its citizens. Existing EPCO staff members transferred to the EPA in Punjab.

Later on December 31, 1996, a separate administrative unit, the Environment Protection Department (EPD)was formed under the government of Punjab.Then, EPA in Punjab was detached from the HP&EP Department and started working as a functional unit under the EPD in Punjab. In all four provinces, the Environmental Protection Agencies were created under the provision of PEPA, 1997.

The EPA Punjab is responsible for controlling pollution levels of effluents from industrial units. The National Environmental Quality Standards (NEQS) for industrial effluents are the same compared to international standards. Few parameters from NEQS are defined with specific industrial activities.

Nevertheless, industries still did not follow the NEQS limits for such selected parameters. They complained that these limits are too strict to follow. They suggested relaxing the limits initially and then restricting them gradually. (Personal communication with industrialist, July 2015)

Overall, the environment protection administration was at initial stages. The main reason was due to a lack of capacity (weak organizational setup and financial assistance due to transitional phases of devolution plan) (Naureen, 2009). There was poor enforcement of environmental protection laws revealed poor performance, and these institutions could not achieve the planned targets (instructed by law); instead, they just existed with limited success during last two decades.

The hierarchy In terms of wastewater management, the Water and Sanitation Agency (WASA) is the most crucial and central agency. Prescribed by laws, the WASA was established in each big city under Development Authorities (DAs). DAs are responsible for constructing drainage infrastructure at city level and WASA is responsible for the maintenance. However, the Housing Physical & Environmental Planning (HP&EP) Department was still responsible for building sewerage system at tehsil level and the Tehsil Municipal Administration (TMAs) is in charge of the maintenance.

viii. Water and Sanitation Agency Faisalabad

Before explaining the role of WASA, Faisalabad, here is a need to look at the institutional terrain responsible for public health and urban development at the provincial level. Provincially, the Housing, Urban Development & Public Health Engineering Department (HUD & PHED) has to managethese tasks since 1997. Under this department, two further institutions the Public Health Engineering Department (PHED) and the Punjab Housing and Town Planning Agency (PHATA) were established and distributed theses duties.

The Directorate General of H & PP Punjab was reinstated as the Punjab Housing and Town Planning Agency (PHATA) under the PHATA Ordinance of 2002. The PHATA was established in 2004 with the objectives of rejuvenating the housing sector in general and providing shelter to low-income groups in particular.

The Public Health Engineering Department (PHED) has strived to enhance the quality of life of people in Punjab by providing safe drinking water. It has also tried to provide a pollution-free environment by executing sewerage and drainage schemes and constructing sewage treatment plants to meet the Millennium Development Goals (MDGs) (Cheema, 2008; The World Bank 2013).

Formerly, the Housing and Physical Health Department and the West Pakistan Housing and Settlement Agency at Lahore merged to establish the Housing and Physical Planning Department (H&PP) in 1972. Later, the Improvement Trusts for *Faisalabad*, *Gujranwala*, *Multan*, *Rawalpindi*, *Sargodha*, and *Murree* incorporated under the administrative control of H&PP in 1973. Such Improvement Trusts soon provided the grounds for the establishment of the Development Authorities in these big cities. With next legislation of the Development of Cities Act 1976, such Development Authorities (DA) and Water and Sanitation Agencies (WASA) a subsidiary of the Development Authority, were established.

However, the Municipal Corporation (MC) operated the water supply and sewerage system in these cities such as Faisalabad until 1978. Then, the Public Health Engineering Department (PHED) instated the DA and WASA under its administrative control, and the whole department was reformed as the Housing Physical & Environmental Planning (HP & EP) Department.

As already mentioned in the previous section, the EPA Punjab was first created as an attached wing of the HP & EP Department and later detached in 1996. Concurrently, the HP & EP Department was transformed into the Housing, Urban Development & Public Health Engineering Department (HUD & PHED) to focus on urban development and public health in 1997. (WASA Faisalabad, 1993; Fichtner, 2006)

The following Figure 7.7 states the institutional terrain of administrative organizations at Provincial level associated with wastewater management. It explained the administrative line of command at different level. The PHED mainly, operates to manage drinking water and wastewater system under the administrative tier of district local government. Under the administrative control of this department, WASA as a subsidiary of DA manage this responsibly within the urban area of big cities. WASA maintain and manage the drains infrastructure and drinking water supply. Whereas, DA is responsible for the construction of new development schemes and projects for up stated purpose. For the case of Tehsils of each district (rural areas), PHED was responsible for the maintenance of drainage infrastructure and supply of drinking water. But under the devolution plan, Tehsil Municipal Administrations (TMA) would be in charge of supplying these services.For this reason, the PHED staff, which was responsible for water and sanitation services in rural areas, was believed to delegate the responsibilities at the Tehsil level.Here, the role of PHED varied from area to area (Saleem & Ahmed, 2013; The World Bank, 2013: pp.10-11).

For instance, one of the main reasons forthe high prevalence rate of water-borne diseases in *Chokera* village (domestic wastewater irrigated) was the absence of a local drainage system within the village. Residents of the village dump into an open pond. It is completely an administrative issue between WASA, the PHED, and the district government. WASA claimed that *Chokera* is not included in the Faisalabad city urban area so they are not responsible to construct the drainage system in the village. District government can include Chokera within city area if livestock farms (*Bhanse colony*) would completely remove from the village according to law. However, farmers were not willing to leave their livestock as their major source of income. Concurrently, *Chokera* is situated just next to the city boundary does not link to TMA. Therefore, the PHED department was not involved there.Finally, it was argued that poor health condition within this village primarily was caused by domestic wastewater irrigation. But the absence of a local drainage system would be the main reason.

The Water and Sanitation Agency (WASA), Faisalabad operates within the urban area of Faisalabad. Lawfully, WASA, Faisalabad is responsible to provide and maintain the services as regards water supply, sewerage, and drainage (FDA, 2015). Simply, the motto of the agency is to ‘take away discharge from the city area at any cost’. It regulates the continuous pumping and drainage flow in drains.

Concerning wastewater management, Wastewater Management (WWM) Wing operates the drainage pumping station on both sides of Faisalabad city (WASA organogram was illustrated in Appendix G4). Whereas, the planning of new schemes for the working efficiency of WASA is the responsibility of the Planning and Design (PDD) Wing. Therefore, the PDD proposed new development schemes for WASA’s infrastructure and referred to the Faisalabad Development Authority (FDA) responsible for construction of project. While, WASA has to maintain the infrastructure and ensure sewerage and drinking water do not get mixed. Moreover, WASA can manage a collective treatment plant to treat domestic discharges.

In reality, WASA behaves like a monopolistic authority in the drainage sector and it carries limited responsibilities. It can propose projects and policies on its own. The core objective was pumping and disposing of wastewater out of the city area at any cost. Thus, environmental consideration is secondary.

In terms of hiring, most staff members had been recruited from PHED and most had qualifications and skills in civil engineering (Fichtner, 2006). In 2011, the total staff number was 2,692, including 99 (BPS 17 and above) professionals and 2,593 (BPS 4-16) others. The staffing ratio was eight (staff per 1,000 water and sewerage connections) while the wastewater staff ratio was 4.54 (per 1,000 wastewater connection) (WASA Faisalabad, 2011). Another issue at an organizational level was the aging of its staff members.

Preferably, WASA has to maintain its expenditure by being an autonomous body. However, it had faced a fiscal deficit every year. The revenue (income from water and sewerage connection and other sources) was less than the expenditures (developmental and non-development). Tariff rates for water and sanitation services had been the same since 2006, which was stagnating the revenues. However, the non-developmental expenditures (salaries, pension, gratuity) had increased yearly (Recorder report, 2018). In 2015, 52 percent of WASA's total budget (3,953 million rupees) was non-developmental expenditures. The share of income received from sewerage charges was 43 percent (WASA Faisalabad, 2015). Privatization of billing collection and water metering had increased its revenue. Still, it had lagged behind the expenses. Another non-developmental expenditure was energy ingesting. In case of a fiscal deficit, WASA has asked the provincial government for a grant. No institution can provide standard quality services without financial stability.

The Deputy Director of Waste Water Management (WWM) justified wastewater irrigation because it was a cheap disposal option. He admitted that groundwater composition had been altered in Faisalabad. However, poor wastewater management was not the only reason for this. Additionally, he said that wastewater management has had no impact on health because the disposal took place outside of the urban area. He further mentioned that Wastewater Treatment Plant (WTP) functions efficiently and has a positive impact on the environment. The operational costs of WTP are low compared to other treatment alternatives, and only the desilting (Cleaning of silt and mud from the bottom of ponds) of anaerobic ponds is required. Even then, this would be expensive due to a lack of funds. (Extracts of in-depth interview with WASA official, July 2015)

Finally, yet importantly, another aspect of wastewater management in Faisalabad is wastewater irrigation. In the following section, the role of the Agriculture department in this regard has been analyzed.

ix. Agriculture Department

The practice of untreated wastewater irrigation is directly linkedto the scope of responsibilities of two wings in the Agriculture Department: The Director General Agriculture (DGA) - Extension and Adaptive Research, and the DGA - On Farm Water Management.

The DGA - Extension and Adaptive Research performs the following duties: conducting village-level farmer training, implementing agriculture laws, and collecting feedback on researchable problems. Under schedule II of the 2011 Punjab Government Rules of Business, there was a long list of responsibilities for the agriculture (extension) officers. However, any task or responsibility related to wastewater irrigation, extension services provision about the impacts of wastewater irrigation, quality standards of irrigation water and food safety issues was not mentioned. For instance, the provision of information to farmers on safety measures after direct contact with wastewater was not mentioned in the list of duties of agricultural extension workers. The DGA - On Farm Water Management aims at organizing and registering Water Users Associations (WUAs) of farmers. This office also looks at the renovation, rehabilitation, and improvement of watercourses. Particular problems that farmers face, such as the low supply of canal water at the tail of the water channel, could be handled under their authority.

In regards to the challenges the DGA face, poor human resource management (absenteeism) is a significant issue in the extension department. All the farmers complained that none of the extension officers ever visited their area. The extension officers, according to the farmers, were absent not only for the highlighted issues but also other issues as well. Unfortunately, farmers were also dissatisfied with the performance of the Farmer's Organization in some areas. The role of influential local individuals remains controversial within this area. (Extracts from focus group discussion with farmers (*Chokera, Kajla, Khurianwala, Aiwanwala*), June 2015)

7.4.2.4 Summary

The historical institutionalism of administrative organizations helped us to find out the inherent challenges ministries, departments, and agencies have faced. A comparative analysis concerning organizational resources and their intrinsic characteristics are briefly elaborated in following Table 7.3. The primary focus of such assessment was to find out the unique capabilities of each organization towards possible sustainable solutions.

Table 7.3: Overview of wastewater related institutions

Name of Department	Human resources	Financial resources	Challenges
PCRWR	The total number of employees is 487, including 298 professionals and 189 supporting staff. Developmental professionals are 26	About 292 million rupees allocated in 2013-14, 42 percent of the budget wasused for development projects.	It is a federal-level agency. The scope of liability is too broad while the agency suffers limited capital and human resources.

Name of Department	Human resources	Financial resources	Challenges
	percent of the total staff.*		
Directorate of Industries	The total staff is 400 at the provincial level, including directors, secretaries, and peons.		Limited financial and human resources for collecting and updating the data (Staff Reporter, 2016)
IDD	Punjab Irrigation Department (PID) has more than 50,000 employees, so it is a significant organization by any aspect (Bandaragoda &Firdousi, 1992).		IDD has historically maintained huge capacities regarding equipment and human resources. However, most of the equipment is un-functional due to lack of O&M funds.
PIDA			Most of PIDAs are still waiting to hire staff members according to the plans for their establishment
The Urban Unit	It employed 1,049 staff members in 2014-15, including 704 hired on a temporary basis for specific projects. (Chaudhary, 2015)		Dependency of development projects on the donor's interest, which limits need-based development
Pak- EPA	178 staff members, among them 48 ranksofficers scale (BS 17-22).		Frequent changes in organizations since the devolution plan,the agency does not regularly coordinate with other institutions, (United Nation Environment Progrramme, 2014)
EPD and EPA, Punjab	23 of total staff at district level	Reduction of the total annual budget of the departmentfrom 335 million (2010) to 190 million rupees (Government of Punjab, 2015a)	Scarcity of funds since establishment, limited capacity to implement regulations (Naureen, 2009)
WASA	Total staff is 2,692, including 99 (BPS 17 and above) professionals and 2593 (BPS 4-16) others. Staffing ratio is 8 (staff per 1000 water and sewerage connections), While the wastewater staff ratio is 4.54 (per 1000 wastewater connection) in WASA Faisalabad.**	Total budget is 3,953 million rupees 52% of expenditure is non-developmental expenditures 43% of income earned from sewerage charges (WASA Faisalabad, 2015a)	Deficits mainly due to energy consumption Weak coordination between the agency and other organizations (Ayesha, 2012)

Name of Department	Human resources	Financial resources	Challenges
	(WASA Faisalabad, 2011)		
Agriculture Department			A substantial extension networks exist, but there is a severe lack of coordination and management has restricted the benefits, which envisaged out of this institution. Most of the on-farm water management projects are not effective.

*Estimated as on 2010, February 1

** 2-5 labor productivity ratio per 1,000 connections is suggested as recommended benchmark for water supply sector

Table 7.3 illustrates that PCRWR is technically skilled but lacking in financial resources; Directorate of Industries isentirely incapable of proper implementation of sustainable industrial development due to limited financial, human resources. Even at the policy level, the concept of environmental conservation and industrial development lack coordination and cooperation.

The IDD is a considerable organization with a large staff size. As its official responsibility, the IDD needs to consider the quality of drainage water. It would also generate income, which could be utilized for treatment.

In the case of the Urban Unit, planning and development—based on local needs—are missing from the organizational motto.

EPAs and other environmental-law-implementing agencies are facing the problem of limited resources.

WASA could efficiently control the water pollution, butlimited technical staff and bounded areas restrict its role to protect natural resources.

Last, but not least, the Agriculture Department has a vast network of extension workers. It could play an active role inthe dissemination of safety rules related to wastewater irrigation and the latest information from research.

As sustainable wastewater management is a social and governance dilemma, it is quite difficult to summarize all obstacles. The following section, which lists challenges in wastewater management, is based on the researcher’s self-evaluation in view of all the evidence and arguments.

7.5 Challenges in wastewater management

This section depicts the overall challenges in the wastewater management sector. Using qualitative data analysis approaches, a wide range of problems and consequences related to poor wastewater management in Faisalabad is listed. Investigation with other stakeholders enriched the basic information level until the saturation point. The following challenges are ranked by their prominence using theoretical frameworks content analysis (qualitative data) and critical analysis (departmental reports). After the focus group discussion with stakeholders, in-depth interviews with key respondents were conducted and real-field situations were observed. The leading challenges are summarized under the following themes.

These enlisted challenges are organized using the evaluation criteria of the IAD framework and governance indicators (Bertelsmann Stiftung, 2016; Evans, 2016; IFAD, 2009).The gaps found inpotential (observed) outcomes are compared to previously planned outcomes (desired goals). These gaps or challenges would then be directed to new predicted (policy) outcomes. Policies are like experiments for new rules (Elinor Ostrom, 1998).

7.5.1 Litigation process (enforcement of laws)

The chief flaw in the enforcement of environmental protection regulations has lied behind the prolonged procedure for the judicial trial (Section 4.5.1). After discussing with the assistant director and director of EPA, a few gaps were pointed out on real grounds. Also, judicial proceedings are delayed and fruitless.Concisely, a free-rider problem persists in regulating wastewater pollution.

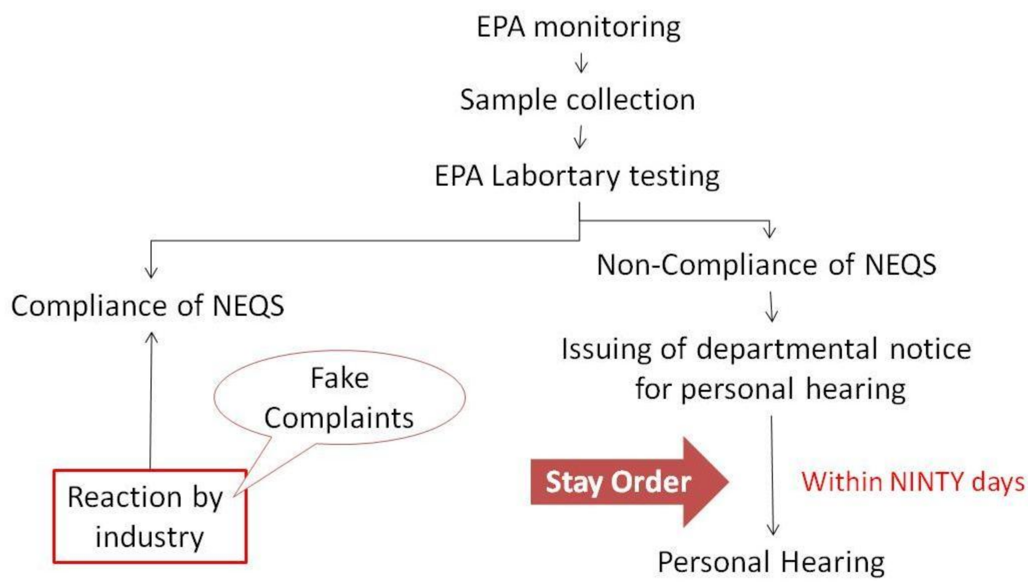

Figure 7.8:Litigation under PEPA, 1997

In Figure 7.7, the whole litigation process is illustrated.

> The lengthy legal process proved to be a major obstacle in controlling the situation efficiently. Usually, the polluter pursued a stay order from the court, to keep the situation unchanged until the final court decision. This position could prolong for years. As a result, the industry was continuously operating and discharging untreated effluents into public drains until the final court decision. If the violation of regulation was proven and the court instructed the polluter to pay a fine and/or to install a treatment plant, the industrialist simply stopped that unit and installed a new factory with a different name in the new area.(In-depth interview with director of EPA, July 2015)

Usually, the polluter was instructed by the court to install the treatment plant within one year. Instead of installing an expensive wastewater treatment plant, the industrialist was given plenty of time to shift the business to another name. Therefore, the whole process has been a loophole.

The EPA official briefed about the complete litigation process under PEPA 1997. Under normal circumstances, the inspector takes three sealed samples of untreated industrial effluent discharged from an industrial unit. This step can be taken either as a response to any complaint or as routine testing. One sample is sent to the EPA lab for testing, the second one is handed over to the industry owner, and the third one is stored for further investigation. In case of exceeding limits on national quality standards (NEQS), a departmental notice (EPO) is issued to the pollutant party for a personal hearing. The party, then, is legally obliged to answer before the District Officer of EPA within 90 days.

Another challenge pointed out were the false complaints by ‘some journalists’ (Such journalist who are reporting some fictitious facts for financial benefits) or rival industrialists about rules violation. If an EPA inspector could not find evidence suggesting rule violation, the industrialist could sue the agency. Moreover, another hurdle in wastewater management has been monitoring the effluent discharges. Mostly, industries had been discharging hazardous effluents at nighttime when there is a lower chance of being caught.

From a policy-recommendation aspect, the EPA cannot propose any project or solution for the specific local situation. Similarly, their financial budget is decided provincially. Therefore, each district EPA office is entirely helpless to control and address its local problems. Still, there is no operational concept of pollution taxes. (Personal communication with EPA respondent, July 2015)

7.5.2 Failure of urban structural planning

Faisalabad has been growing without any proper development plans for the past years. There was no peri-urban architectural plan for city development. With the rapid increase in the demand for industrial labor, residential colonies have been constructed in the surroundings of industries. As a result, industrial, agricultural and residential areas have emerged without any planning.

> In 1968, my textile mill was constructed in the Abdullahpur. It was declared as an industrial area at that time. Afterward, the industrial workers and rural migrants shifted to

adjacent areas. Recently, this area converted to a residential area for low-income communities. Now everyone is blaming the industries for pollution and suggesting to shift these industries somewhere else. It is the failure of all management bodies, including the city district government, Faisalabad Development Authority (FDA) and TMAs.(In-depth interview with the owner of M.A. textile Private Limited, July 2015)

The search for a structural plan in Faisalabad directed the researcher to the city district government and the Urban Unit. The prescribed story Faisalabad's urban planning is based on the available evidence (Box 2).

Box 2: Review of the structural urban planning of Faisalabad

After independence, the 'Master Plan of Greater Lyallpur' was prepared during 1962-1968 for the first time. This Plan was only partially implemented, which caused an uncontrolled and chaotic growth. At that time, no qualified town planner was working in a municipal corporation. Therefore, no one was able to understand the policies of the document. A weak institutional setup, inadequate financial resources and a lack of political will were also key impediments (Hassan, n.p.). After the establishment of FDA in 1976, the first initiative to prepare a 'Master Plan' took place in 1979. The FDA did not hire any consultants because the government was focused on reducing the scope of work so that the Plan would be prepared within two years. Consequently, in 1981 the FDA prepared a Plan by its own and finalized PC-II (feasibility report). Regrettably, a separate Directorate of Structure Plan was established in 1982, which started the plan preparation process. The process, however, was too slow that only surveys were conducted during the next two years. In the meantime, the Directorate faced organizational transformation and was renamed as the Directorate of Environment Control (DEC). A draft of the Plan was reviewed by consultants and key stakeholders. After the final clearance, the draft was submitted to the Housing and Physical Planning Department. Nonetheless, the Plan was never approved.

The FDA implemented some components from the Plan in bits and pieces half-heartedly. The FAD Master Plan in 1994 was much similar to the Structural Plan of 1986. Thus, the divisional commissioner and civic agencies in Faisalabad started to implement the FDA's 1986 Structural Plan on their own. This remained in practice until 2000 when the local government assumed authority. In 1997, the DEC again realized the need to update the plan. This time, however, resources influenced the pace of work because authorities were unable to find town planners. Eventually, the DEC stopped the updating process.

Sources: (Sultana, 2010, p. 23; Government of Punjab, 2011, p. 14; TheUrban Unit, 2015, p. 48-57)

The Structural Plan of 1986 faced many obstacles. The projected population growth was lagging behind the real population growth (Government of Punjab, 2011, p. 15). The reason was to project a lower population density than the immigration population from rural areas. The projection of land utilization for industries was also unrealistic with more than one percent reduction of area. The Plan divided the whole city into residential, commercial, and industrial zones but it did not explain any zoning regulation. The real strategic planning was absent from the Plan which lacked a clear vision (Sultana, 2010).

The Master Plan of 1994 successfully implemented some proposals such as relocating the vegetable markets and dry ports and shifting land uses (Government of Punjab, 2011, p. 12). However, This Plan could not pave its ways because there were no periodical updates on identified projects and there were financial constraints(The Urban Unit, 2014, 2015).

After the devolution plan, Faisalabad achieved city-district status. The Works and Services Department of city-district government, which works under the Town Administration according to the LGO 2001, was then responsible for planning and implementation. From 2004 to 2009, with the assistance of international agencies and local philanthropists, the city government developed and implemented many strategic, operational plans.Such plans were short-term development plans proposed to direct the attention of all stakeholders to something common to many of them and to prioritize those agendas. During the Strategic Development Plan 2006-2001, the city government proposed constructing three more sewage treatment plants but it was not implemented. Because of the frequent changes in government and implementing officials and financial constraints, any plans could not be properly implemented(Government of Punjab, 2011, p. 13; The Urban Unit, 2015).

In 2015, the Faisalabad Peri-urban Structural Plan FPUSP 2035 was approved and implemented. City areas were allocated among zones and zoning regulations were stated (The Urban Unit, 2015). However, plans regarding wastewater treatment or separate collection of industrial discharge were not clearly visualized (see appendix A4).

7.5.3 Nepotism

The bureaucracy of Pakistan has a long history and Pakistan has continued policies and procedures from its colonial past. The colonial bureaucracy has stemmed from the exercise of power (authority) rather than service (Shahzad, 2017, p. 20). The ‘governance in public interest’ is absent. The mentality to ‘rule’ and not to ‘serve’ was inherited from officials from the previous establishment. The hidden informal rules provide the grounds for official proceedings; virtually, after confirming the substantial and direct benefit it would receive from participating in public administration, any department can wholly support the elite group(Davis, 2004).

The concentration of power in the hands of a small number of authorities at multiple levels of government (including national level) is main chrachteristic of ‘monocentric governance.’

38

SCHEDULE

Name of the Department	Pay Scale	Name of the post	Appointing Authority	Minimum qualifications for initial recruitment	Method of recruitment	Age for initial recruitment		Remarks.
						Minimum years	Maximum years	
WATER AND SANITATION AGENCY OF THE Faisalabad Development Authority Finance and Administration Wing.	Grade 20	Managing Director	Government	-				
	Grade 19/20	Deputy Managing Director	do	-	By deputation from the Govt. or by promotion from amongst the senior most Director Engineering who hold at least B.Sc. Engg. Degree.			
	Grade 19	Director Administration	Director General	-	By deputation from the Government or promotion by selection on merit from amongst the 3 senior most Deputy Directors with at least 12 years service in Grade 17 or above including 5 years service in Grad 18.			
	Grade 19	Director Finance and Director Revenue	Director General	-	By deputation from the Government or promotion by selection on merit from amongst the 3 senior most Deputy Directors (Finance and Revenue) with at least 12 years service in Grade 17 and above including 5 years service in Grade 18.			
	Grade 18	Deputy Director (Administration)	Managing Director	-	By deputation from Government or promotion on the basis of seniority-cum-fitness from amongst the Asstt. Directors (Administration) with at least 5 years service in Grade 17.			
	Grade 18	Senior Special Magistrate	Government	-	By deputation from Government.			

Figure 7.9:Recruitment requirement for managing director of WASA

Source: Faisalabad Development Authority (Appointment and Conditions of Service) Regulations 1990, Schedule, page 38, for the appointment of Managing director of WASA

The authority of decision-making resides at the top level, such as in the EPA, WASA, IDD, and PIDA. Personnel for such top-ranking posts is recruited the positions are used for political and financial interests. The recruitment procedure and the required qualifications for managers and directors of these organizations (federal and provincial) are vague and no not favorable for lower-ranking staff members to apply and even for selection of similar and lower staff officers (see Figure 7.8).

In most cases, these top rank posts are appointed on political grounds, recommended by the ruling government. Political and family background also influences the selection criterion regardless of the qualification and aptitude of the candidate. The Managing Director of WASA or the heads of other departments such as EPA and IDD—possessing the authority to regulate departmental affairs—sometimes are not capable of administering the department. Consequently, it restricts the overall efficiency of the organization.

Another kind of nepotism, intra-institutional politics that badly affects departmental decision-making procedures has explored. The EPA Director used the term ‘departmental references’ to clarify such influences or interactions. In fact, it negatively affects the public administration operations.

> External political pressure only hinders the organizational operations in extraordinary cases. Usually, the pressure is exerted from within through our department colleagues or seniors. The interference of any departmental colleague either in favor or against the

pollutant party or on any departmental inquiry immensely affects the investigation process. (Director EPA informed during in-depth interview, July 2015)

While dealing with the inquiry proceedings, most public administrative organizations face the issue of departmental references than other forms of corruption such as bribery.The gatekeepers, influencers (junior staff), and seniors (own department) can directly influence the decision-making process of the decision maker (designated officer). (Personal communication with EPA respondent, July 2015)

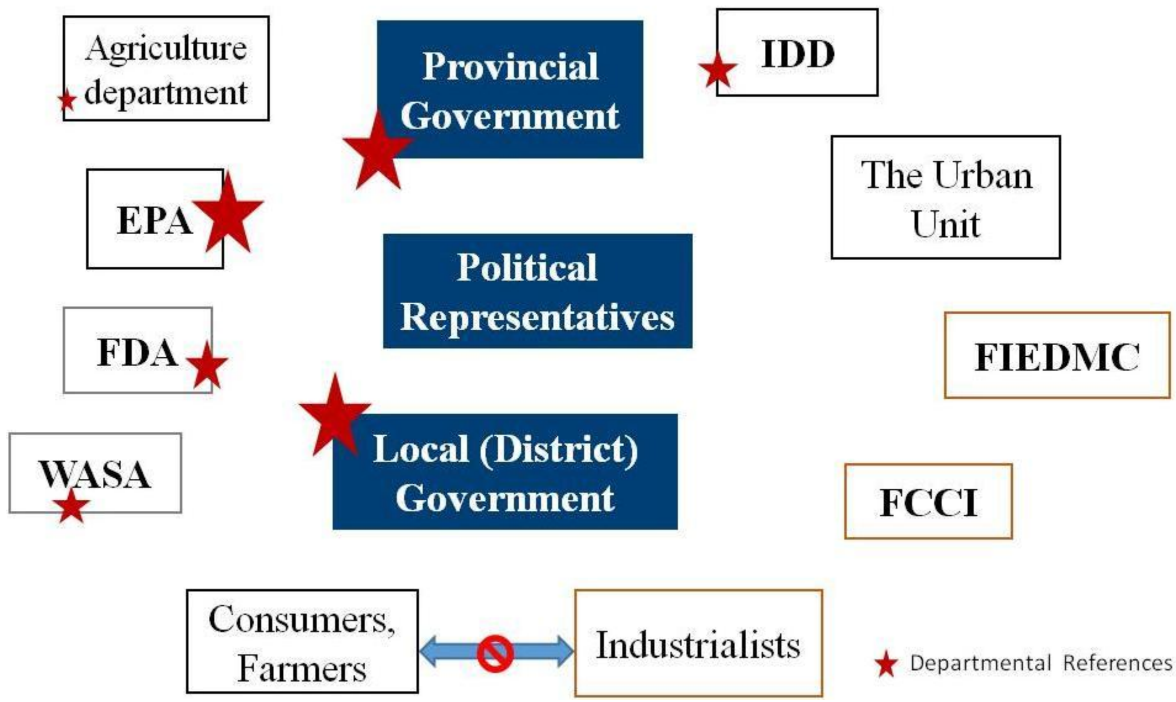

Figure 7.10:Incidence of intra-institutional politics

The prevalence of such influence is depictedin Figure 7.9. The size of the star refers to prevalence within each department. (Extracts from in-depth interviews with EPA officials, July 2015). The bigger the size of the department (number of employees), the higher the level of red-tape bureaucracy is. It automatically increases the size and number of influences. The bitter story of departmental references is quite evident for every civil servant. Such pressures even threaten the job satisfaction level. In case of disobedience to departmental references, the decision-maker faces lobbying against him at his workstation. 'Never say no to your seniors or bosses' is one of the unspeakable and ultimate rules for every public servant. The prevalence of departmental references is directly linked to a centralized government structure. Some other researcher used the term 'toxic worker' to express such phenomenon.

A quite unusual tactics 'juggling inquiry reports' was reported while exploring the corruption in public administration (see box 3).

Box 3: Juggling inquiry reports

Another insider story regarding departmental inquiries was brought to the researcher's attention. Departmental inquiries are normally arranged to investigate any issues about departmental officials or official complaints. The complaint may be regarding the use of authority by some official. Primarily, the inquiry committee is selected at the departmental level and the number of committee members varies depends on the concerned department's head authority. The inquiry officer is the head of the committee; often, he is the well-experienced department staff. He is responsible for finalizing the comments regarding the complainant and the involved officials and witnesses after the investigation. He is also responsible for submitting his final decision, in written form, to the head of the department who arranged this inquiry. At the end of the inquiry, the appointed inquiry officer writes the inquiry report in a juggling, abstruse way (in official English language). As it is hard to understand his final decision for both the victim and the offender, the ball is on the court of the decision maker (head of the department) who can use this report for announcing the decision in the favor of the party who can bribe him more. (Extracts from discussion with junior staff of ´anonymous´ public department on the topic of 'bribing within department', July 2015)

7.5.4 Influence and deterrence due to the bonding of social capital

Although formal inter-organizational links was lacking, however, individuals could influence the departmental proceedings through political (politicized bureaucracy) and private links (Shahzad, 2017, p. 24). The political environment always plays a crucial role in the failure or success of any public organization. Mostly, politicians are a member of leading groups of a society that include 'landlords,' industrialists, or any influential ethnic group in Pakistan. Such groups exploit politicians to achieve personal interests. In return, politicians receive personal favors or benefits. In Faisalabad, industrialists are a dominant influential group as either a political body or a supporter of a political figure. These industrialists persuade public management to support the relaxed enforcement of regulations.

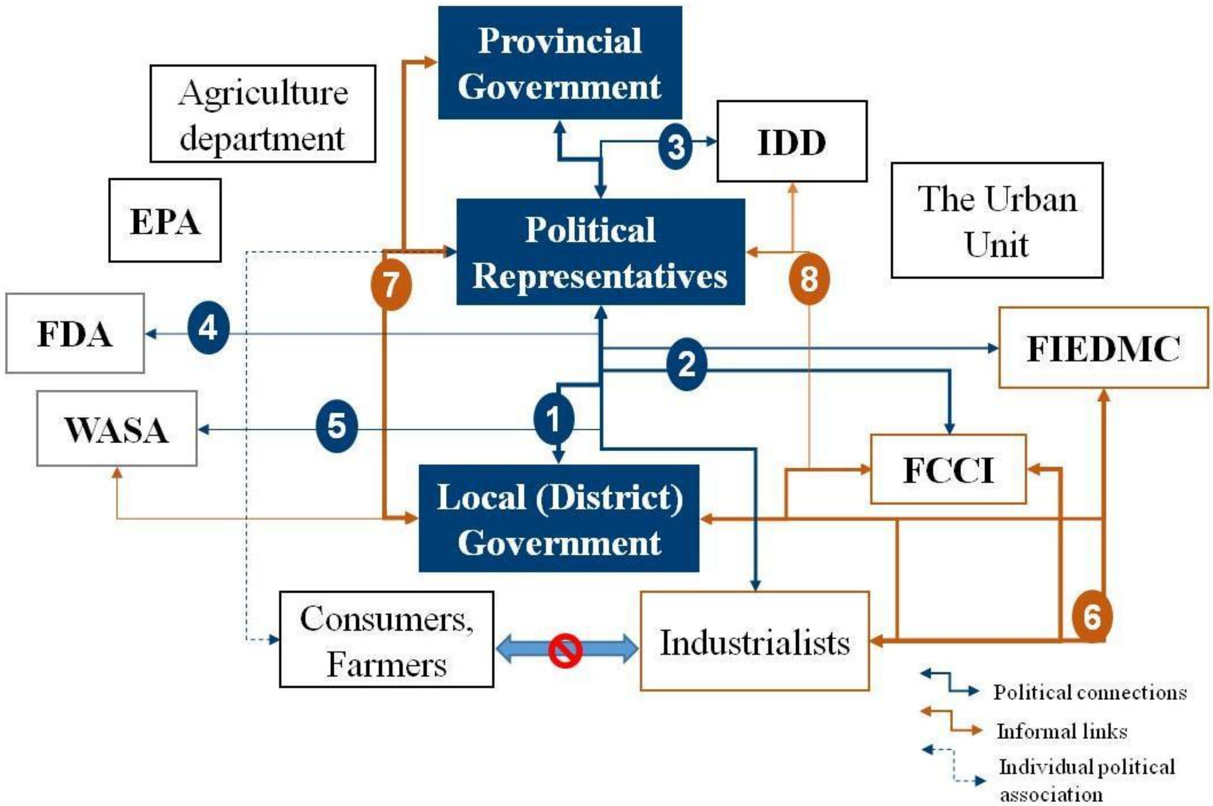

Figure 7.11:Influence and deterrence based on political and informal connections

Here, the influence of social capital over the desired administrative duties was observed. Figure 7.10 explains the contacts and links in society (social capital) which influence the departmental proceedings. The mapped information was collected from stakeholders using qualitative data collection techniques. The numbers describe specific interactions between stakeholders. No doubt, social capital (political, informal, regional, social, and cultural) could help manage collective action problems. Such contacts can develop from political grounds, ethnicity, family relationship or financial class (status). Consequently, such links—in case of any departmental inquiry—affect a particular decision to be influenced. Mostly, these links are in the favor of the strong party (either politically, or economically). Within our context, the influence of social capital interrupts the impartial proceeding of institutions.

In Figure 7.10, dark blue arrows represent the political influences and brown arrows represent other informal interactions among stakeholders. Through the head of each department, politicians (depicted by blue rectangles) insert direct influence at provincial and district governments. Another link is between political members and industrial organizations. Third, political influence can be found in IDD (at Water User Association and Farmer Organization), especially in the west circle of Faisalabad (*Khurianwala*). Fourth and fifth numbers pointed out the appointment of political (locally elected) agents to top managerial positions in administrative organizations (such as FDA and WASA). Also, informal links among industrial groups exist for mutual benefits (number 6). The seventh link represents strong unofficial references among bureaucrats at each level (secretary office—chief minister staff—district government officials). Last, the eighth one symbolizes the influence of a local influential group on the functioning of WUAs or FOs.

7.5.5 Feedback and learning from experiences

A feedback system for a public institution that provides any good or service is key to improvement and efficiency.

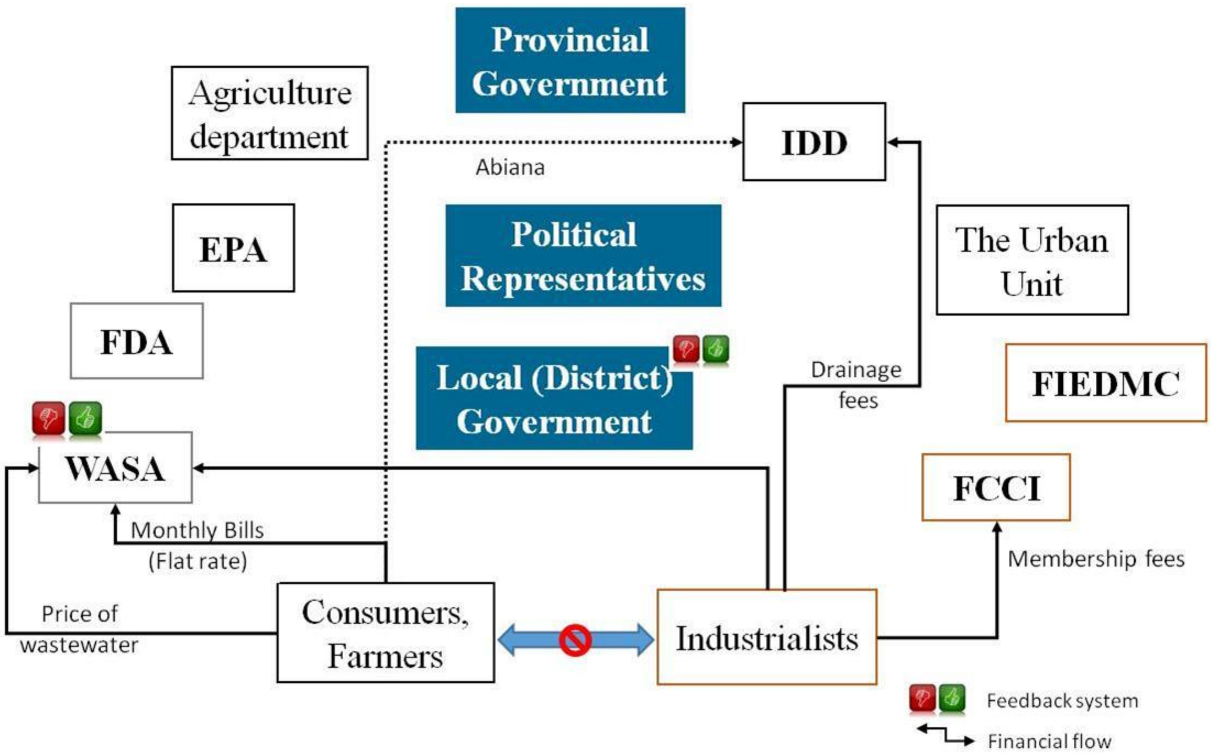

Figure 7.12:Ascendency system

Officially, the feedback system functions at the district government office (Figure 7.11).The traditional procedure to file a complaint in the DCO office functions without any efficient output. One can submit his complaint to the district office but normally it takes months to get a formal reply. Most of the time, the complaints are being rejected, especially if they are against some elite group or government organization. (Extract from the interviews with farmers at *Kajla* and *Khurianwala*, August 2015)

The consumers or buyers are paying WASA and IDD but there is no effective complaint system. WASA recently set up a complaint call center but it only addresses blockage of the drainage system within the city area. Poor feedback systems in regards to the quality of service delivery hamper the performance of the department. Overall, there is no problem-solving attitude.

7.5.6 Absence of inter-institutional official interactions

Furthermore, another reason for a poor governance system within public organizations is weak linkages between governmental organizations (hierarchal terrain of organization setups, attached in Appendix G).

Absence of formal linkages among public institutions (such as Agriculture Department-IDD, IDD-EPA, EPA-WASA, and EPA-Directorate of Industries) hindered the simultaneous execution of policies. Linkages here referred to both informational and operational links. Such poor collaboration among organizations was widespread over the entire system of public governance.

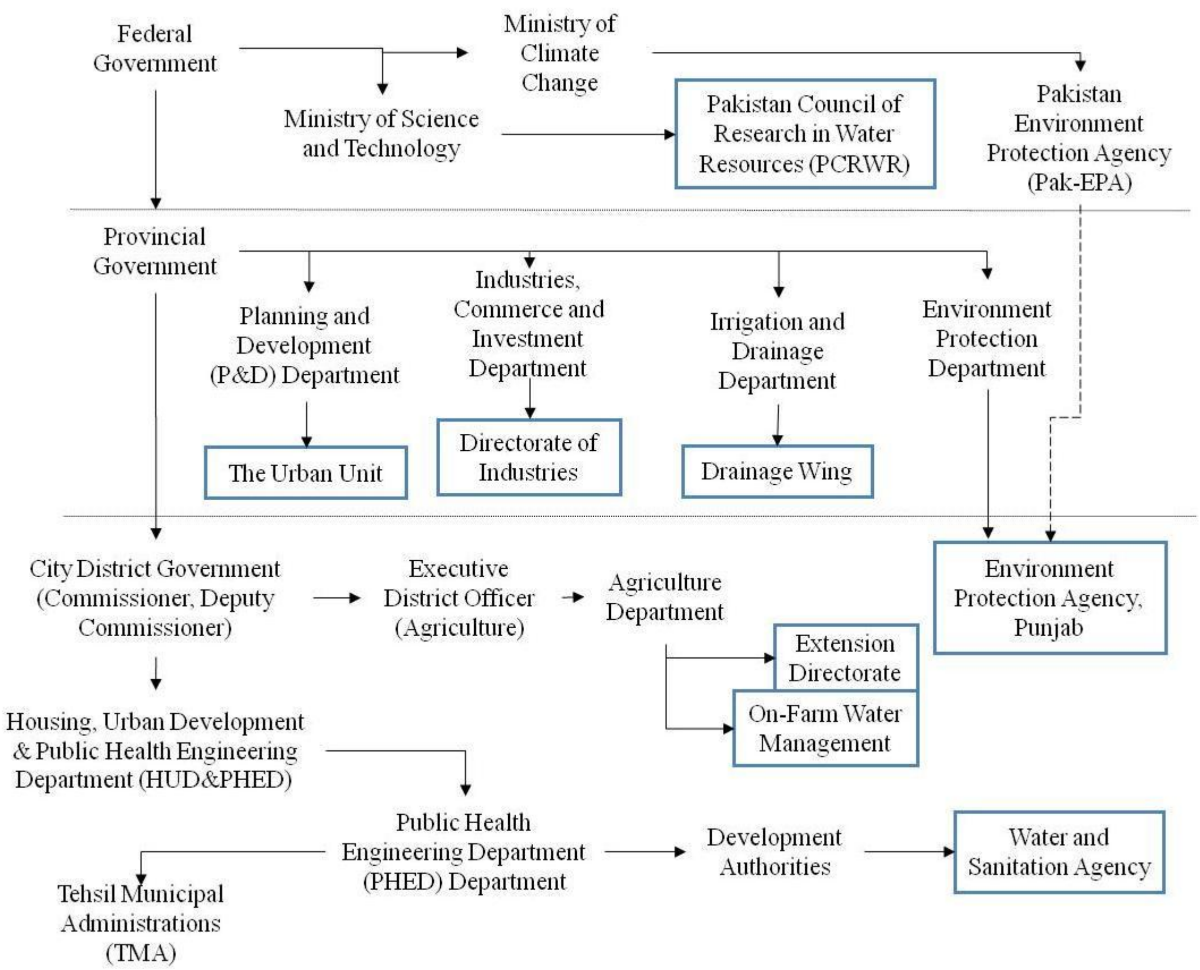

Figure 7.13:Institutional terrain of administrative organizations

Multi-level governance is depicted in Figure 7.12. The hierarchal arrangement showed the vertical hierarchy among these institutions. These top-down administrative institutions were responsible for the proper functioning of full governing machinery. The wastewater management was governed at three different administrative tiers.The organizations bordered in blue were included in the stakeholder analysis in 2015. Inter-institutional formal interactions were lacking across these studies organization. Particularly, insubstantial organizational interaction was observed between Pak-EPA and provincial EPAs (presented by dotted line).

7.5.7 Wastewater as a negligent resource

Concerning this study, water is a limited resource and such situations are becoming increasingly alarming (The World Bank, 2005). Wastewater is the only resource that is ever increasing under such circumstances. An efficient wastewater management sector is lacking and is missing from future strategic planning. The consideration of wastewater as a problem and not as a resource has been explored with evidence.

Actors involved with wastewater management such as industries, commercial users, local authorities, farmers, and regulating and implementing agencies advocate their own interests. Farmers are the weakest group with the least appreciation of water for commercial use (do not want to pay more than canal water charges). For instance, in case of *Kajla* village, farmers were well informed about their issues and want to solve them.On weekends, they gather at *Numberdar*'s kiosk and discuss their problems. Even they submitted their application to the DCO in Faisalabad, but all ended in vain.

> About 15 to 16 research parties visited this area during the last 10 to 12 years. Nevertheless, practically no significant policy has been adopted and implemented for the betterment of the situation. (Focus group discussion with *Numberdar* of *Kajla* village, June 2015)

Such situation reduced the trust of farmers on researchers and policymakers. *Numberdar* (collector of canal water charges from farmers at the village level) mentioned that the main reason is the lack of personal interest from researchers. Practically, no one considers wastewater as an alternative water resource for irrigation. Wastewater generation is not an actual problem. Ultimately, population and industrial growth took place and the absence of proper management caused the problem. (Extracts form discussion with *Numberdar* of *Kajla* village, June 2015)

A similar situation exists at the IDD. The IDD charges an annual fee of 35,000 rupees per outlet from each industrial unit for providing the dumping facility of effluents into their storm drains. However, the IDD does not collect any fees from WASA for dumping gallons of untreated wastewater into the drains (IDD officials informed). It is a managerial gap or deliberate ignorance, which, if corrected, may generate revenues and regulate the water market.

Ignorance about safe wastewater irrigation from the extension worker's list of duties was also an observable fact. All farmers from various sites reported that extension officers (agriculture officer) never visited them. Therefore, the information concerning safe wastewater irrigation and food safety was never delivered to them through any source.

7.5.8 Infeasible solutions or Blue Print

Ostrom (1990) used the term "Blue Print" in reference to some successful solutions that were applied to the same problem but in a different locality. Mostly, such solutions failed andpolicymakers could not achieve the desired outcomes. The reason lies behind the adoption of strategies that were not compatible with ground realities (Anderies, Janssen, & Ostrom, 2004, p. 2;Ostrom, 1992; 1999, p. 7; 2004;2009, p. 25;Lam & Ostrom, 2010, p. 2).

The same situation (Blue Print) also exists in the wastewater management sector of Faisalabad. Generally, foreign consultants (companies or organization) conductthe feasibility study and propose the planning, implementing, and management schemes for development project. In most of cases, such proposals were prepared considering hypothetical or unreal information. As, no baseline data was available to guide them to the real prevailing situations. Even inputs from local holder and implementing institution were deficit while preparing such recommendations. (verbal communication with EPA respondent).

For instance, industrialists of Faisalabad were not in favor of installing a sophisticated technology to perfectly treat industrial effluents at each industry level (Aftab, Ali, Khan, Robinson, & Irshad, 2000, p. 122). One of them explained in detail that absolute, perfect enforcement of laws could stop the industrial wheel for economic development. He further mentioned that an industrialist had to compromise with the laws a bit to maintain his returns, especially for an industrialist of a developing country like Pakistan. Otherwise, the country cannot compete in the international market (compared to India and Bangladesh in the textile sector) for our export-oriented products. (Interview extracts from chairman of M.A. textile)

> Recently, azo-free dyes are applied in the dying process, which is not hazardous to the environment. Therefore, limited treatment for textile wastewater is required. Only a physiochemical treatment such as sedimentation ponds can fulfill the requirement of textile wastewater treatment. Expensive scientific technology will increase the cost of production, which enhances the risk of losing international buyers in the competitive world market. (In-depth interview with the chairman of FCCI describing water pollution by textile industry, July 2015)

Azo dyes are the group of synthetic dyes,which are included in 'German banned dye list' due to being potential carcinogens. He also further clarified his opinion on the infeasibility of every industrial unit installing a treatment plant:

> At present, everyone emphasizes installing a wastewater treatment plant in each industrial unit, as the last option. If each industry treated wastewater individually, it would not manage to find the alternative for sale. Consequently, everyone would has to dump the treated expensive water into the public drain having polluted water. (In-depth interview with chairperson of FCCI describing the industrial's point of view, July 2015)

The economic and social aspects of wastewater recycling are still unknown, which are the main obstacles for the private sector's invovlement in wastewater management. There is no market to sell the treated water.

The primaryemphasis of most of new proposed was to construct a collective wastewater treatment plant at the drain level. As, current development schemes for sustainable wastewater management were reviewed in the next chapter. Practically, it would be infeasible due to massive financial costs including construction and operational costs.

> A centralized treatment plant is neither feasible nor affordable with international standards. (In-depth interview with Assistant District Officer of EPA describing the hurdles for planning the WWTP, June 2015)

A collective treatment plant cannot be a feasible solution until a separate drainage system for industrial and domestic effluents would be developed. This option would only be a possible solution if treatment would be done based on type of pollution. When industrial wastewater drainedand treated separately, industrial units would pay installation and operational fees based on their volume and nature of the discharge.Otherwise, all system would fail to operate sustainably. (Extracts from in-depth interview with chairman of FCCI describing the industrial's concern with centralized wastewater treatment plant, July 2015)

Another option for tackling wastewater management problems is flow segregation. The flow segregation would reduce the treatment cost of collective effluents. On the other hand, constructing a flow segregation system would be the opening of a new Pandora 's box.

> The system is too old and cannot change within days. To change it, we first have to stop the machinery, and practically speaking, this is not affordable. (In-depth interview with director of Wastewater management [WWM] wing, WASA, June 2015)

Developing an industrial estate was considered as the most suitable solution to control industrial pollution. Such an estate would have a proper drainage system. Recently, 200 industries selected to relocate their units to the M3 Industrial Estate of *Sahianwala*. The process of relocating industrial units from Faisalabad's urban area to an industrial estate also faced many hurdles that make this process slow (Saleem, 2013). Future consequences with these industrial estates were still unknown. The industrialists, who were reluctant to relocate, required assurance that the same situation would not repeat in the future at new place. Recently, all these industrial estates have established away from residential areas. However, after some time, workers and employees may start to buy land near the industrial estate for residence purposes. In this context, the environmental issue caused by industrial pollution may again rise in this area. (Extracts from the in-depth interview with industrialist, July 2015)

7.5.9 Blame game

Mismanagement of sustainable wastewater in Faisalabad faces a situation where no one is willing to accept the responsibility; instead, one is just blaming others for his or her malpractices.

While evaluating the efficiency of development projects Ostrom (1992, p. 16-17) cited Freeman and Lowdermilk (1985) and shared an interesting insight on the blame game.

> "The first phase is the designers' high enthusiasm and publicized expectations. Second comes disillusionment, when the implementors discover that the designs are sorrowfully

inadequate. The third phase is one of panic, when the operational staff discovers that the system will not operate as designed. Fourth comes the search for the guilty, characterized by a round robin of blame among designers, implementors, operators, and extension workers. Naturally, the fifth phase consists of blaming the innocent-that is,the farmer who had nothing to do with designing, implementing, operating, or extending the system. Thus, reports sadly conclude that ignorant and stubborn farmers remain set on destroying structures, stealing water, and creating all kinds of other problems and in general will notcooperate with well-meaning project authorities. Phase six is the time for praise; if a system works at 40 to 50 percent of design efficiency the praise and honor for the success go not to the planners, engineers, technicians, or the farmers, but the politicians."(pp. 91-92)

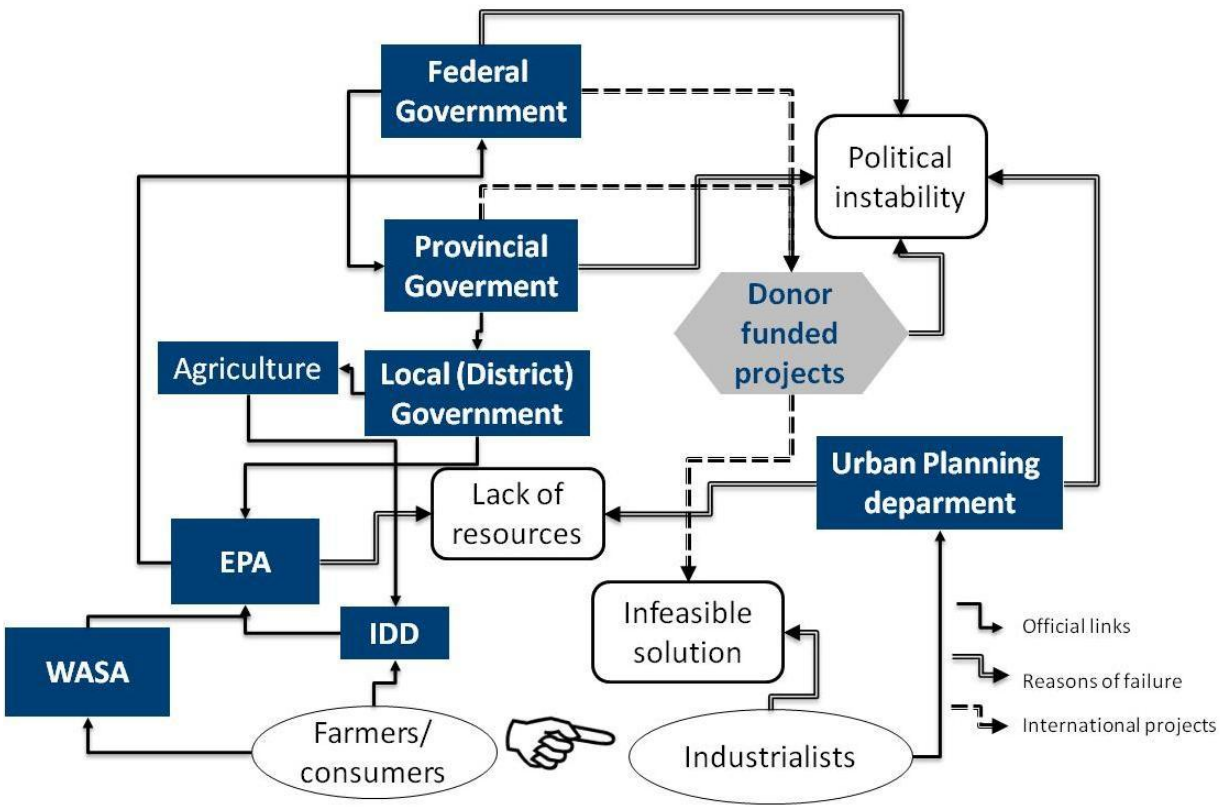

Figure 7.14:The existent blame game

Figure 7.13 depicts the existing blame game among individuals, governing organizations and investors (parties concerned). Black bold arrows indicate official links between public institutions but also tell the story of who is blaming whom. The shaded gray arrows indicate the reasons for poor management. Moreover, the dotted black lines reveal the role of internationally funded projects. The information regarding the "blame game" was collected through focus group discussions and in-depth interviews with stakeholders.

The local community pointed at industrialists and blamed them for all kind of pollution. At that time, it ignored the benefits of industrial production. Next, the local community blamed the ‘government’ by stating that the government is doing nothing. Although the IDD and WASA are directly linked to wastewater management, both organizations considered that EPA is responsible for environmental protection. The Pak-EPA, accused of poor enforcement (under MoCC), answered that now the environment is subject to provincial government’s administration under the 18th amendment; in return, the provincial government answered that such responsibilities and authorities have been delegated to the district government. District government deflected such blame to the lack of resources. Further, the federal and provincial government depended on internationally funded development projects due to the limited development budget. Infeasible solutions proposed under such projects were the imaginary exercise of external consultants. Such solutions were not fruitful because they lacked inputs from the local community and implementing agencies. Not surprisingly, the international community blamed the political instability and corruption in Pakistan. The blame game never ended. The game can only end when everyone stops blaming others and starts improving his part.

7.6 Summary and conclusions

This chapter’s primary goal was to address wastewater management as a governance dilemma. Gaps in sustainable wastewater management existed due to the nature of the goods or services provided by the wastewater management sector. Furthermore, CPR involved in this sector was discussed in detail. After defining all stakeholders linked with wastewatermanagement including governing institutions, attributes framed at three institutional levels were described.

The most important objective of this part of the study was to identify some of the specific governance challenges in Faisalabad city regarding urban wastewater management. Therefore, coding specific themes identified the governance challenges in the wastewater management sector, which helped to address potential improvements in wastewater management. The entire process of a lawsuit against violators was lengthy and the verdict ended up being a nominal punishment. Ultimately, violators benefitted through legal loopholes and implementation gaps. A properly coherent policy for sustainable wastewater management was lacking at the district level for all concerned authorities.Such qualitative study helped to point out the cause of this mismanagement:consistentlyweak communication between ministries and other government authorities.

8. CURRENT AND FUTURE POLICY INTERVENTIONS

The chapter is intended to explore the present and future development projects in the wastewater management sector of Faisalabad. First, a brief narrative of the planning process for development projects in Punjab is described. Second, a review of the current development projects (national and international)linked with any aspect of wastewater management is discussed. Thirdly, a few methods for potential strategy-level interventions are exercised using the already collected information (qualitative data).

8.1 Planning of development projects

At the provincial (Punjab) level, PND is responsible for all future development projects in every sector either ADP (Annual Development Program) or MTDF (Medium-Term Development Framework) for three years. The authority to accept or reject proposed projectshas varied depending on the nature of the project, the involvement of foreign partners, and the cost of the project. The detailed procedure for approval of schemes is elaborated in the 'Punjab Planning Manual'. The project is thoroughly reviewed through a strict criterion by the PND board(Government of Punjab, 2015).

8.2 Current development projects

A review of ongoing and new proposeddevelopment projects concerning sustainable wastewater management is evaluated in this section. All current national and international development projects within our study of concern are considered and examined to depict the premise of the current planning. It further guides us towards the gaps in current planning within the wastewater management sector.

In Figure 8.1, recent on-going development projects and schemes are elaborated at the stakeholder level. The grey circles represent different foreign-funded projects, whereas the black star represents national development schemes. The numbered international projects are divided into different government institutions. The black, dotted arrow represents the national development funding to the locally elected members (MPAs or MNAs) for the development of their area. These development schemes completely depend on the political will of the provincial government. The black arrows represent the national funding of institutions for approved projects.

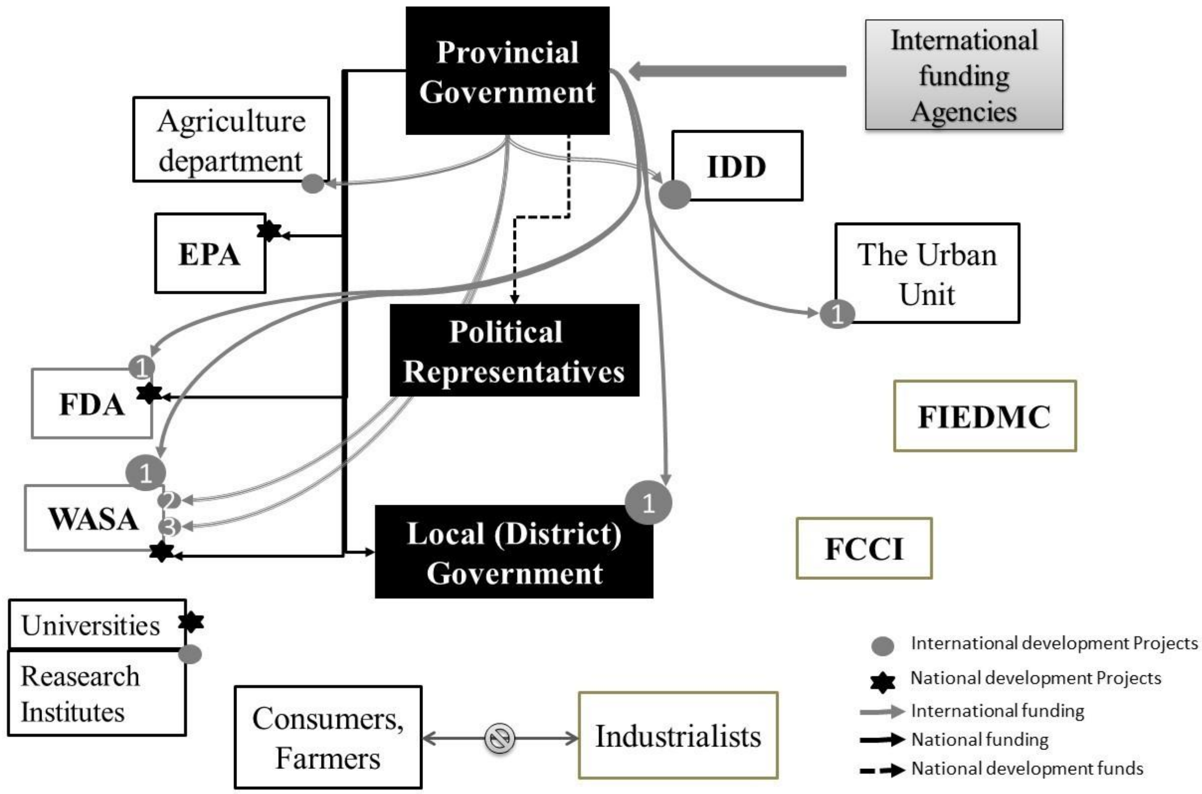

Figure 8.1:Development projects and schemes

Administratively, international donor agencies have supplied the entire financial outlay to the provincial government's account, and the funds have been further released to responsible authorities for specific development projects. This step took place for the transparent use of funding. The provincial government manages the foreign-funded projects using their civil framework and even takes part in some projects as a partner. The PND also aids managing these projects through 'The Urban Unit'.

8.2.1 National development projects

It was evident from the review of the development program planned by the Punjab government that national development projects for sustainable wastewater management were limited (CDG Faisalabad, 2012; Government of Punjab, 2014).Although the distribution of development funds across departments may vary over time, the distribution of development funds during 2014-15 may elucidate the vision for future planning with respect to sustainable wastewater management.A few highlights from the 'Annual development plan 2014-15' are described below.

The development projects in IDD primarily focused on irrigation infrastructure and PIDAs. Overall, four drainage and rehabilitation schemes were in progress and seven schemes were further proposed provincially. However, no drainage development scheme for Faisalabad proceeded and future projects were not proposed. The same situation existed in the Agriculture and Industries departments. Development schemes in the agricultural sector targeted facilitating agricultural research. In the environment department, overall, there were five on-going schemes and five were additionally proposed provincially (p. 435) but the target was for the whole province. Therefore, the scope was limited.

No regular rural and urban sewerage/drainage scheme in Faisalabad had been proposed under the water supply and sanitation sector to achieve the MDGs. In contrast, two urban sewerage/drainage schemes (in *Khurianwala* and *Samundri* tehsils) were ongoing under District development program(DDP) and two additional schemes were proposed.

Mainly in WASA-Faisalabad, four sewerage schemes are in progress. Furthermore, six schemes were proposed, including two foreign aided projects. (for detail see Government of Punjab, 2014, p. 325, 329)

8.2.2 Current international development projects

The big development projects were mostly internationally funded in different ways, such as loans, grants, or technical assistance. The details of current international development projects within the wastewater management sector are summarized in Appendix F. The role of the World Bank (WB), the Asian Development Bank (ADB), and the Japan International Cooperation Agency (JICA), as international funding institutions, was too prominent, especially in the wastewater management, urban development, and environmental protection sectors in Faisalabad. Here, the current involvement of these funding institutions and others is discussed in the following subsections.

8.2.2.1 Projects funded by World Bank Group and Asian Development Bank

The World Bank has provided substantial financial assistance to Pakistan, especially in the irrigation and agriculture sector. Likewise, the Asian Development Bank (ADB), as a financial partner of WB, also played a vital role in financing the development projects in Pakistan. However, no prominent project is currently funded by ADB within the wastewater management sector in Faislaabad[9].

Recently, WB funded the most important project “Punjab City Governance Improvement Project” (PCGIP) to improve the governance capability of five major cities in Punjab Province, including Faisalabad (details in Appendix F). The project covers two sectors, first is sub-national government administration and public administration, and second is information and

[9]Being the most significant development partner, ADB provided more than 25 billion dollars in the form of loans, and more than 200 million dollars in the form of grants until the end of 2014. The purpose of this funding, including 316 loans, was to support the projects to improve the infrastructure and services sector.[9]The financial support in the water management sector also carried out. The *“Punjab Community Water Supply and Sanitation Sector Project”* launched from 2003 to 2007. The financial outlay was fifty million US dollar (Asian Development Bank, 2006: p 259-263).

communication. Under this project, WASA Faisalabad has improved its infrastructure and revenue collection system. According to the World Bank, the current rating of this project is satisfactory (Directorate General Monitoring & Evaluation, 2016; World Bank Group, 2015).

Under the umbrella of the “Punjab Green Development Program,” EPD Punjab and the government of Punjab initiated another project called “Environmental and Social System Assessment” (ESSA). The World Bank would also fund ESSA that runs 2018-2023. Under this program, disbursement-linked indicators (DLI) 1-Improving EPD capacity, DLI 2-Air, and Water Quality Monitoring, and DLI 3-Disclosure of Environmental Information and Citizen Engagement are targeted (The World Bank, 2018; World Bank and Government of Punjab, 2012).

Both projects involve huge financial outlays. As the government of Punjab is a partner to these projects, the political will of the government will be the main driver for the direction of these projects. Currently, these projects are in progress, and the final evaluation after the project completion can inform the effectiveness of these projects on local bodies.

8.2.2.2 Japan International Cooperation Agency (JICA)

As an investment partner, JICA participated in Pakistan’s development projects (JICA, 2007,2012b, 2014). Its activities, especially in the water management sector, were highly admirable (JICA, 2008, 2014b). JICA supported supplying drinking water for three million inhabitants as well as providing sewerage facilities for six million people all over Pakistan. These particularly challenging issues, such as supplying drinking water and operating a sewerage facility, have improved through the assistance of JICA (JICA, 2016b).

In Faisalabad, JICA’s assistance, in water and sewerage projects, has totaled 6.6 billion yen (approx. 5.5 billion rupees) in the past decade. In addition, JICA greatly contributed to improving the capacity of WASA Faisalabad so that the city could become a role model in the country. In 2014, the "Project for Upgrading of Mechanical System for Sewerage and Drainage Services in WASA Faisalabad" launched (Newspaper’s Staff correspondent, 2014).

Figure 8.2:Image showing Photo of dumping trucks funded by JICA

Source: Image downloaded from JICA press releases(JICA, 2014)

JICA provided WASA the pumps and other equipment needed to improve sewerage and drainage system in the third most populous city of Pakistan (Figure 8.2). Under this project, pumps and cleaning equipment were replaced to reduce damages from flooding, which chronically hampered the lives of Faisalabad residents.

The other on-going projects are "The project for Replacement of Pumping Machinery at Inline Booster Pumping Station & Terminal Reservoir in Faisalabad" and "The Project for Improving the Capacity of WASAs in Punjab Province" (Hamano, 2014;JICA, 2012b, 2015a).

Overall, Japan continues to provide significant assistance for the improvement of water and sanitation conditions in Faisalabad, which is now the model city of Japanese assistance in the water sector (JICA, 2015b, 2016a,2019). However, Japan is investing in Faisalabad for its own policy target (to provide assistance and facilitation to other developing countries). Therefore, it selects problem areas and corresponding projects. Under this setup, the local voice and the will for finding solutions are not represented.

8.2.2.3 Projects funded by various funding agencies

Another relatively small project to treat 0.5 MGD of wastewater "Construction of Pilot Wastewater Treatment Plant at *Shahbaz Nagar*, Faisalabad" was launched. Carried out in a slum area of Faisalabad, the project was partially funded by UNICEF, who always emphasizes hygiene and sanitation for children's health.

The District Collector in Faisalabad issued an NOC for six canal lands required for this plant (Figure 8.3). Tendering process was completed in January of 2015. The project was completed in six months. An Up-flow Anaerobic Sludge Blanket (UASB) reactor was a part of the plant that will help treating effluent and generating energy (WASA Faisalabad, 2014).

In 2014, the government of Punjab proposed a project named "Planning and Designing of Wastewater Treatment Plants," which would receive funds from the French government. The primary target of this project was to prepare the concept clearance paper for 100 MGD capacity treatment plants in Faisalabad. In this regard, the project proposal and cost estimation (PC-II) reports of this project were submitted to the PND board of the government of Punjab in March 2014. Six months later, the provincial development working party (PDWP) approved the project budget of 53.30 million rupees. Later in October 2014, the proposals were forwarded to the central development working party (CDWP)—Federal Ministry of Planning, Development, and Reforms—for further consideration (WASA Faisalabad, 2014). Based on the above-mentioned study, the government of Punjab selected two international partners for the construction of collective wastewater treatment plants in Faisalabad.

8.2.2.4 Projects with international companies

A collective treatment plant 'Eastern Wastewater Treatment Plant' has been proposed on the southeast side of Faisalabad.

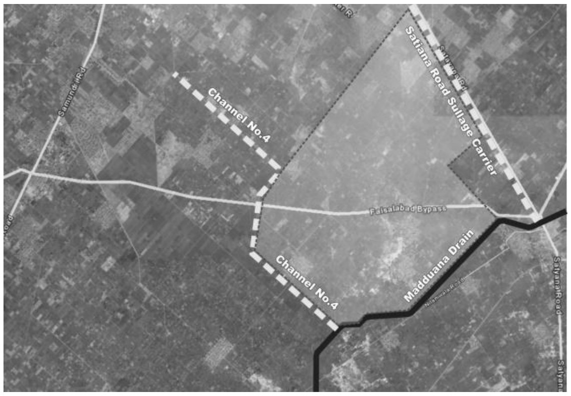

Figure 8.3:Proposed location of collective wastewater treatment plant at Channel 4

Source: Image downloaded from WASA Faisalabad in March 2016

Industrial units located on *Maqbool* Road and Samundri Road disposed their industrial effluents into Channel 4, which were dumped into the Madhuana drain without any treatment (Figure 8.3). The Madhuana drain carried this raw sewage about 100 km away from Faisalabad and dumped it into River Ravi.

A Memorandum of Understanding (MoU) has been signed with STFA INSAAT A.S. (STFA Construction Company) 10from Turkey to construct the Eastern Wastewater Treatment Plant." This agreement is a public-private partnership (PPP), in which the STFA Construction Company builds, owns, and operates (BOO) the plant. Although the Punjab government does not provide direct investment, it may offer other financial incentives (WASA Faisalabad, 2015b).

The second massive project for collective treatment plants "Wastewater Treatment Plant," in Faisalabad has been proposed. Recently, WASA (Faisalabad) signed an MOU with the Danish government (DANIA) for the construction of the wastewater treatment plant. The details are attached in Appendix F. It is a design, build, operate, and transfer (DBOT) partnership with the Danish government (Danish Ministry of Foreign Affair, 2017; SEWACO, 2018).

8.2.3 Discussion

The general findings from this sectionshow that all proposed solutions are civil engineering-oriented using market-based approaches. The proposed solutions are not addressingthe governance challenges.

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[10]STFA INSAAT A.S. is one of the most well-established and reputable Turkish companies that provide services in the areas of construction, energy and heavy equipment. STFA has been involved in Pakistan since 1992 to provide services in the construction of highways, airports, marine structure and so on (Raporu, Şen, & Müsteşarlığı, 2011). Today, it provides its construction expertise as an investor.

Administrative institutions at the local level cannot decide the desired or required development projectsthat are specific to their locality (such as the case of *Chokera* village drainage system). As,Project under 90 thousand rupees can be decided by department. Every project is centrally (provincially) decided and carried out to maintain the transparency in funds utilization. Consequently, small demands/requirements, which can be managed locally on a smaller scale (might be not fully but partially possible), are converted to huge, expensive (externally funded) development projects.

Here, a question arises: what would be actually the ultimate goal for policy planning? It may be to either deliver bread to one head or distribute among different heads based on priority(Mara, 2003). An investment (more than 100 million Euros) for the construction of collective wastewater treatment plant in Faisalabad has been planned, even though other vulnerable issues (health and education) are still waiting for consideration.

A huge collective treatment plant could not exactly fulfill the international standards, because constructing one thatfulfillsallthe standards would require huge capital investment. There would again be the question of how to recover that capital in the long run. Managing such big infrastructure may increase the debt burden on wastewater-managing administrative institutions. On the other hand, if private companies were involved, the obligation would shift to local consumers and industrialists. However, there is still no market (quite a low price for canal water) for such costly treated water.

Sophisticated and expensive technology for the collective treatment plant (at the eastern or western site) may perfectly treat the wastewater according to international standards, but it may solve just one aspect of sustainable wastewater management. There a number of challenges—loan repayment, local management (administration) of the plant, higher cost of production for industrialists after including wastewater treatment cost, poor law enforcement due to gaps in the legal framework, farmer's unwillingness to pay for expensive treated wastewater, poor drainage infrastructure (absence of source separating system) in the city, etc.—that needs to be addressed.

The next step is to explore the feasible solutions for the above-mentioned challenges. Policy-oriented research would help connect on-going research and policymakers.Policy-oriented research supports to look at the problem using different angles, such as causation, the extent of the problem, risk assessment, comparing alternate solutions within limited budget, and calculating benefit-investment ratio for development projects.

Due to the limited scope of this study, the possible policy analysis—analyzing all policy options—for addressing the current situation was not included. Here, few feasible options for future planning towards sustainable wastewater management are considered using the already collected data/information (secondary analysis).

8.3 Analysis of potential policy intervention

After reviewing the entire policy formulation procedures in Pakistan (Chapter 6), a persistent communication gap between the policymakers and local researchers was found. In fact, there was a weak direct connection between researchers (either academic or research institutes) and policymakers (government policy wing) in general. Researchers were mostly interested in accelerating their academic achievements and had little interest in advising policymakers. On the other hand, policymakers were unaware of the on-going research within the country and mainly consulting the international research organizations and institutes. When hiring an international consultant as a policy advisor, the fundamental prerequisite was the credibility (internationally) of that researcher (or institute). No doubt, these foreign consulting agencies provided competent assistance; however, the proposed recommendations were mainly based on limited baseline information. The limited availability of the required data for future policy planning is the main issue for most developing economies like Pakistan. It is also one of the reasons why foreign-agency-consulted policies and strategies are not fulfilled. Thus, there is a need to bridge such research policy gaps (Bandaragoda, 1993). A number of approaches/methods/techniques are available to decide the most suitable policy options.The purpose of the next few subsections is to introduce a few methods for future policy interventions using the already collected data to explain ways for research-based policies. Few possible policy-based analyses are revealed in the following subsections.

8.3.1 Principles for collective action

The overall premise of this subsection was to explore the grounds for addressing the wastewater management from Ostrom's angle of governing the commons. Looking at the nature of goods and services involved with the wastewater management sector, a framework—based on the Ostrom's eight design principles (Elinor Ostrom, 1992) for governing commons—can be applied to redefine the problem. Rosenbloom (2012) critically observed the application of these design principles to address the role of local government governing the CPRs (p. 470-478). Few other researcher also advocatedthe application of design principles with reference to the management natural resources such asBenjamin et. al.(1994), Ostrom (1999) and Stern 2011.

The first step of future policy formulation based on this framework would be to define the legal rights of each stakeholder (industrialist, consumers, administrative agencies, and farmers) to use the natural resources (freshwater, groundwater, and wastewater). A sound legal framework to address the issue is prerequisite for future planning. The next important point is to reconsider the NEQS while considering local circumstances and needs. Involving the industrial sector for establishing such quality standards can enhancelocal communities' commitment to abide by thelaw. Ultimately, the participation of all affected people (farmers, consumers, local community) should be considered to contribute to modifying the rules and regulations. Along with it, other authorities, such as the legislature and the executive branch, should respect the consent of the local community before the legislating and enforcing regulations. Moreover, developing alocalcommunity-led feedback system to check the behavior of monitoring agencies—such as EPA, local Government, and WASA—would improvethe overall competence of governance structure. For this feedback system, imposinggradual sanctions on industrialists, domestic consumers, farmers, and governing organizations when they violate rules and regulations would play a useful role (like the polluter pays principle in the Coase Theorem). To attain legal rights, an affordable and easilyaccessible system to take legal actions against the violators should be available. Finally, yet importantly, the most salient feature should be to create awareness among all stakeholders, informing them about their responsibility on governing the commons. A collective action approach is required to handle an uncertain situation. It should be dealtwith and tackled at each level.

The above-mentioned framework providedthe basic context for strategic planning in wastewater management. Few particular policy recommendations connected with this study are described in the next subsections.

8.3.2 Stakeholder analysis

Stakeholder analysis is a tool for mapping the stakeholder by their interest and influence level. The interest and influence level was evaluated during the Net-Mapping process. Here, influence (power) refers to resources (human and financial) and salience (say in making policies) of the stakeholder,whereas interest (stake) depicts the legal and institutional objectives/duties/goals (Grimble & Wellard, 1997; IIED, 2001; Schmeer, 2000).

Table 8.1: Influence and interest level ranked by stakeholders

Stakeholders	Interest	Influence	Response (%)
Industries	4	4	100
Farmers	4	1	100
EPA	4	2	90
DCO	3	4	100
Urban Unit	2	3	80
Political Agents	3	2	60
WASA	2	4	100
Research Institutes	2	1	100
Agriculture	1	1	100
FDA	1	2	80
IDD	1	3	90

For a stakeholder analysis, influence and interest levels were ranked 1-4 using a questionnaire (Appendix H4). Each stakeholder positioned himself and others across the stakeholder map (Table 8.1). Almost all of them ranked the stakeholder groups in the same status except the role of politicians. The role of local politicians was controversial depending on the location. Political representatives of areas irrigating with domestic wastewater strongly recommended the supply of domestic wastewater and sought out the consent of local farmers. In contrast, the politicians of eastern site (industrial wastewater irrigated areas) did not take any step in the favor of farmers. These influential political stakeholders were even involved with stealing canal water, which led farmers to irrigate using industrial wastewater. (Extract from the FGD with farmers, June 2015)

Except than these areas, politicians are not practically interested and involved with the issue of wastewater irrigation in other areas.

The Influence and Interest matrix represents the role of stakeholders over decision making and policy implication concerning wastewater management (for detail see Loudjeva & Jorgensen, 2005, p.29-30).

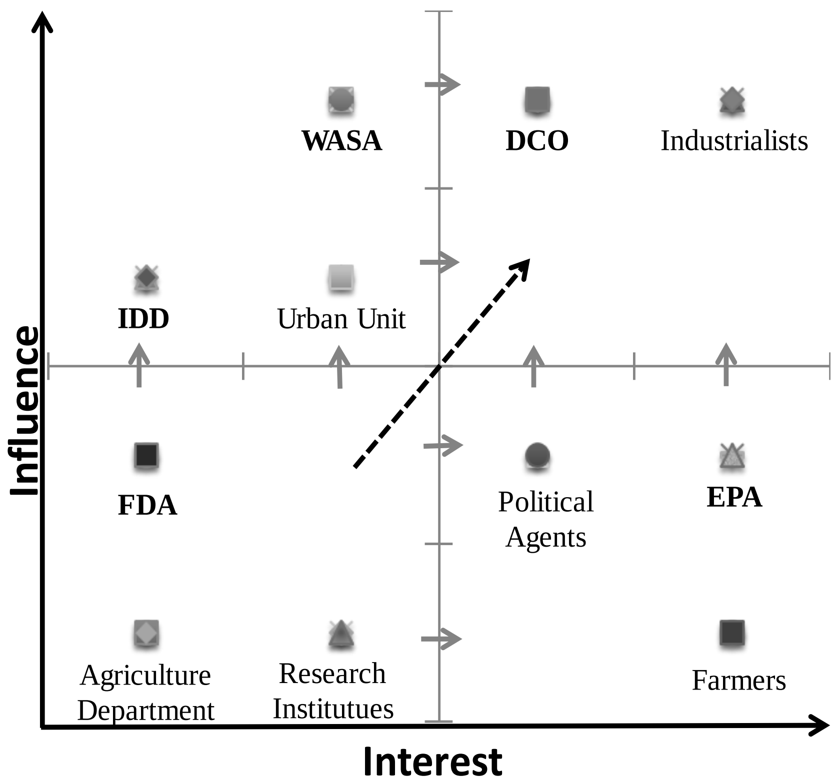


Figure 8.4:Stakeholder matrix

Figure 8.4 shows the matrix prepared using the collected information regarding the status of each stakeholder. The black dotted line from lower left to upper right portrays the theoretical way to empower the institutions (IIED, 2001, p. 24). The four small grey arrows crossing the middle line from the left half to the right half represents the strategic target by increasing the interest level (Figure 8.4). Whereas, increasing the level of interest would be feasible by providing information, legislative engagement opportunities, and motivation to stakeholders on the left half. On the other hand, the increase in influence is possible by improving financial and human capacities of administrative institutions. Good connections and public relations with individuals in powerful positions may increase the influence level of the suffering stakeholders (local community). Moving to the right side is relatively easy as compared to moving up—improving the level of influence—due to budget constraints.

In Figure 8.4, farmers possess the least influence; however, scored the highest level of interest. Improving the level of influence needs the improvement of financial (infrastructure) and human resources (capacity building) through long-term strategic planning. Through short-term planning, the interest level of stakeholders can get better (move from the left half to right half). After an in-depth look at the positioning of the institution, it can be concluded that there is a need to increase the interest of IDD and WASA Faisalabad. Both managed physical infrastructure for water and drainage and were in critical, high-level positions to influence the policy formulation and implementation process regarding wastewater management. Thus, there is a room for improvement by enhancing their legal obligations regarding the quality of drainage.

8.3.3 Ethical Matrix

An ethical matrix is a schema that specifies and interprets selected acknowledged ethical principles according to each stakeholder's situation. Such ethical principles are important targets for future planning. This approach originated from Beauchamp and Childress (1979, 1994) and was modified by Ben Mepham's matrix for biotechnological issues (Beauchamp & Childress, 2008; Mepham, 2000). It is based on the researcher's point of view, but stakeholders can structure it too. Three main pillars or principles are recognized. The first centralprincipleis wellbeing or beneficence. The second idea is to assess autonomy or freedom of choice. Finally, justice and fairness within the system are the third ethical aspect. This matrix can be evaluated through the legal status or informed consent of the stakeholders.

Table 8.2: A specified principal matrix, Ethical Matrix

Stakeholder category	Actors	Well-being/ Beneficence	Autonomy/ Choice	Justice/ Fairness
Polluting	Industrialists	Profit	Choice of work	Affordability
Regulating	Politicians, PND	Policy formulation	Democracy	Justice
	Academic and researcher	Knowledge production	Freedom of work	Right of information
Enforcing	WASA	Returns	Autonomous	Fair service
	EPA	Pollution control	Freedom of work	Laws enforcement
	DCO	Good governance	Managerial freedom	Equal opportunities
Suffering	Environment	Conservation	Restoration	Sustainability
	Farmer	Farm income	Managerial freedom	Fair trade
	Local community	Good health	Freedom to influence	Welfare of society

In Table 8.2, a principle matrix indicates the desired ethical targets concerning wastewater management in Faisalabad. Based on their interests, stakeholders were categorized into four groups for simplification. The ethical targets specified for each stakeholder group—well-being/benefits, autonomy/choice, and justice/fairness—were identified by the researcher's point of view (Ben Mepham, 2010). The first ethical target, well-being, represents the priority of each stakeholder to achieve maximum benefits for themselves. The second ethical target, autonomy, sets on the principle that treats others as themselves. The third target, fairness, indicates what is considered as justice, legal rights, and duties (that are declared legally) (Kaiser & Forsberg, 2001; B Mepham, 2008)

Keeping in view of the role of each stakeholder group for sustainable wastewater management, the three ethical targets for each actor in each stakeholder category are described (Table 8.2). The ethical matrix also explained whether the role of each stakeholder is ethically acceptable or not (from the researcher'sperspective). Sometimes, one negative impact (industrial water pollution) possessed higher weight as compared to many positive impacts (product availability).Fair trade indicates the fair pricing system depending the quality of produce.It also helped to specify the stakeholders involved in this sectoron ethical grounds (Mepham & Tomkins, 2003; Mepham et al. 2006).

As all three ethical principles for each stakeholder group regarding wastewater management are suggested, the ethical matrix's specification provides the grounds for future desired policy intervention on ethical grounds. The next step was to check whether these ethical targets were achieved or not. Based on the information collected by these stakeholders during FGDs and in-depth interviews, the researcher evaluated the relevanttargets.

Table 8.3:A proposed specified principle matrix (SPM)

Category	Stakeholders	Well-being/ Beneficence	Autonomy/ Choice	Justice/ Fairness
Polluting	Industrialists	✓	✓	✓
		Profit	Choice of work	Affordability
Regulating	Politicians, PND	✓	✗	✗
		Policy formulation	Democracy	Justice
	Academic and researcher	✓	✓	✗
		Knowledge production	Freedom of work	Right of information
Enforcing	WASA	✓	✓	✗
		Returns	Autonomous	Fair service
	EPA	✗	✗	✗
		Pollution control	Freedom of work	Laws enforcement
	DCO	✗	✓	✗

Category	Stakeholders	Well-being/ Beneficence	Autonomy/ Choice	Justice/ Fairness
		Good governance	Managerial freedom	Equal opportunities
Suffering	Environment	✘	✘	✘
		Conservation	Restoration	Sustainability
	Farmer	✓	✓	✘
		Farm income	Managerial freedom	Fair trade
	Local community	✘	✘	✘
		Good health	Freedom to influence	Welfare of society

The ticks in Table 8.3 symbolize achieving the prescribed ethical targets. Conversely, the crosses represent the stakeholder's failure to achieve their goals. Based on the information collected from the stakeholders, the researcher concluded the successes and failures. The unachieved ethical targets provide the ground for future policy as Mepham (2010) followed in his study, 'the ethical matrix as a tool in policy interventions: The obesity crisis'. The reasons for not achieving these targets are already explained in previous chapters (Chapter 5, 6, and 7). Overall, the EPA, the environment, and local communities completely failed to achieve their targets. On the contrary, industrialists were successful in the current scenario.

Table 8.4:A policy objective matrix (POM) indicating some proposals

Stakeholder category	Well-being/ Beneficence	Autonomy/ Choice	Justice/ Fairness
Polluting	Legislate/regulate to significantly reduce the generation of untreated wastewater	Protect innovation and entrepreneurial practices	Promote fair trade and eco-friendly labels
Regulating	Produce up-to-date information and policy options	Ensure a neutral opinion	Protect the right to get information and investigate
Enforcing	Provide facilities for enforcement of laws	Enhance managerial and technical skills	Promote equal opportunities
Suffering	Provide facilities to promote wellbeing	Promote awareness through education and non-discriminatory practices	Ensure availability of sustainable environment through long-term planning

Adapted and modified fromMepham(2010)

Based on the SPM analyzing a stakeholder's successes and failures achieving targeted goals, anticipated future policy proposals are documented in Table 8.4. The proposed policy objective matrix (POM) is based on the actor's failures in Table 8.3.

The next subsectiondetails the recommendations proposed by the stakeholders to improve the current wastewater management situation.

8.3.4 Recommendations by stakeholders

The stakeholderspointed out some appropriate solutions for an improved system for both the environment and human beings. All stakeholders have different perspective towards a sustainable wastewater management. Their opinions are based on their objectives, social set-up, influential status, and former experiences regarding the problem. Qualitative techniques were usedtoneutralize pessimistic and optimistic behaviors. One stakeholder's response provided a counterargument to another stakeholder's response or point of view.

Table 8.5:Proposed recommendation by stakeholders

Stakeholder category	Proposed recommendations
Industrialists	• Gradually restrict national environment quality standards specified for each industry • Pollution tax that is based on the quality and quantity of effluents • Promote eco-friendly labels
Farmers	• Supply ample amount of irrigation water to farmers otherwise negotiate with farmers for alternate options • Supply treated wastewater at minimal prices (*Abiana*)
EPA officials	• Enforce environmental laws at each stakeholder level • Establish of an environment fund board
WASA officials	• Construct an effluents collection system that differentiate wastewater by quality. • Strictly implement the peri-urban structural plan • Institute a new tariff plan according to quantity and quality of wastewater
IDD officials	• Adopt environmental laws at drainage wing • Reconsider drainage fees with WASA and industries

Finally, the suggestions proposed by each stakeholder category are elaborated in Table 8.5.

Stakeholders proposed suggestions which they personally desire to see come to fruition. The in-depth evaluation of problems identified that a system that is ultimatelyguiding towards a solutionis lacking.Precise monitoring and feedback should recordto ensure the continuous evolution of the data.

8.4 Summary and conclusions

A number of legal and administrative requirements are necessary before proposing and planning any development project;these requirements restrict local bodies to be involvedin the policy interventionsprocess.

After reviewing existing projects within the wastewater management sector, it was clear thatcurrently proposed solutions were mostly engineering-oriented. The main emphasishas was on collective wastewater treatment at the drain level. In addition, the provision of sanitation facilities to all is also a target of current development projects under SDGs, and foreign donors, through either loans or grants, mostly fund these huge development projects.

The general idea within the minds of policymakers was deeply rooted in that a big external hand (donor) could only solve the problems.Currently, the administrative organizations in Pakistan, including public departments, authorities, agencies, and companies,continue to seek grants, technical assistance or loans from donor agencies toprovide public services (privatization of public sector). On the other side, funding institutions also want to secure their interests (based on their own policies). Consequently, even if local stakeholders and administrative organizations were not fully convinced with the donor's strategies,local administrative organizations had to adopt and follow specific international policy criteriaalong the process. As a result, local resistance hindered the project goals to be fully achieved. If something is being done for the betterment of others, why is it considered to be against them or thought to be something that is being imposed on them? It is irrational but actually, it happens. Therefore, such large treatment plants should be constructed with the willing consent of local stakeholders after the complete detailed study highlights future consequences of such projects. The current situation shows that mutual trust between local stakeholders and policymakers to improve the situation is completely lacking.

The on-going and proposed projects are mostly based on civil engineering-based solutions. The local strategic planning for collective action is missing,which means that a locally adapted approach to finding suitable solutions after looking at the real situation is absent and local stakeholders are not involved in the policy planning process.

The policymakers are not considering that there would be some possible planning options to address the current situation locally with own limited resources. The researcher further applied few policy-intervention approaches to recommend some policies. The Ostrom's design principles for CPR were modified using the information of this study's research problem. Afterward, the Stakeholder Matrix showed the position of stakeholders along with their influence and interest. The interest level can improve by improving legal and institutional frameworks;also, the influence (or salience) level can be raised by providing resources to the targeted institution. The key player in the top right corner of the matrix would directly influence the problem-solving situation. Importantly,the Ethical Matrix recommended desired policies rendering the researcher's point of view.Lastly, all stakeholders recommended a few suggestions for the betterment of the situation.

9. CONCLUSIONS AND RECOMMENDATIONS

This chapter elaborates the main critical points and overall conclusions, as well as the related recommendations.

9.1 Conclusions

In this thesis, the challenges of sustainable wastewater management in Faisalabad, Pakistan have been addressed using a mixed-method approach. Trying to find possible solutions, this thesis was conducted in a problem-oriented manner.

This study collected available information in all associated disciplines regarding sustainable wastewater management. The contribution here is twofold. First, the study collected available information, and second, it contributed with its methodological framework.

One of the main contributions of this work is that it elaborated on approaches that can be applied to assess sustainable wastewater management in developing countries that face nearly the same situations.

A comprehensive study covering all possible aspects of sustainable wastewater management (socio-economic, natural resources, health, legal, and institutional) in Faisalabad was conducted. Most past literature on 'wastewater irrigation' could not differentiate how different types of wastewater (domestic or industrial) had different impacts on the environment, farmers' health, and socio-economic conditions. This differentiation was covered in this study. No doubt, impacts depended upon the quality of wastewater. Farmers possessing an adequate supply of canal irrigation water enjoyed higher crop yields, crop diversity, and crop incomes. Industrial wastewater and domestic wastewater showed a high level of salinity due to the utilization of saline groundwater. Application of untreated highly saline wastewater for irrigation increased the salinity level of soil and groundwater as well (i.e. secondary salinity). Untreated industrial wastewater irrigation adversely affected the crop yield, crop diversity, cropping intensity, and farm income. Whereas, domestic wastewater irrigated areas show higher average yields. The reason was the sufficient supply of water throughout the year. Furthermore, total days of illness in these farming communities were also higher as compared to other communities. This finding highlighted the microbial risk associated with domestic wastewater irrigation. But untreated domestic wastewater irrigation was not only a single factor causing poor health within these areas. The results show that the reuse of wastewater in agriculture has demand, there is just a need to properly manage it to reduce the involved risk. Another influence of the quality of irrigation water on the socio-economic condition of farmfamilies was revealed through farm income. Due to the high-income level, overall sanitation and hygiene conditionswere better than farms with lower income levels. On the contrary, industrial wastewater irrigators practiced subsistence farming and most of them depended on off-farm income to fulfill their livelihood.

Existing legal frameworks with the vision of sustainable wastewater management were reviewed in detail, somethingpreviouslyunaddressed at any level in Pakistan. The review of the legislation pointed out several gaps, which go into the favor of violators or polluters. The legal framework gradually developed overtime to target the overexploitation of natural resources and the provisionof sanitation facilities. Few clauses or sections addressing wastewater management were found within different legislations. Mainly, environment protection law (PEPA 1997) defines the water pollution levels and levies strict penalty and punishment against violators. National environment quality standards were officially endorsed but practically could not be implemented, even twenty years after sanction. Since it is hard to timely test disposed wastewater, and due to lengthy legal process, it is practically impossible to properly enforce these laws. Lately, WASA regulations (2015) specified lists of parameters with given ranges, but punishments and penalties are significantly fewer as compared to PEPA 1997. Irrigation and Industry laws did not consider sustainable wastewater management at any level. Strategically, at the national level, sustainable wastewater management has never been addressed. National drinking water policy, sanitation policy, and environment policy partially look at water pollution, but even then, these policies could not properly be integrated due to institutional incapability. Since 2000, decentralization (institutional change) has also created chaos among institutions and departments concerning their obligation and authorities. Such local unawareness may make the situation worse in upcoming years. The absence of a local pressure group while framing legislation was also one of the main reasons for the weak enforcement of laws within society.

The other focus of the study was to explore the gaps in the institutionalsetup responsible for wastewater management. Using evaluative and governance criteria, a list of challenges was identified within the wastewater management of Faisalabad. The incapability of administrative organizations (financial and capacity-related constraints staff members face) is a big challenge for sustainable wastewater management. Other challenges included the lack of local consent for understanding the problem and the absence of a local platform for finding solutions.

Finally, another contribution was reviewing the current and future development projects within this sector. National development schemes exist, but their scope has been quite limited as compared to the extent of the problem. WASA and the government of Punjab, the most influential stakeholders, currently have plans to construct collective treatment plants with the help of foreign funding as a solution. Alternatively, some possible policy options (other than just constructing collective treatment plants with external funding) are applying a few policy intervention tools using already collected data.

For high-income countries, sustainable wastewater management is not only a future development strategy but also a current one that receives a lot of attention. Many developing countries, however, still look at it as a policy target with little to no importance. Sustainable wastewater management is considered as a new slogan to interpret the new trend of development work. The goal of sustainable wastewater management is not so easy to achieve just by constructing a collective treatment plant, and there is no guarantee that the collective treatment plant can solve the problem forever. What will happen if the existing legal framework (with implementation gaps) still has difficulty being effectively implemented in the future? The administrative organizations still would not be able to properly enforce laws due to their limited resources (financial and technical staff), and the existing inefficient drainage system will further deteriorate. Furthermore, weak linkages (within organizations, among organizations, and between communities and organizations) would restrict collaboration for the effective operation of treatment plants. If all multidisciplinary aspects linked with sustainable wastewater management are not considered at proper strategic levels, after a few years, future reports may find that expensive treatment plants just overburdened the local economy. As, it was mention before (see section 4.2.4), no farmer wants to use the treated water from existing WTP due to low nutrients (N:P:K) and high salinity (higher than ground water), even after the huge investment for this treatment plant. Exactly evaluating this very situation, one cannot understand how such engineering-based solutions or market-based approaches are being proposed and what the targeted goals are, either providing welfare for farmers or just for increasing WASA's returns.

Without a proper sustainable wastewater management strategy, problems are just reshaped not solved. A single-track development project cannot fulfill future requirements (as the city is growing faster than planned). A comprehensive approach is required, not only for Faisalabad but for other areas that face nearly the same situations.

9.2 Recommendations

Some possible and feasible strategies are shown below.

9.2.1 Economic/Operational

As mentioned earlier, a wastewater management system that separates different types of discharge would be the first step to operational improvement. The industrial effluents must be keptseparate from municipal discharge.

Both effluents can be treated based on the type of pollution. This differentiation would help reduce the costs of recycling. Domestic wastewater can be usedfor irrigation purposes after minimal treatment whereas industrial effluents can be treated through a collective treatment plant.

This research completely favors the argument that industrialists should pay for the treatment of wastewater (i.e. polluters should pay). Eventually, the cost for effluent collection and treatment would be collected from industrialists. For them, the system can be more specific to their needs and collection fees can be based on the quantity and quality of their industrial effluents.

A public-private partnership can help establish such treatmentplants. However, the local industrialist community must be involved as an active partner in sucha partnership structure.

A new tariff system, based on environmental laws, would assess fees according to the quantity and quality of wastewater (at both WASA and IDD).An efficient revenue collection system (Water fund) would reduce the government burden.

9.2.2 Strategic/Legal

There is a need for a long-term strategy targeting sustainable wastewater management at all administrative levels. The policymakers should consider wastewater as a resource and try to reduce the risks involved with its mismanagement. Gradual and small steps to address and solve the causes of the problem should be strategically planned.

Currently, a vertical (top-to-bottom) hierarchy has essentially failed to manage the issue across various departments (weak linkages). Only a multi-objective, intersectoral, and horizontal policy would be able to address the issues of wastewater management at the executive level of each department.

Legally, a gradual restriction of National Environment Quality Standards (NEQS) for specified parameters particular to each industry would ensure that laws are properly implemented within the prescribed period. It may take longer, but this strategy can make the implementation process easier.

WASA, IDD, and the Agriculture Department should also consider environmental issues at a departmental level during the planning process.

Command-and-control policy or checks and balances can be effectively implemented either by increasing the penalty to equate to the monthly operational cost of a treatment plant and by providing seizing authority to EPA officials who can effectively monitor and regulate the spot (in case of noncompliance with NEQS).

Public awareness regarding the issues, approaches, and solutions should be an essential part of future policies and strategies

9.2.3 Administrative/Organizational

Public investment in a drainage system infrastructure is unavoidable; thus, local resources (share in construction cost) can be utilized for this purpose. The local community can contribute to the construction of a separate sewerage system (1/4 or 1/5 of the cost of the total project). It would then garner local concern in further maintaining the system. Therefore, a mixed governance system, combining private ownership with community-level commons institutions, can manage problems such as exclusion and subtractability.

Communication and negotiation between local communities and administrative officials should be handled openly. A regular feedback system can improve the service delivery status. Workshops and pieces of training to help make sound decisions and a manual that guides instructing procedures for finding solutions can improve public officials' attitudes on future planning.

9.2.4 Collective action and Local consent

A collective action approach (Theory of collective actions) is mostly suggested when self-interested individuals want to manage a common-pool resource such as wastewater (option of a drainage system or collective treatment plant). Collaboration-based and nature-based solutions with a multi-perspective vision can provide a way to collectively manage limited resources.

The incentives and local platform for negotiation among stakeholders were not there which worsened the situation day by day. There is a need simply to start thinking about finding solutions that involve local communities, local researchers, and local administrations.

Local representation (industrialists, administrative agencies, communities) should have a say while deciding on new projects (maybe through media).

Media campaigns (social, electronic, and paper) engagethe local populationabout theproblems and the ways to handle them. Furthermore, they can greatly influence the rational thinking of involved actors on a specific issue.

9.2.5 Site-specific/Situational

Searching for a 'point to start' to further improve the situation varies from case to case, and location to location. Policy-oriented research by local researchers can help in this regard.

Big engineering-based solutions can only be proposed after a complete feasibility study of the project on sustainability grounds has been conducted.

The best option is to construct small wastewater treatment plants specific to the requirement of each site while involvinglocal stakeholders tomanage such structures. These planning-oriented solutions would reduce the dependence on donor funding.

9.3 Proposed future research

The study reveals the need for a shift ofwastewatermanagement from an economicfocus to a sustainabilityfocus. Within this research, sustainability refers to a win-win scenario for all actors including the current generation, future generations, and natural resources. It refers to collective-action-based management options that are environmentally friendly, socially acceptable, economically feasible to construct and maintain, and technologicallyinnovative and smart. Sustainable wastewater management ultimately shifts from a linear to a circular water economy. Another future study could evaluate the possible options to achieve sustainable wastewater management in the scenario of developing countries.

The further focus of this research could be on sustainability assessment tools that would provide concrete grounds for future planning. The lack of data limited the scope of this research. Multi-perspective research would help establish a coherent, multi-level perspective that uses insights from sociology, institutional theory, and innovation studies (Geels, 2004). The 'point to start' in the current scenario is based on transitional theory. Transitional sustainable wastewater management in developing countries could be the title for subsequent research.

One othercriticalissue in the study areawas health concerns due to water-borne diseases. The health status was quite complicated in the study area. Untreated domestic wastewater irrigation was not the only reason for the poor health of villagers. There wereseveral other intertwined factors such as local hygiene and drainage systems, existing health care facilities, precautionary measures, and drinking water quality. A comprehensive study for health (particularly water-borne diseases) in line with the SDGs is also required.

REFERENCES

Abbas, Q., Yousaf, B., Liu, G., Zia-ur-Rehman, M., Ali, M. U., Munir, M. A. M., & Hussain, S. A. (2017). Evaluating the health risks of potentially toxic elements through wheat consumption in multi-industrial metropolis of Faisalabad, Pakistan. *Environmental Science and Pollution Research*, 24(34), 26646–26657. Retrieved from doi.org/10.1007/s11356-017-0311-9

Abbas, Z., Chaudary, M. N., Raza, A., & Mehmood, A. (2012). Toxicity of mercury in different samples (water and soils) and its exposure in Pakistan. *Sci. Int. (Lahore)*, 24(4), 421–429.

Abedullah, Kouser, S., & Ali, H. (2016). Pesticide or wastewater: Which one is a bigger culprit for acute health symptoms among vegetable growers in Pakistan's Punjab?. *Human and Ecological Risk Assessment: An International Journal*, 22(4), 941-957. DOI: 10.1080/10807039.2015.1121375

Adil, S. A., Waqas, M., Chattha, A., Bakhsh, K., & Hassan, S. (2007). Profitability analysis of summer vegetables by farm size. *Pakistan Journal of Agricultural Sciences*, 44(1), 184–188.

Aftab, Z., Ali, C., Khan, A., Robinson, A., & Irshad, I. (2000). Industrial policy and the environment in Pakistan (Industrial Policy and Environment). *United Nation Industrial Development Organization*, No. NC/PAK/97/018. Retrieved from Industrial Policy and the Enviornment in Pakistan

Ahmad, B., Bakhsh, K., & Hassan, S. (2006). Effect of sewage water on spinach yield. *International Journal of Agriculture and Biology*, 3, 423–425.

Ahmad, I., Akhtar, M. J., Zahir, Z. A., & Mitter, B. (2015). Organic amendments: effects on cereals growth and cadmium remediation. *International Journal of Environmental Science and Technology*, 12(9), 2919–2928. Retrieved from https://doi.org/10.1007/s13762-014-0695-8

Ahmad, K., Khan, Z. I., Ashfaq, A., Akram, Yasmeen, S., Laudadio, V., … Cazzato, E. (2016). Contamination and accumulation of heavy metals in brinjal (Solanum Melongena L .) grown in a in a long-term wastewater-irrigated. *Fresenius Environmental Bulletin*, 25(7), 2404–2410.

Ahmad, M. D. (2002). *Estimation of net groundwater use in irrigated river basins using geo-information techniques a case study in Rechna doab , Pakistan*. (Doctoral dissertation). Wageningen University. Wageningen, Netherland.

Ahmad, R., Ali, S., Hannan, F., Rizwan, M., Iqbal, M., Hassan, Z., … Abbas, F. (2017). Promotive role of 5-aminolevulinic acid on chromium-induced morphological, photosynthetic, and oxidative changes in cauliflower (Brassica oleracea botrytis L.). *Environmental Science and Pollution Research*, 24(9), 8814–8824. Retrieved from https://doi.org/10.1007/s11356-017-8603-7

Ahmed, A. N., & Basit, A. (2012). Good governance in Pakistan: problems and possible solutions. *Journal of History and Social Sciences*, 3(2), 11–131.

Ahsan, I., & Khawaja, S. A. (2013). Development of environmental laws and jurisprudence in pakistan development of environmental laws and jurisprudence in Pakistan. Retrieved from https://www.adb.org/sites/default/files/publication/31140/environmental-law-jurisprudence-pakistan.pdf

Akhtar, N., Khan, S., Naveen, S., Masood, S., & Khattak, M. R. (2018). Effect of wastewater on physiological and biochemical characteristics of rice (Oryza sativa L.). *Intercienia J.*, 43, 102–123.

Al-Lahham, O., El Assi, N. ., & Fayyad, M. (2003). Impact of treated wastewater irrigation on quality attributes and contamination of tomato fruit. *Agricultural Water Management*, 61(1), 51–62. Retrieved from https://doi.org/10.1016/S0378-3774(02)00173-7

Alexander, E. R. (2010). Introduction: Does planning theory affect practice, and if so, how? *Planning Theory,* 9(2), 99–107. Retrieved from https://doi.org/10.1177/1473095209357862

Ali, H., & Akhtar, S. (2015). People's perception about poor quality of drinking water and its impact on human health in rural areas of tehsil Samundri Pakistan. *International Journal of Science and Research (IJSR),* 4(10), 523-528. Retrieved from https://www.ijsr.net/archive/v4i10/SUB158659.pdf

Ali, N. (2002). Economic and institutional issues of wastewater use in Faisalabad, Pakistan. *UA-Magzine*, 26–28. Retrieved from http://ideas.repec.org/p/iwt/jounls/h031708.html

Ali, R. Z. (2011). Advanced sugarcane production technology. Retrieved from https://www.scribd.com/document/371757688/03-Advance-Sugarcane-Production-Technology-ranazulfiqar-Ali

Aligica, P. D. (2006). Institutional and stakeholder mapping: Frameworks for policy analysis and institutional change. *Public Organization Review*, 6(1), 79–90. Retrieved from https://doi.org/10.1007/s11115-006-6833-0

Alzheimer's Association. (2016). *Alzheimer's association needs assessment toolkit*. USA: Centers for Disease Control and Prevention (CDC). Retrieved from https://www.alz.org/media/documents/spotlight-needs-assessment.pdf

Amahmid, O., Asmama, S., & Bouhoum, K. (1999). The effect of waste water reuse in irrigation on the contamination level of food crops by Giardia cysts and Ascaris eggs. *International Journal of Food Microbiology,* 49(1–2), 19–26. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/10477066

Amerasinghe, P., Simmons, R., Evans, A., Blummel, M., & Drescher, A. (2009). *Ensuring health and food safety from rapidly expanding wastewater irrigation in South Asia: BMZ final report 2005-2008*. Hyderabad, India: International Water Management Institute (IWMI). 24p. doi: http://dx.doi.org/10.5337/2011.0015

Amerasinghe, P., Weckenbrock, P., Simmons, R., Acharya, S., & Drescher, A. (2009). *An atlas of water quality, health and agronomic risks and benefits associated with "wastewater" irrigated agriculture: a study from the banks of the Musi River, India.* [Report prepared for the IWMI-BMZ project]. Hyderabad, India: International Water Management Institute (IWMI). 62p. Retrieved from https://freidok.uni-freiburg.de/data/6963

Amin, N. U., Hussain, A., Alamzeb, S., & Begum, S. (2013). Accumulation of heavy metals in edible parts of vegetables irrigated with waste water and their daily intake to adults and children, District Mardan, Pakistan. *Food Chemistry*, 136(3–4), 1515–1523. Retrieved from https://doi.org/10.1016/j.foodchem.2012.09.058

Amir, R. M., Randhawa, M. A., Sajid, M. W., Nadeem, M., Ahmad, A., & Wattoo, F. M. (2018). Evaluation of various soaking agents as a novel tool for heavy metal residues mitigation from spinach. *Food Science and Technology*, 2061, 1–5.

Amoah, P., Drechsel, P., Henseler, M., & Abaidoo, R. C. (2007). Irrigated urban vegetable production in Ghana: microbiological contamination in farms and markets and associated consumer risk groups. *Journal of Water and Health*, 5(3), 455–466. Retrieved from https://doi.org/10.2166/wh.2007.041

Amoatey, P., & Bani, R. (2011). Wastewater Management**.** In Einschlag, F. S. G., (Ed.), In Waste Water - Evaluation and Management (pp. 379–398). ISBN: 978-953-51-4509-7

Anastas, J. W. (2004). Quality in qualitative evaluation: issues and possible answers. *Research on Social Work Practice,* 14(1), 57–65. Retrieved from https://doi.org/10.1177/1049731503257870

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), 2. Retrieved from https://doi.org/10.5751/ES-00610-090118

Andersson, K., Rosemarin, A., Lamizana, B., Kvarnström, E., McConville, J., Seidu, R., … Trimmer, C. (2016). *Sanitation, wastewater management and sustainability: from waste disposal to resource recovery*. (S. Caspar Trimmer, Ed.). United Nations Environment Programme and Stockholm Environment Institute. Retrieved from http://www.susana.org/_resources/documents/default/3-2636-7-1473948467.pdf

Anwar, H. N., Nosheen, F., Hussain, S., & Nawaz, W. (2010). Socio-economics consequences of reusing wastewater in agriculture in Faisalabad. Pakistan. *Journal of Life and Social Science*, 8(2), 102–105.

Anwar, M. M., & Bhalli, M. N. (2012). Urban population growth monitoring and land classification by using gis and remote sensing techniques : a case study of Faisalabad city. *Asian Journal of Social Sciences & Humanities*, 1(1), 5–13.

Anwar, S. (2014, November 20). Long gap: Environmental tribunal becomes operational after 20 months, *The Express Tribune*, Pakistan. Retrieved from https://tribune.com.pk/story/794048/long-gap-environmental-tribunal-becomes-operational-after-20-months

Apau, K. B. (2017). *Developing a conceptual solution for domestic wastewater management in developing countries : Kumasi (Ghana) as a case study*. Brandenburg University of Technology Cottbus – Senftenberg.

Ardakanian, R., Sewilam, H. & leibe J. (Eds.). (2012). *Capacity development for the safe use of wastewater in agriculture*. United Nations University UN Campus, Bonn, Germany: UN-Water Decade Programme on Capacity Development (UNW-DPC).

Arif Saeed, M., Iram, M., Hussain Chandio, N., Ahmed Khan, M., Mushahid Anwar, M., Kareem, M., & Naeem Hassan, M. (2018). Spatial pattern of industrial soil fertility in selected towns of Faisalabad City, Punjab Pakistan. *J. Bio. & Env. Sci*, 340(5), 340–346. Retrieved from http://www.innspub.net

Asad, E. A. B., Chaudhary, D. A., Sattar, D. A., Nasir, D. A., & Rashid, D. H. (2018). Wastewater characterization of paharrang drain in Faisalabad and evaluation of subsurface contamination using geographical information system. *Pakistan Journal of Geology*, 2(2), 11–17. Retrieved from https://doi.org/10.26480/pjg.02.2018.11.17

Ashraf, M. A., Maah, M. J., Yusoff, I., & Mehmood, K. (2011). Effects of polluted water irrigation on environment and health of people in Jamber, District Kasur , Pakistan. *International Journal of Basic & Applied Science*, 10(03), 37–57.

Ashraf, S., Abbas, F., Ibrahim, M., Rashid, U., Khalid, S., Ahmad, H. R., … Majeed, T. (2015). Application of GIS for the identification and demarcation of selective heavy metal concentrations in the urban groundwater. *Journal of Geographical Sciences*, 25(2), 225–235. Retrieved from https://doi.org/10.1007/s11442-015-1164-0

Asian Development Bank. (2006). Urbanization and sustainability in Asia: Case studies of good practice. (B. Roberts & T. Kanaley, Eds.). Philipines. Retrieved from http://www.adb.org/sites/default/files/publication/27965/urbanization-sustainability.pdf

Aslam, F. (2006). *Environmental impact assessment in Pakistan – Overview, implementation and effectiveness*. KTH Royal Institute of Technology, Stockholm.

Aslam, M. M., Baig, M. A., Hassan, I., Qazi, I. A., & Saeed, M. H. (2004). Textile wastewater characterization and reduction of its COD & BOD by oxidation. *Electron. J. Environ. Agric. Food Chem.*, 3(6), 804–811.

Asrar-ul-Haq. (1998). *Case study of the Punjab Irrigation Department.* Consultancy report. Pakistan National Program, IWMI Lahore, Pakistan. Retrieved from https://publications.iwmi.org/pdf/H_30079i.pdf

Ather Naseem. (2005). *Brief on environment policy and legal framework.* Islamabad, Pakistan.

Auditor General of Pakistan. (2017). Financial attest audit report on the accounts of jobs and competitiveness program for the financial year 2016-17. Loan No. 8600-PK World Bank, Planning and Development Department, Government of the Punjab, Financial Islamabad, Pakistan. Retrieved from http://documents1.worldbank.org/curated/en/898161517910585571/pdf/P155963-Punjab-J-C-Project-for-FY17-FSs.pdf

Ayers, R. S., & Westcot, D. W. (1989). *Water quality for agriculture* (1st ed.). Rome, Italy: FAO Publications.

Ayesha, A. (2012). Field verification of social and environmental issues of selected water sector projects in Punjab – Pakistan. *Pakistan Journal of Engineering & Applied Sciences*, 11(July), 82–95.

Azizullah, A., Khattak, M. N. K., Richter, P., & Häder, D.P. (2011). Water pollution in Pakistan and its impact on public health — A review. *Environment International*, 37(2), 479–497. Retrieved from https://doi.org/10.1016/j.envint.2010.10.007

Badruddin, M., Skogerboe, G. V, & Shafique, M. S. (1996). *Proceedings of the national conference on managing irrigation for environmentally sustainable agriculture in Pakistan*, (November 5-7), Volume I - Inauguration and deliberation, Conference Proceedings h020180, International Water Management Institute. Islamabad, Pakistan. Retrieved from https://publications.iwmi.org/pdf/H_20180i.pdf

Bahri, B. A. (2009). Managing the other side of the water cycle - Making wastewater an asset (TEC Background Papers, 13). Stockholm, Sweden: Global Water Partnership (GWP) Technical Committee (TEC).

Baig, I. A., Ashfaq, M., Hassan, I., Javed, M. I., Khursid, W., & Ali, A. (2011). Economic impacts of wastewater irrigation in Punjab, Pakistan. Journal of Agricultural Research, 49(2), 5–14.

Bain, R., Beise, J., Benali, N., Cappa, C., Evans, M., Carvajal-Aguirre, L., … Reuter, N. (2018). *Progress for every child UNICEF SDG*. Retrieved from https://data.unicef.org/resources/progress-for-every-child-2018/

Bandaragoda, D. J.; Firdousi, G. R. 1992. *Institutional factors affecting irrigation performance in Pakistan: research and policy priorities*. Colombo, Sri Lanka: International Irrigation Management Institute (IIMI). vii, 81p. (IIMI Country Paper Pakistan 4). Retrieved from https://cgspace.cgiar.org/handle/10568/36198

Bandarogoda, D. J. (1992). *Institutional framework for irrigation - some salient features of the south Asian situatio*n. International Irrigation Management Institute, Colombo, Sri Lanka.

Bandaragoda, D. J. (1993). *The role of research-supported irrigation policy in sustainable irrigated agriculture: an interpretive precise of the case of Pakistan*. Colombo, Sri Lanka. xiv + 68 pp. (IIMI country paper Pakistan 6). Retrieved from https://publications.iwmi.org/pdf/H013468.pdf, https://hdl.handle.net/10568/36377

Bandaragoda, D. J. (1999). *Institutional change and shared management of water resources in large canal system: result of an action research program in Pakistan*. Colombo, Sri Lanka: International Water Management Institute (IWMI) v, 33p. (Research Report No.

36). [doi: 10.3910/2009.042] Retrieved from https://www.iwmi.cgiar.org/publications/iwmi-research-reports/iwmi-research-report-36/

Bandaragoda, D. J. (2000). *A framework for institutional analysis for water resources management in a river basin context*. Working Paper No. 5. Colombo, Sri Lanka: International Water Management Institute. Retrieved from https://www.iwmi.cgiar.org/publications/iwmi-working-papers/iwmi-working-paper-5/

Banuri, T. (1993). *The Pakistan national conservation strategy : A plan of action for the 1990s* (Policy Paper Series No. 3). Islamabad, Pakistan. Retrieved from https://dataspace.princeton.edu/handle/88435/dsp01dn39x391t

Barbara Czarniawska, 1998, *A narrative approach to organization studies. Qualitative Research Method, Volume 43.* Sage Publications International Educational and Professional Publisher, Thousand Oak, California.

Bassan, M., Mbéguéré, M., Tchonda, T., Zabsonre, F., & Strande, L. (2013). Integrated faecal sludge management scheme for the cities of Burkina Faso. *Journal of Water Sanitation and Hygiene for Development,* 3(2), 216–221. Retrieved from https://www.researchgate.net/publication/255709887_Integrated_faecal_sludge_management_scheme_for_the_cities_of_Burkina_Faso

Basurto, X., Kingsley, G., McQueen, K., Smith, M., & Weible, C. M. (2010). A systematic approach to institutional analysis: applying Crawford and Ostrom's grammar. *Political Research Quarterly,* 63(3), 1–16. Retrieved from https://doi.org/10.1177/1065912909334430

Beauchamp, T. L., & Childress, J. F. (2008). *Principles of biomedical ethics* (ed. 7). New York, USA: Oxford University Press. Retrieved from https://doi.org/10.1016/S0033-3182(95)71674-7

Benjamin, P., Lam, W. F., Ostrom, E. & Shivakoti G. (1994). *Institutions, incentives, and irrigation in Nepal.* Workshop in Political Theory and Policy Analysis, Indiana University.

Berg, B. L. (2001). *Qualitative research methods for the social sciences*. (Seventh Ed). California State University, Long Beach: A Pearson Education Company, ISBN 0-205-31847-9

Bernhardt, L. M., & Pieron, M. (Eds.). (2012, May). *Safe use of wastewater in agriculture*. CAPACITY POOL, (14), 36. Retrieved from publisher: UN-Water Decade Programme on Capacity Development (UNW-DPC) United Nations University UN Campus

Bertelsmann Stiftung. (2016). *Policy performance and governance capacities in the OECD - Sustainable governance indicators*. Retrieved from http://hdl.handle.net/10945/49701

Bhalli, N. M., Ghaffar, A., Shirazi, S. A., Parveen, N., & Anwar, M. M. (2012). Change detection analysis of land use by using geospatial techniques : A case study of Faisalabad- Pakistan. *Science International*, 24(4), 539–544.

Birner, R., & Wittmer, H. (2006). Better public sector governance through partnership with the private sector and civil society: the case of Guatemala's forest administration. *International Review of Administrative Sciences*, 72(4), 459–472. Retrieved from https://doi.org/10.1177/0020852306070077

Birner, R., Davis, K., Pender, J., Nkonya, E., Anandajayasekeram, P., Ekboir, J., … Cohen, M. (2009). From Best Practice to Best Fit: A framework for designing and analyzing pluralistic agricultural advisory services worldwide. *The Journal of Agricultural Education and Extension,* 15(4), 341–355. Retrieved from https://doi.org/10.1080/13892240903309595

Biswas, A. K. (1993). Water for Agricultural development: opportunities and constraints. *International Journal of Water Resources Development*, 9(1), 3–12. Retrieved from https://doi.org/10.1080/07900629308722569

Biswas, A. K. (2006). Water management for major urban centres. *International Journal of Water Resources Development,* 22(2), 183–197. Retrieved from https://doi.org/10.1080/07900620600690789

Bitsch, A., Jacobi, S., Melber, C., Wahnschaffe, U., Simetska, N., & Mangelsdorf, I. (2006). REPDOSE: A database on repeated dose toxicity studies of commercial chemicals-A multifunctional tool. *Regulatory Toxicology and Pharmacology*, 46(3), 202–210. Retrieved from https://doi.org/10.1016/j.yrtph.2006.05.013

Black, M. (1998). *Learning what works : a 20 year retrospective view on international water and sanitation cooperation*. Water and sanitation program,Washington, D.C. USA: World Bank Group. Retrieved from http://documents.worldbank.org/curated/en/1998/09/693170/learning-works-20-year-retrospective-view-international-water-sanitation-cooperation

Blackman, A., Lahiri, B., Pizer, W., Rivera Planter, M., & Muñoz Piña, C. (2010). Voluntary environmental regulation in developing countries: Mexico's Clean Industry Program. *Journal of Environmental Economics and Management*, 60(3), 182–192. Retrieved from https://doi.org/10.1016/j.jeem.2010.05.006

Blacksmith and Green Cross. (2013). *The worlds worst the top ten toxic threats in 2013: Cleanup, progress, and ongoing challenges*. Blacksmith institute and Green Cross Switzerland. Retrieved from https://www.worstpolluted.org/2013-press-release.html

Bravo, G. (2002). *Environment institutions and society in the management of common-pool resources: Linking IAD framework with the concept of social capital*. Ninth Conference of the International Association for the Study of Common Property Victoria Falls Zimbabwe,1–16. Retrieved from http://dlc.dlib.indiana.edu/dlc/bitstream/handle/10535/2249/bravog290302.pdf?sequence=1

Briscoe, J. & Qamar, U. (2005). *Pakistan's water economy: running dry* (English). Washington, D.C.: The World Bank. Oxford University press. Retrieved from http://documents.worldbank.org/curated/en/989891468059352743/Pakistans-water-economy-running-dry

Brogan, J., Müller, K., Erlmann, T., & Sorokovskyi, V. (2017). *SDG 6 along the water and nutrient cycles*. Using the water and nutrient cycles as a tool for creating a common understanding of a water and sanitation system - including workshop material. Bern (Switzerland): AGUASAN and Swiss Agency for development and Cooperation (SDC).

Bryson, J. M., Patton, M. Q., & Bowman, R. A. (2011). *Working with evaluation stakeholders: A rationale, step-wise approach and toolkit*. Evaluation and Program Planning, 34(1), 1–12. Retrieved from https://doi.org/10.1016/j.evalprogplan.2010.07.001

Burger, J., & Gochfeld, M. (1998). The Tragedy of the commons 30 years later. *Environment: Science and Policy for Sustainable Development,* 40(10), 4–13. Retrieved from doi.org/10.1080/00139159809605104

Butt, M. S., Sharif, K., Bajwa, E. B., & Aziz, A. (2005). Hazardous effects of sewage water on the environment. *Management of Environmental Quality: An International Journal*, 16(4), 338–346. Retrieved from https://doi.org/10.1108/14777830510601217

Byrnes, K. (1992). *Water users associations in world bank-assisted irrigation projects in Pakistan.* Papers 173, World Bank – Technical Papers. Retrieved from http://ideas.repec.org/p/fth/wobate/173.html

Bäckman, A. (2011). *The Nordic electricity system as a common-pool resource*. C-level thesis. Department of Economic History, Uppsala University, Sweden. Retrieved from https://www.diva-portal.org/smash/get/diva2:437865/FULLTEXT01.pdf

C.T. de Wit. (1992). Resource use efficiency in agriculture. *Agricultural Systems*, 40(1), 125–151. Retrieved from doi.org/10.1016/0308-521X(92)90018-J

Camacho, D. (2013). *A timeline of human rights*. Retrieved May 31, 2016, from http://www.cisv.org/EasySiteWeb/GatewayLink.aspx?alId=98702

Canfield, S., Claessens, L., Jr., C. H., Rastetter, E., & Vallino, J. (1999). Long-term effect of municipal water use on the water budget of the Ipswich river basin. *Biological Bulletin*, 197(2), 295–297.

Carr, R. (2001). Excreta-related infections and the role of sanitation in the control of transmission. *Water Quality: Standards and Health*, 89–113.

Casiano Flores, C., Bressers, H., Gutierrez, C., & de Boer, C. (2018). Towards circular economy – a wastewater treatment perspective, the Presa Guadalupe case. *Management Research Review*, 41(5), 554–571. Retrieved from doi.org/10.1108/MRR-02-2018-0056

Charmaz, K. (2006). Constructing Grounded Theory: a practical guide through qualitative analysis. London, UK: SAGE Publications.

Chaudhary, H. H. (2015). *Auditor's report of urban sector planning and management services unit (private) limited*. Faisalabad, Pakistan.

Cheema, A. H. (1998). *Environmental impact assessment system in punjab, pakistan: review and proposals for improvement*. The University of Hong Kong. Pokfulam, Hong Kong SAR. Retrieved from http://dx.doi.org/10.5353/th_b3125960

Cheema, Ali, Khwaji, A., & Qadir, A. (2005). *Decentralization in Pakistan: context, content and causes* (KSG Faculty Research Working Paper Series No. RWP05-034). Retrieved from https://doi.org/10.1017/CBO9781107415324.004

Cheema, M. A., Farooq, M., Ahmed, R., & Nisar, H. (2006). Climatic trends in Faisalabad (Pakistan) over the last 60 years. *Journal of Agriculture & Social Sciences*, 2(1), 42–45.

Cheema, S. A. (2008). Technical and service delivery standards for water supply and sanitation sectors. Lahore, Pakistan.

Chou, W., & Melbourne, A. (2000). *A Case study of timeline investigation: the timeline in time*. Taichung, Taiwan. Retrieved from https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.134.1971&rep=rep1&type=pdf

Cifuentes, E., Gomez, M., Blumenthal, U., Tellez-rojo, M. M., Romieu, I., Ruiz-palacios, G., & Ruiz-velazco, S. (2000). Risk factor for giardia intestinalis infection in agricultural villages practicing wastewater irrigation in Mexico. *The American Society of Tropical Medicine and Hygiene*, 62(3), 388–392.

Cinar, T. (2009). Privatisation of urban water and sewerage services in Turkey: some trends. *Development in Practice*, 19(3), 350–364. Retrieved from https://doi.org/10.1080/09614520902808076

CDG Faisalabad. (2012). *Faisalabad: consolidated annual development programme 2012-13*. City District Government (CDG) Faisalabad/ Faisalabad Development Authority (FDA)/ Water and sanitation Agency (WASA), Faisalabad, Pakistan.

Clemett, A. E. V., & Ensink, J. H. J. (2006). *Farmer driven wastewater treatment : A case study from Faisalabad, Pakistan*. Refereed Paper. 32nd WEDC International Conference 2006-Sustainable development of water resources, water supply and environmental sanitation. Colombo, Sri Lanka. Retrieved from https://wedc-knowledge.lboro.ac.uk/resources/conference/32/Clemett.pdf

Coase, R. (1998). The new institutional economics. *The American Economic Review*, 88(2), 72–74. Retrieved from http://www.jstor.org/stable/116895

Cole, D. H. (2014). Formal institutions and the IAD framework: bringing the law back in. *SSRNElectronic Journal*, (297), 1–43. Retrieved from https://doi.org/10.2139/ssrn.2471040

Corcoran, E., C. Nellemann, E. Baker, R. Bos, D. Osborn, H. Savelli (eds). 2010. *Sick Water? The central role of wastewater management in sustainable development.* A Rapid Response Assessment. United Nations Environment Programme, UN-HABITAT, GRID-Arendal. www.grida.no

Correspondent. (2015, September 1). Time to act: Waste-water irrigation making land barren. *The Express Tribune*. Retrieved on 7 September 2018, Retrieved from https://tribune.com.pk/story/948468/time-to-act-waste-water-irrigation-making-land-barren

Correspondent. The Express tribune. (2013, October 11). Post-devolution: Pak-EPA working with provinces for better environmental protection. *The Express Tribune*. Retrieved on 9th January 2019 from https://tribune.com.pk/story/616397/post-devolution-pak-epa-working-with-provinces-for-better-environmental-protection

Danish Ministry of Foreign Affair. (2017). *Faisalabad Wastewater Treatment Plant Project, Pakistan*. (Ref. No.: F.2 No. 2017-23060, IFU No. L662-1). VBE and Danida Business Finance Departmet, Denmark. Retrived from https://um.dk/en/~/media/UM/English-site/Documents/Danida/About-Danida/Danida%20transparency/Consultations/2017/Faisalabad%20Pakistan.pdf.

Daud, M. K., Nafees, M., Ali, S., Rizwan, M., Bajwa, R. A., Shakoor, M. B., … Zhu, S. J. (2017). Drinking Water Quality Status and Contamination in Pakistan. *BioMed Research International*, 2017, 1–18. Retrieved from https://doi.org/10.1155/2017/7908183

Davis, J. (2004). Corruption in public service delivery: Experience from South Asia's water and sanitation sector. *World Development*, 32(1), 53–71. Retrieved from https://doi.org/10.1016/j.worlddev.2003.07.003

DAWN, (2003, November, 19). Lyell finds original touch in new city. *DAWN*. Retrieved from https://www.dawn.com/news/125643

Devi, M. G., & Samad, M. (2006). Wastewater Treatment and Reuse : an Institutional Analysis for Hyderabad, India. *Water*, (July), 513–523. Retrieved from https://publications.iwmi.org/PDF/H041888.pdf

Dimitrov, D. (2010). *The paradox of sustainability definitions*. In J. Professor Guthrie, K. Professor Jacobs, & J. Professor Baxter (Eds.), Asia Pacific Interdisciplinary Perspectives on Accounting (APIRIA) Conference (2010) Vol. APIRA-2010-073 (pp. 1-27). Sydney Australia: APIRA. Retrieved from http://apira2010.econ.usyd.edu.au/

Directorate of Industries. (2006). *Directory of Industrial Establishments*. Lahore, Pakistan: Government of Punjab.

Directorate of Industries. (2012). *District Pre-Investment Study - 2012: Faisalabad*. Lahore, Pakistan. Retrieved from https://www.punjab.gov.pk/directorate_industries_district_pre_investment

Merrey, D. J., Wolf, J. M. (1986). *Irrigation management in Pakistan: four papers*. Digana Village, Sri Lanka: International Irrigation Management Institute (IIMI). 66p. (IIMI Research Paper 4). Retrieved from https://cgspace.cgiar.org/handle/10568/36247

Drechsel, Pay; Scott, C. A.; Raschid Sally, Liqa; Redwood, M.; Bahri, Akissa. (Eds.) 2010. *Wastewater irrigation and health: assessing and mitigating risk in low-income countries*. Colombo, Sri Lanka: International Water Management Institute (IWMI); London, UK:

Earthscan; Ottawa, Canada: International Development Research Centre (IDRC). 404p. Retrieved from https://cgspace.cgiar.org/handle/10568/36471

Drechsel, P; Giordano, M; Gyiele, L. 2004. *Valuing nutrients in soil and water: Concepts and techniques with examples from IWMI studies in the developing world*. Research Report 82. Colombo, Sri Lanka: International Water Management Institute. Retrieved from https://www.iwmi.cgiar.org/publications/iwmi-research-reports/iwmi-research-report-82/

Drechsel, Pay; Graefe, S.; Fink, M. 2007. *Rural-urban food, nutrient and virtual water flows in selected West African cities*. Colombo, Sri Lanka: International Water Management Institute (IWMI). 29p. (IWMI Research Report 115) doi: http://dx.doi.org/10.3910/2009.115

Ensink, J. H. J., Van der Hoek W., Matsuno Y., Munir S., and Aslam, M. R. (2002). *Use of untreated wastewater in peri-urban agriculture in Pakistan: Risks and opportunities*. Research Report 64. Colombo, Sri Lanka: International Water Management Institute Retrieved from https://doi.org/http://dx.doi.org/10.3910/2009.069

Ensink, J. H. J., Mahmood, T., Van der Hoek, W., Raschid-Sally, L., & Amerasinghe, F. P. (2004). A nationwide assessment of wastewater use in Pakistan: An obscure activity or a vitally important one? *Water Policy*, 6, 197–206. Retrieved from https://doi.org/10.2166/wp.2004.0013

Ensink, J. H. J., Simmons, R. W., Van der Hoek, W. (2004). Wastewater use in Pakistan: the cases of Haroonabad and Faisalabad. In C. A. Scott, N. I. Faruqui, & L. Raschid-Sally (Eds.), *Wastewater use in irrigated agriculture: confronting the livelihood and environmental realities*. (pp. 91-100). International Water Management Institute (IWMI), South Asia Regional Office, Patancheru 502 324, Andhra Pradesh, India. ISBN: 9780851998237, DOI:10.1079/9780851998237.0091

Ensink, J. H.J. (2006). *Wastewater quality and the risk of hookworm infection in Pakistani and Indian sewage farmers.* (Doctoral dissertation). London School of Hygiene and Tropical Medicine, Faculty of Infectious and Tropical Diseases, University of London, London.

Ensink, J. H. J., Van der Hoek, W., Mara, D. D., & Cairncross, S. (2007). Waste stabilization pond performance in Pakistan and its implications for wastewater use in agriculture. *Urban Water Journal*, 4(4), 261–267. Retrieved from https://doi.org/10.1080/15730620701427429

Ensink, J. H. J., Mahmood, T., & Dalsgaard, A. (2007). Wastewater-irrigated vegetables: market handling versus irrigation water quality. *Tropical Medicine & International Health : TM & IH*, 12(s2), 2–7. Retrieved from https://doi.org/10.1111/j.1365-3156.2007.01935.x

Ensink, J. H. J., & Van der Hoek, W. (2009). Implementation of the WHO guidelines for the safe use of wastewater in Pakistan: balancing risks and benefits. *Journal of water and health*, 7(3), 464-468. Retrieved from https://doi.org/10.2166/wh.2009.061

Espinosa-orias, N., & Sharratt, P. N. (2006). *A hierarchical approach to stakeholder engagement*. In proceedings of 13th CIRP international conference on life cycle engineering (pp. 525–530). Manchester, England. Retrieved from https://www.mech.kuleuven.be/lce2006/145.pdf

Evans, A. E. V. (2016). *Institutional arrangements for resource recovery and reuse in the wastewater sector*. (Doctoral dissertation). Loughborough University. London, UK

Faisalabad Development Authority [FDA]. (1990). *Faisalabad Development Authority (Appointment and Conditions of Service) Regulations, 1990*, (Pub. L. No. Admn/174/PA/DA&C/FDA), 1 (1990). Pakistan: The Punjab Gazette

Faisalabad Development Authority [FDA]. (2015). *Faisalabad Development Authority (Water and Sanitation Agency) Faisalabad - Sewerage and Drainage Faisalabad Regulations, 2015*. (Pub. L. No. 552/MD/WASA/2015, 2260 (2015). Pakistan: The Punjab Gazette.

Farahat, E., & Linderholm, H. W. (2015). The effect of long-term wastewater irrigation on accumulation and transfer of heavy metals in Cupressus sempervirens leaves and adjacent soils. *Science of the Total Environment*, 512–513, 1–7. Retrieved from https://doi.org/10.1016/j.scitotenv.2015.01.032

Farhat, J., Noureen, A., Hussain, S., Shakoor, A., Irfan, M., Shabbir, S., … Shaheen, T. (2015). Chemical and mineral composition of Cyprinus carpio, Labeo rohita and Wallago attu inhabiting river Indus in Mianwali district. *International Journal of Biosciences* (IJB), 6(5), 333–342. Retrieved from https://doi.org/10.12692/ijb/6.5.333-342

Farid, G., Sarwar, N., Saifullah, Ahmad, A., & Rehman, M. (2015). Heavy metals (Cd, Ni and Pb) contamination of soils, plants and waters in Madina town of Faisalabad metropolitan and preparation of GIS based maps. *Advances in Crop Science and Technology*, 4(1), 1–7. Retrieved from https://doi.org/10.4172/2329-8863.1000199

Farid, M., Ali, S., Rizwan, M., Ali, Q., Abbas, F., Bukhari, S. A. H., … Wu, L. (2017). Citric acid assisted phytoextraction of chromium by sunflower; morpho-physiological and biochemical alterations in plants. *Ecotoxicology and Environmental Safety*, 145(July), 90–102. Retrieved from https://doi.org/10.1016/j.ecoenv.2017.07.016

Farid, S., Baloch, M. K., & Ahmad, S. A. (2012). Water pollution : Major issue in urban areas. *International Journal of Water Resources and Environmental Engineering*, 4(March), 55–65. Retrieved from https://doi.org/10.5897/IJWREE11.086

Farooq, M., Mateen, A., & Cheema, M. A. (2005). Determinants of migration in Punjab, Pakistan: a case study of Faisalabad metropolitan. *Journal of Agriculture Sciences & Social Sciences*, 1(3), 280–282.

Faruqee, R., & Colema, J. (Eds.). (1996). *Pakistan economic policies, institutions, and the environment*. (Report No. 15781-PAK). The World Bank doucument. Washington, D.C. USA.

Federal Bureau of Statistics. (2014). Poverty and Social Safety Nets. In M. S. Wazir (Ed.), *Pakistan Economic Survey 2013-14* (pp. 231–243). Islamabad, Pakistan: Ministry of Finance, Government of Pakistan.

Feenstra, S., Hussain, R., Van der Hoek, W., (2000). *Health risks of irrigation with untreated urban wastewater in the southern Punjab, Pakistan*. Lahore, Pakistan: International Water Management Institute (IWMI). Pakistan National Program; Lahore, Pakistan: Institute of Public Health. v, 13p. (IWMI Pakistan Report R-107) Retrieved from doi:http://dx.doi.org/10.3910/2009.453.

Ferguson, D. G., Dakers, A., & Gunn, I. (2003). *Sustainable wastewater management: A handbook for smaller communities*. Wellington: The Ministry of Environment, New Zealand. Retrieved from https://www.mfe.govt.nz/publications/waste/wastewater-mgmt-jun03/index.html

Fichtner. (2006). Urban water supply and sewerage reform strategy. WASA Faisalabad, Pakistan.

Government of Pakistan. (2014). *Pakistan econmic survey 2013-14*. Islamabad. Fianace Department, Government of Pakistan. Retrieved from http://www.finance.gov.pk/survey/chapters_14/02_Agriculture.pdf

Fossey, E., Harvey, C., McDermott, F., & Davidson, L. (2002). Understanding and evaluating qualitative research. *Australian and New Zealand Journal of Psychiatry*, 36(6), 717–732. Retrieved from https://doi.org/10.1046/j.1440-1614.2002.01100.x

Foster, S., Garduño, H., Tuinhof, A., Kemper, K., & Nanni, M. (2005). Urban wastewater as groundwater recharge - evaluating and managing the risks and benefits. Sustainable groundwater management (Concepts and Tools), *Briefing Note Series* (Note 12), 1–6. Retrieved from www.worldbank.org/gwmate

Friedel, J. K., Langer, T., Siebe, C., & Stahr, K. (2000). Effects of long-term waste water irrigation on soil organic matter, soil microbial biomass and its activities in central Mexico. *Biology and Fertility of Soils,* 31(5), 414–421. Retrieved from https://doi.org/10.1007/s003749900188

Gallegos, E., Warren, A., Robles, E., Campoy, E., Calderon, A., Sainz, M. G., … Escolero, O. (1999). The effects of wastewater Irrigation in groundwater quality in Mexico. *Water Science and Technology*, 40(2), 45–52.

Gandhi, A., Sucahyo, Y. G., and Ruldeviyani, Y. (2018). Investigating the Protection of Customers' Personal Data in the Ridesharing Applications: A Desk Research in Indonesia. 15th International Conference on Electrical Engineering/Electronics, Computer, *Telecommunications and Information Technology (ECTI-CON*), pp. 118-121, doi: 10.1109/ECTICon.2018.8619912

Garcia, X., & Pargament, D. (2015). Reusing wastewater to cope with water scarcity: Economic, social and environmental considerations for decision-making. *Resources, Conservation and Recycling,* 101, 154–166. Retrieved from https://doi.org/10.1016/j.resconrec.2015.05.015

Geels, F. W. (2004). From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research Policy,* 33(6–7), 897–920. Retrieved from https://doi.org/10.1016/j.respol.2004.01.015

Ghafoor, A., Raur, A., Arif, M., & Muzaffar, W. (1994). Chemical composition of effluents from different industries of the Faisalabad city. *Pak. J. Agri. Sci.*, 31(4), 367–370. Retrived from https://www.pakjas.com.pk/papers/856.pdf

GHK Consulting Limited. (2010). *Infrastructure Investment Proposal: Industrial Waste Management - Package 2*. Faisalabad, Pakistan.

GHK Consulting Limited. (2011). *Punjab Cities Improvement Investment Program*. Faisalabad, Pakistan.

Gomes, K. (2009). *Wastewater management: A UN-Water Analytical Brief.* UN Water, 55

Government of Pakistan. (2003). *Constitution (Seventeenth Amendment) Act, 2003*. Pakistan: The Gazette of Pakistan (Extraordinary).

Government of Pakistan. (2005). *Brief on Establishment of Environmental Monitoring*. Islamabad.

Government of Pakistan. (2006). *National Sanitation Policy*. Islamabad, Pakistan.

Government of Pakistan. (2009). *National Drinking Water Policy,2013*. Islamabad, Pakistan

Governemnt of Pakistan. (2010). *Agricultural census 2010: Pakistan report*. Government of Pakistan, Statistics division, Agricultural Census Organization. Lahore, Pakistan Retrieved from http://www.fao.org/fileadmin/templates/ess/ess_test_folder/World_Census_Agriculture/Country_info_2010/Reports/Reports_5/PAK_ENG_REP_2010.pdf

Government of Pakistan. (2011). *National Industrial Policy 2011*: Implementation Framework. Islamabad, Pakistan.

Government of Punjab. (1940). *Factories (Punjab Amendment) Act, 1940*. Pakistan: Punjab Government Gazette, Extraordinary.

Government of Punjab. (1976). *Punjab Development of Cities Act, 1976*. Pakistan.

Government of Punjab. (1997). *The Punjab Environmental Protection Act, 1997*. Pakistan: The Gazette of Pakistan, Extraordinary.

Government of Punjab. (2001). *The Punjab Local Government Ordinance, 2001*. Pakistan: Punjab Gazette (Extraordinary).

Government of Punjab. (2011a). *Assessment of Land Development and Management Practices Large Cities of Punjab*. Lahore, Pakistan.

Government of Punjab. (2011b). *The Punjab government rules of business 2011*. Pakistan: Services and General Administration Department (Cabinet Wing).

Government of Punjab. (2013). *Agenda for provincial punjab assembly*. Lahore, Pakistan: Government of Punjab.

Government of Punjab. (2014). *MTDF 2014-17: development programme 2014-15*. Lahore, Pakistan.

Government of Punjab. (2015a). *Environment: In MTDF 2014-17* (pp. 431–436). Lahore, Pakistan.

Government of Punjab. (2015b). *Punjab industries sector plan 2018*. Lahore, Pakistan.

Government of Punjab. (2015c). *Punjab Planning Manual*. Lahore, Pakistan.

Government of Punjab. (2015d). *Drinking water, sanitation, and hygiene: Punjab sector development plan 2014-2024*. Lahore, Pakistan. Planning and Development Board, Government of Punjab. Retrieved from https://pnd.punjab.gov.pk/system/files/Punjab%20WASH%20Sector%20Development%20Plan%202014-24.pdf

Graham, J. P., & Polizzotto, M. L. (2013). Pit Latrines and Their Impacts on Groundwater Quality: A Systematic Review. *Environmental Health Perspectives*, 5(121), 521–530.

Greenman, D., Bennett, G., & Swarzenski, W. (1967). *Ground-water hydrology of the Punjab, West Pakistan, with emphasis on problems caused by canal irrigation*. USGS Water Supply Paper 1608-H,. Washington, D.C. USA. Retrieved from: https://doi.org/10.1016/0022-1694(70)90289-1

Grimble, R., & Wellard, K. (1997). *Stakeholder methodologies in natural resource management: A review of principles, contexts, experiences and opportunities*. Agricultural Systems, 55(2), 173–193. Retrieved from https://doi.org/10.1016/S0308-521X(97)00006-1

Habiba, U.-, Taj, L., Farid, M., Anwar-ul-haq, M., Sharif, N., Farheen, H., & Sharif, N. (2013). Quality analysis of ground water resources of paharang drain Faisalabad , Pakistan. International Journal of Science, *Environment and Technology*, 2(6), 1175–1184.

Hall, P. A., & Taylor, R. C. R. (1996). Political science and the three new institutionalisms. *Political Studies*, XLIV, 936–957.

Hamano S. (Presenter). (2014, January 10-12). *JICA's Cooperation for Urban Water Supply and Sanitation.* In South Asian Cities Conference. 2nd Pakistan Urban Forum - Karachi Pakistan: The Urban Unit.

Hamilton, A. J., Stagnitti, F., Xiong, X., Kreidl, S. L., Benke, K. K., & Maher, P. (2007). Wastewater irrigation: the state of play. *Vadose Zone Journal*, 6(4), 823. Retrieved from https://doi.org/10.2136/vzj2007.0026

Hanif, M. ., Nadeem, R., Rashid, U., & Zafar, M. . (2005). Assessing pollution levels in effluents of industries in city zone of Faisalabad, Pakistan. *Journal of Applied Sciences*. 5 (10), 1713-1717.

Hanjra, M. A., Blackwell, J., Carr, G., Zhang, F., & Jackson, T. M. (2012). Wastewater irrigation and environmental health: Implications for water governance and public policy. *International Journal of Hygiene and Environmental Health*, 215(3), 255–269. Retrieved from https://doi.org/10.1016/j.ijheh.2011.10.003

Hanson, J., Bass, S., Bouzaher, A., Samdani, G. M., & Zehra, M. (2000). *Pakistan's national Conservation strategy: Renewing Commitment to Action*. Islamabad, Pakistan.

Haque, I. ul. (2014). Toward a competitive Pakistan: The role of industrial policy. *The Lahore Journal of Economics*, 19, 61.

Haruvy, N. (1997). Agricultural reuse of wastewater: nation-wide cost-benefit analysis. Agriculture, *Ecosystems & Environment*, 66(2), 113–119. Retrieved from https://doi.org/10.1016/S0167-8809(97)00046-7

Haruvy, N., Bachmat, Y., Shalhevet, S., & Yaron, D. (2000). *Effect of Urban Devlopment on Water Quality-Environmental Concerns*. In 40th Congress of the European Regional Science Association. Barcelona, Spain.

Haruvy, N., Offer, R., Hadas, A., & Ravina, I. (1999). Wastewater irrigation-economic concerns regarding beneficiary and hazardous effects of nutrients. *Water Resources Management*, 13(2222), 303–314. Retrieved from https://doi.org/10.1023/A:1008114225469

Hassan, A. (n.p.). *Assessment of land development and management practices in five large cities of punjab.* City and Regional Planning, University of Engineering & Technology Lahore, Pakistan. Retrieved on October, 2016 from https://www.academia.edu/11646173/Assessment_of_Land_Development_and_Management_Practices_in_Five_Large_Cities_of_Punjab

Hassan, J. (2001). Pakistan: Country report. *Asia Pacific Journal of Environmental Law*, 6 (3/4), 319- 332.

Hassan, M., Memon, Y., & Hamid, A. (1999). Returns to facilitating farmers' organisations for distributary maintenance: empirical results from a pilot project in southern punjab. *The Pakistan Development Review*, 3(Autumn), 253–268. Retrieved from http://www.jstor.org/stable/10.2307/41260171

Hayat, K., Ahmad, K., Ezaz, S., Gilani, H., Naveed, M., & Ahmed, Z. (2016). A comparative study of heavy metals (Cd & Hg) in ground fresh water, sewage water and baen nala water (Shakargarh) and their accumulation in vegetables irrigated by these water (a case study). *Science International (Lahore)*, 28(4), 3843–3848.

Hayat, M. U., Waqas, A., Ali, S., Farid, M., Ahmad, R., Muhammad Tauqeer, H., … Hannan, F. (2015). Determination of lead (Pb), iron (Fe) and manganese (Mn) concentration in sewage water and vegetable leaf samples. *Journal of Microbiology, Biotechnology and Food Sciences*, 04(05), 387–392. Retrieved from https://doi.org/10.15414/jmbfs.2015.4.5.387-392

Hernández-Sancho, F., Lamizana-Diallo, B., Mateo-Sagasta, J., & Qadir, M. (2015). *Economic valuation of Wastewater - The cost of action and the cost of no action.* Nairobi, Kenya: United Nations Environment Programme.

Hess, C., & Ostrom, E. (2003). Ideas, Artifacts, and Facilities: Information as a Common-Pool Resource. *Law and Contemporary Problems*, 66(12), 111–145.

Hill, M. (2013). A starting point: understanding governance, good governance and water governance. In Climate Change and Water Governance: Adaptive Capacity in Chile and Switzerland, *Advances in Global Change Research* 54 (Vol. 54, pp. 17–29). © Springer Science+Business Media Dordrech. Retrieved from https://doi.org/10.1007/978-94-007-5796-7

Hoek, W. Van Der, Hassan, M. U., Ensink, J. H. J., Feenstra, S., Raschid-sally, L., Munir, S., … Matsuno, Y. (2002). *Urban wastewater: a valuable resource for agriculture a case study from Haroonabad, Pakistan* (Research Report No. 63). Colombo, Sri Lanka.

Hoffman, R., & Ireland, D. (n.p.). *Elinor Ostrom, institutions and governance of the global commons.* Second Draft (Robert Hoffman and Derek Ireland July 2013). Retrieved from

Hoppe, T., Arentsen, M., Mikklia, M., & Linnanen, L. (2012). *Transition management and the sustainable nutrients economy in the Netherlands*. Positioning Paper, University Twente.

Hussain, I., Raschid, L., Hanjra, M. A., Marikar, F., & Hoek, W. van der. (2002). *Wastewater Use in Agriculture: Review of impacts and methodological issues in valuing impacts* (Working Paper No. 37). IIMI Colombo, Sri Lanka.

Hussain, M., & Kokab, R. U. (2012). Eighteenth amendment in the constitution of Pakistan: Success and controversies. *Asian Social Science*, 8(1), 81–88. Retrieved from https://doi.org/10.5539/ass.v8n1p81

Hussain, S. S., & Ahmed, V. (2012). *Experiments with industrial policy: The Case of Pakistan*. SDPI Working Paper, 48.

Hussain, S. T., Khan, U., & Malik, K. Z. (2012). The Constraints to Industry in Punjab, Pakistan. *The Lahore Journal of Economics*, (September), 135–189.

Ijaz, K. (1999). *Urban environmental situation of faisalabad: an analysis* (AUICK Newsletter No. 35). Faisalabad, Pakistan.

Ijaz, M., Waheed, A., Ul-Allah, S., Nawaz, A., Wasaya, A., Sattar, A., & Sher, A. (2019). Sewage waste water application improves the productivity of diverse wheat (Triticum aestivum L.) cultivars on a sandy loam soil. *Environmental Science and Pollution Research*, 26, 17045–17054. Retrieved from https://doi.org/10.1007/s11356-019-05061-w

Ilyas, M., Gilani, A. ., & Bhatty, N. (2008). Study of chemical quality of drinking water available to the children of different schools of Ghulammohammad abad, Faisalabad-Pakistan. *Pakistan Journal of Science*, 60(1–2), 26–29.

Imran, A., Ayaz, M., & Noureen, K. (2015). *Weather and wheat crop development in central Punjab (Faisalabad)*. National Agromet Centre Pakistan Meteorological Department, Islamabad, Pakistan. Retrieved from https://tripleis.org/wp-content/uploads/2019/12/Weather-and-Wheat-crop-development-in-central-punjab.pdf

Imperial, M. T., & Yandle, T. (2005). Taking institutions seriously: Using the IAD framework to analyze fisheries policy. *Society and Natural Resources*, 18(6), 493–509. Retrieved from https://doi.org/10.1080/08941920590947922

International Commission on Irrigation and Drainage [ICID]. (1999*). Country profile: pakistan*. in irrigation & drainage in the world – a global review. Islamabad.

International Institute for Environment and Development [IIED]. (draft June 2001). *Power tools series: stakeholder power analysis* (Power Tool: Tools for working on policies and institutions No. 2). Series number: 2. UK.

International Fund for Agriculture development [IFAD]. (2009). *Guidance notes for institutional analysis in rural development programmes.* Anyonge, T., & Messer, N. (Eds.). Rome, Italy. Retrieved from https://www.ifad.org/documents/38714170/39144386/Guidance+Notes+for+institutional+analysis+in+rural+development+programmes+-+an+overview.pdf/20cd8002-6c4c-4a83-9e14-034beb66c3ef

International Finance Corporation [IFC]. (2007). *Environmental, health, and safety general guidelines.* International Finance Corporation, World Bank Group. Retrieved from https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/policies-standards/ehs-guidelines

Iqbal, F., Ali, S., Hafiz Muhammad Tauqeer, M. B. S., Farid, M., Iftikhar, U., & Nazir, M. M. (2013). Assessment of ground water contamination by various pollutants from sewage water in chakera village, Faisalabad. *International Journal of Environmental Monitoring and Analys*is, 1(5), 182–187. Retrieved from https://doi.org/10.11648/j.ijema.20130105.13

IUCN—The World Conservation Union. (2000, February 29). *Mid-term review of national conservation strategy, environmental legislation.* HBP Ref.: R0C01NCS. The World Conservation Union, Islamabad. Retrieved from https://www.environmental-mainstreaming.org/nssd/country/pakistan/pamtr03.htm

IUCN Pakistan. (2005). *Environmental law in Pakistan — Federal*. IUCN Pakistan, Environmental Law Programme, Karachi, Pakistan. 78 pp. Retrieved from http://103.27.22.20:8080/jspui/bitstream/123456789/1359/1/EnvLaw%20Part1%20-%20Federal.pdf

IIMI. (2014). *Focus on Pakistan: Reforming farmer-run irrigation schemes* (Policy Brief No. 1). IIMI Colombo, Sri Lanka.

Jabareen, Y. (2009). Building a conceptual framework: philosophy, definitions, and procedure. *International Journal of Qualitative Methods*, 8(4), 49–62. Retrieved from https://doi.org/10.1177/160940690900800406

Jabeen, F., Aslam, A., & Salman, M. (2018). Heavy metals toxicity and associated health risks in vegetables grown under soil irrigated with sewage water. *Universal Journal of Agricultural Research,* 6(5), 173–180. Retrieved from https://doi.org/10.13189/ujar.2018.060505

Jadoon I. B. K., Ali, S., Jadoon, Q. B. K., Shakoor, M. B., Bharwana, S. A., & Farooq, M. A. (2013). Effects of irrigation with waste water from different industries on vegetables grown in vicinity of Faisalabad, Pakistan. *International Research Journal of Plant Science*, 4(6), 144–148.

Jamal, Q., Durani, P., & Khan, K. (2013). Heavy metals accumulation and their toxic effects: review. *Journal of Bio-Molecular Sciences (JBMS)*, 1(1-2), 27-36. Retrieved from http://www.cls.irp.edu.pk/index.php/jbms/article/view/170

JICA. (2007, August). *Japan's official development assistance for Pakistan*. ODA-Japan. Pp.7

JICA. (2008). *Ex-ante Evaluation: Punjab Irrigation System Improvement Project*. Retrieved from https://www2.jica.go.jp/en/evaluation/pdf/2008_PK-P59_1_f.pdf

JICA. (2012a). *WASA Faisalabad upgrading sanitation Report.* Faisalabad, Pakistan.

JICA, (2012b). *Technical cooperation for establishment of environmental monitoring system*. Final Report. JICA: Pakistan. Retrieved from https://openjicareport.jica.go.jp/pdf/12066700_01.pdf

JICA. (2014, October 17). Japan gifts WASA Faisalabad equipments for sanitation. *JICA Press Releases*. Retrieved form https://www.jica.go.jp/pakistan/english/office/topics/press141017.html

JICA. (2015a). *Map of JICA major projects in Pakistan. Japan International Cooperation Agency* (JICA): Pakistan. Retrieved from https://www.jica.go.jp/pakistan/english/activities/index.html

JICA. (2015b, March 31). JICA to establish water and sanitation agency for Punjab. *JICA Press Releases.* Retrieved from https://www.jica.go.jp/pakistan/english/office/topics/press150331_02.html

JICA. (2016a). *The Project for water supply, sewerage and sanitation*. Faisalabad, Pakistan. Retrieved from The Project for Water supply, sewerage and Sanitation. Faisalabad

JICA. (2016b, March 3). JICA to help WASA with Master Plan for water supply, sewerage and drainage in Faisalabad. *JICA Press Releases*. Retrieved from https://www.jica.go.jp/pakistan/english/office/topics/press160303.html

JICA. (2019). *The Project for water supply, sewerage and drainage master plan of Faisalabad* (Vol. II). Faisalabad, Pakistan.

Ju, X. T., Kou, C. L., Zhang, F. S., & Christie, P. (2006). Nitrogen balance and groundwater nitrate contamination: comparison among three intensive cropping systems on the North China Plain. *Environmental Pollution* (Barking, Essex : 1987), 143(1), 117–125. Retrieved from https://doi.org/10.1016/j.envpol.2005.11.005

Kahlown, M. A., Ashraf, M., Hussain, M., Salam, A., & Zeeshan, A. (2006). *Impact assessment of sewerage and industrial effluents on water resources, soil, crops and human health in Faisalabad.* PCRWR, Islamabad, Pakistan.

Kaiser, M., & Forsberg, E. M. (2001). Assessing fisheries-Using an ethical matrix in a participatory process. *Journal of Agricultural and Environmental Ethics*, 14(2), 191–200. Retrieved from https://doi.org/10.1023/A:1011300811590

Kaiser, M., Millar, K., Thorstensen, E., & Tomkins, S. (2007). Developing the Ethical Matrix as a decision support framework: GM fish as a case study. *Journal of Agricultural and Environmental Ethics*, 20(1), 65–80. Retrieved from https://doi.org/10.1007/s10806-006-9023-8

Katzenelson, E., Buiun, I., & Shuval, H. I. (1976). Risk of communicable disease infection associated with wastewater irrigation in agricultural settlements. *Science*, 194(4268), 944–946.

Khalid, S., Shahid, M., Dumat, C., Niazi, N. K., Bibi, I., Gul Bakhat, H. F. S., … Javeed, H. M. R. (2017). Influence of groundwater and wastewater irrigation on lead accumulation in soil and vegetables: Implications for health risk assessment and phytoremediation. *International Journal of Phytoremediation*, 19(11), 1037–1046. Retrieved from https://doi.org/10.1080/15226514.2017.1319330

Khan, F. (2016, November, 6). Water shortage. *The News International*. Retrieved on 14/01/2019. Retrieved from https://www.thenews.com.pk/print/162733-Water-shortage

Khan, I., Iqbal, M., Ashraf, M. Y., Ashraf, M. A., & Ali, S. (2016). Organic chelants-mediated enhanced lead (Pb) uptake and accumulation is associated with higher activity of enzymatic antioxidants in spinach (Spinacea oleracea L.). *Journal of Hazardous Materials*, 317, 352–361. Retrieved from https://doi.org/10.1016/j.jhazmat.2016.06.007

Khan I, G. A. (2015). Amelioration of Lead toxicity in Pisum sativum (L.) by foliar application of salicylic acid. *Journal of Environmental & Analytical Toxicology*, 05(04), 4–6. Retrieved from https://doi.org/10.4172/2161-0525.1000292

Khan, J. Z. (2013, December). Origin of textile industry in Faisalabad. *Journal Asian Development Studies*, 2(4), 68–79.

Khattak, A. (2011, July 16). *Water and sanitation in Pakistan*. Retrieved from https://azamkhattak.wordpress.com/2011/07/16/water-supply-and-sanitation-in-pakistan/

Khattak, M. I., & Shahida, N. J. (2014). Effect of legislation on environmental matters in light of eighteenth amendment. *Science International Lahore*, 26(4), 1855–1862.

Khoso, S., Wagan, F. H., Tunio, A. H., & Ansari, A. A. (2015). An overview on emerging water scarcity in Pakistan, its causes, impacts and remedial measures. *Journal of Applied Engineering Science*, 13(1), 35–44. Retrieved from https://doi.org/10.5937/jaes13-6445

Khwaja, M. A. (2013, September). Mercury poisoning dentistry. *Research & News Bulletin*, 20(3), 1–2.

Kirby, A., Rucevska, I., Yemelin, V., Cooke, C., Simonett, O., Novikov, V., & Hughes, G. (Eds.). (2013). *Mercury–time to act*. United Nations Environment Programme, 2013. Geneva, Switzerland.

Kirkevold, M., & Bergland, Å. (2007). The quality of qualitative data: Issues to consider when interviewing participants who have difficulties providing detailed accounts of their

experiences. *International Journal of Qualitative Studies on Health and Well-Being*, 2(2), 68–75. Retrieved from https://doi.org/10.1080/17482620701259273
Kjellén, M. (2018). Wastewater governance and the local, regional and global environments. *Water Alternatives*, 11(2), 219–237.
Klein, P. G. (2000). New institutional economics. *Encyclopedia of Law and Economics*, 1, 456–489: SSRN 115811, 1998
Kordlaghari, K. P., Sisakht, S. N., & Saleh, A. (2013). Soil chemical properties affected by application of treated municipal wastewater. *Annals of Biological Research*, 4(3), 105–108.
Krippendorff, K. (1989). Content analysis. In E. Barnouw, G. Gerbner, W. Schramm, T. L. Worth (Eds.), *The International Encyclopedia of Political Communication* 1, 403–407. New York: Oxford University Press. Retrieved from http://repository.upenn.edu/asc_papers/226
Krippendorff, K. (2004). *Content analysis: an introduction to its methodology*. (M. H. Seawell, J. Meyers, C. A. Hoffman, & J. Selhorst, Eds.), Education (Second Edi, Vol. 79). London,UK: SAGE Publications, Inc. Retrieved from https://doi.org/10.2307/2288384
Kuhlman, T., & Farrington, J. (2010). What is sustainability? *Sustainability*, 2(11), 3436–3448. Retrieved from https://doi.org/10.3390/su2113436
Kugelman, M. (2016, September 30). Why the India-Pakistan war over water is so dangerous. Froeign's Policy, *weekly South Asia Brief*. retrieved on 14/01/2019 Retrieved from https://foreignpolicy.com/2016/09/30/why-the-india-pakistan-war-over-water-is-so-dangerous-indus-waters-treaty/
Labite, H., Lunani, I., van der Steen, P., Vairavamoorthy, K., Drechsel, P., & Lens, P. (2010). Quantitative microbial risk analysis to evaluate health effects of interventions in the urban water system of Accra, Ghana. *Journal of Water and Health*, 8(3), 417–430. Retrieved from https://doi.org/10.2166/wh.2010.021
Lam, W. F., & Ostrom, E. (2010). Analyzing the dynamic complexity of development interventions: Lessons from an irrigation experiment in Nepal. *Policy Sciences*, 43(1), 1–25. Retrieved from https://doi.org/10.1007/s11077-009-9082-6
Langeweg, F., Hilderink, H., & Maas, R. (2000). *Urbanisation, industrialisation and sustainable development.* Global Dynamics and Sustainable Development Programme. (Globo Report Series no. 27). Bilthoven, Netherland. Retrieved from Retrieved from http://www.pbl.nl/sites/default/files/cms/publicaties/402001015.pdf
Last, J. M. (2001). *A dictionary of epidemiology* (6th ed). New York: Oxford U. Press.
Letts, L., Wilkins, S., Law, M., Stewart, D., Bosch, J., & Westmorland, M. (2007). *Guidelines for critical review form: Qualitative studies (Version 2.0*). McMaster university occupational therapy evidence-based practice research group. Retrieved from https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.600.223&rep=rep1&type=pdf
Li, Q., Tang, J., Wang, T., Wu, D., Busso, C. A., Jiao, R., & Ren, X. (2018). Impacts of sewage irrigation on soil properties of a farmland in China: A review. *International Journal of Experimental Botany*, 87(January).
Lincoln, Y. S., & Guba, E. G. (1990). Judging the quality of case study reports. International *Journal of Qualitative Studies in Education*, 3(1), 53–59. Retrieved from https://doi.org/10.1080/0951839900030105
Loudjeva, Z., & Jorgensen, S. L. (2005). *A poverty and social impact analysis of three reforms in Zambia : land, fertilizer, and infrastructure* (Social Development Papers No. 49). Washington, DC 20433, USA. Retrieved from http://documents.worldbank.org

Lucho-Constantino, C. A., Álvarez-Suárez, M., Beltrán-Hernández, R. I., Prieto-García, F., & Poggi-Varaldo, H. M. (2005). A multivariate analysis of the accumulation and fractionation of major and trace elements in agricultural soils in Hidalgo State, Mexico irrigated with raw wastewater. *Environment International*, 31(3), 313–323. Retrieved from https://doi.org/10.1016/j.envint.2004.08.002

Mahmood, A., & Malik, R. N. (2014). Human health risk assessment of heavy metals via consumption of contaminated vegetables collected from different irrigation sources in Lahore, Pakistan. *Arabian Journal of Chemistry*, 7(1), 91–99. Retrieved from https://doi.org/10.1016/j.arabjc.2013.07.002

Malik, P. K., & Datta, S. (2005). Financial sustainability of environmental investment under an empirical pollution abatement policy instrument in India: the case of wastewater treatment. *Environmental Science & Policy*, 8(1), 67–74. Retrieved from https://doi.org/10.1016/j.envsci.2004.08.007

Mapanda, F., Mangwayana, E. N., Nyamangara, J., & Giller, K. E. (2005). The effect of long-term irrigation using wastewater on heavy metal contents of soils under vegetables in Harare, Zimbabwe. *Agriculture, Ecosystems & Environment*, 107(2–3), 151–165. Retrieved from https://doi.org/10.1016/j.agee.2004.11.005

Mara, D. D. (2003). *Domestic wastewater treatment in developping countries*. Earthscan, London. ISBN 9781844070190

Mara, D., & Cairncross, S. (1989). *Guidelines for the safe use of wastewater and excreta in agriculture and aquaculture: Measures for Public Protection*. World Health Organization in collaboration with the United Nations Environment Programme, WHO, Geneva. 187 pp., ISBN 92 4 154289.

Mateo-sagasta, J., & Burke, J. (2010). *Agriculture and water quality interactions: a global overview* (No. TR08). SOLAW Background Thematic Report (Vol. 08). FIAT-PANIS

Mateo-Sagasta, J., Medlicott, K., Qadir, M., Raschid-Sally, L., Drechsel, P., & Liebe, J. (2013). *Proceedings of the UN-Water project on the safe use of wastewater in Agriculture*. (J. Leibe & R. Ardakanian, Eds.), UN-Water Decade Programme on Capacity Development (UNW-DPC). Proceedings Series No. 11. 82 pp. UNW-DPC, Bonn, Germany. Retrieved from https://collections.unu.edu/view/UNU:2661

Mateo-Sagasta, J., & Salian, P. (2012, November 3). *Global database on municipal wastewater production, collection, treatment, discharge and direct use in agriculture*. AQUASTAT, Food and Agriculture Organization of United nation. (1–10).

Matsuno, Y., Ensink, J. H. J., Van der Hoek, W., & Simmons, R. W. (2003). *Assessment of the use of wastewater for irrigation: a case in Punjab, Pakistan. Wastewater Re-use and Groundwater Quality* (Proceedings symposium 11S04 held during IUGG2003 at Sapporo. July 2003). (28–33). IAHS Publ. 285. 2004.

Mayda, J. (1985). Environmental legislation in developing countries: some parameters and constraints. *Ecology Law Quarterly*, 12(4), 997–1024. Retrieved from https://doi.org/10.15779/Z383F9Q

Mazhar, F., & Jamal, T. (2009). Temporal residential growth of Faisalabad City. *Journal of Scientific Research*, XXXIX(1), 245–247.

Mburu, J., Birner, R., & Zeller, M. (2003). Relative importance and determinants of landowners' transaction costs in collaborative wildlife management in Kenya: An empirical analysis. *Ecological Economics*, 45(1), 59–73. Retrieved from https://doi.org/10.1016/S0921-8009(03)00002-8

Mccord, P., Dell'Angelo, J., Baldwin, E., & Evans, T. (2016). Polycentric Transformation in Kenyan Water Governance: A Dynamic Analysis of Institutional and Social-Ecological

Change. *The Policy Studies Journal*, 45(4), 26. Retrieved from https://doi.org/10.1111/psj.12168
McGranahan, G., & Marcotullio, P. (2005). *Urban systems*. In J. Eades & E. Ezcurra (Eds.), Ecosystems and Human Well-being: Current State and Trends (pp. 797–825). Retrieved from https://doi.org/http://dx.doi.org/10.1016/B978-008045405-4.00364-5
McGinnis, M. D. (2011a). 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. Retrieved from https://doi.org/10.1111/j.1541-0072.2010.00401.x
McGinnis, M. D. (2011b). *Updated guide to iad and the language of the ostrom workshop: a simplified overview of a complex framework for the analysis of institutions and their development.* (Version 2h). Indiana University, Bloomington. Retrieved from https://mcginnis.pages.iu.edu/iad_guide.pdf
Melbourn water. (n. p.). *Werribee Farm.* Retrieved from https://www.melbournewater.com.au/water-data-and-education/water-facts-and-history/history-and-heritage/history-sewerage/werribee
Memon, M. Y., Scheumann, W. (2003). *Reforming governance systems for drainage in Pakistan: toward an interdisciplinary and integrated approach to agricultural drainage* (English). Agriculture and Rural Development working paper series no. 11. Washington, D.C. World Bank Group. Retrieved from http://documents.worldbank.org/curated/en/557541468283497201/Reforming-governance-systems-for-drainage-in-Pakistan-toward-an-interdisciplinary-and-integrated-approach-to-agricultural-drainage
Ménard, C., & Shirley, M. (2014). The contribution of douglass north to new institutional economics. In S. Galiani & I. Sened (Eds.), *Institutions, Property Rights, and Economic Growth: The Legacy of Douglass North* (pp. 11-29). Cambridge: Cambridge University Press. doi:10.1017/CBO9781107300361.003
Mepham B. (2006). The ethical matrix as a decision-making tool, with specific reference to animal sentience. In Turner, J. & D'Silva, J. (Eds.), *Animals, Ethics and Trade: The Challenge of animal sentience* (pp. 134- 146). Earthscan, London
Mepham, B. (2008). *Bioethics: An introduction to the biosciences* (2nd Edition). Oxford University Press, UK.
Mepham, B. T. (2000). The role of food ethics in food policy. *Proceedings of the Nutrition Society*, 59(4), 609-618. doi:10.1017/S0029665100000860
Mepham, B. (2010). The Ethical Matrix as a tool in policy interventions: the obesity crisis. In F.T. Gottwald, H. W. Ingensiep, & M. Meinhardt (Eds.), *Food Ethics* (pp. 17–29). Springer, New York, NY. Retrieved from https://doi.org/10.1007/978-1-4419-5765-8
Mepham, B., & Tomkins, S. (2003). *Ethics and animal farming: A Web-based interactive exercise for students using the Ethical Matrix*. http://www.ethicalmatrix.net (accessed October 2015).
Mepham, B., Kaiser, M., Thorstensen, E., Tomkins, S., & Millar, K. (2006). *Ethical matrix manual.* Centre for Applied Bioethics and School of Biosciences University of Nottingham, UK.
Merrey, D. J. (1997). *Expanding the frontiers of irrigation management research: results of research and development at the international irrigation management research, 1984 to 1995*. Colombo, Srilanka: IMII. Xlii, 217p.
Metcalf, E., & Eddy, H. (2003). *Wastewater engineering: treatment and reuse*. Tata McGraw-Hill Publishing Company Limited, 4th edition. New Delhi, India. Retrieved from https://doi.org/10.1016/0309-1708(80)90067-6

Mezzera, M., Aftab, S., & Yusuf, S. (2010). *Devolution row: An assessment of Pakistan's 2001 Local Government Ordinance.* Hague, Netherland: Desktop publishing: Nicole den Heijer Netherlands.

Mian, Q. J. (n.p.). *Environmental law*. Director research/faculty member Punjab Judicial Academy, Pakistan.

Milgrom, P. R., North, D. C., & Weingast, B. R. (1990). The role of institutions in the revival of trade: the medieval law merchant. *Economics and Politics*, 2(I), 1–23. Retrieved from https://doi.org/doi:10.1111/j.1468-0343.1990.tb00020.x

Ministry of Environment. (2002). *Brief on environmental concerns-pakistan scenario*. Islamabad, Pakistan.

Ministry of Environment. (2005). *National environmental policy pakistan*. Ministry of Environment, Government of Pakistan.

Ministry of Climate Change. (2012). *Pakistan environmental newsletter*. In World Environment Day Special (pp. 1–8). Islamabad, Pakistan: Ministry of Climate Change, Government of Pakistan.

Mojid, M. A., Biswas, S. K., & Wyseure, G. C. L. (2012). Interaction effects of irrigation by municipal wastewater and inorganic fertilizers on wheat cultivation in Bangladesh. *Field Crops Research*, 134, 200–207. Retrieved from https://doi.org/10.1016/j.fcr.2012.06.010

Moloney, K. (2013). Governing without collaboration: state and civil society relations in Jamaica. *International Public Management Review*, 14(1), 1–26.

Moulaert, F. (2005). Institutional economics and planning theory: A partnership between ostriches? *Planning Theory*, 4(1), 21–32. Retrieved from https://doi.org/10.1177/1473095205051440

Muhmood, A., Majeed, A., Javid, S., Niaz, A., Majeed, T., Shahid, S., & Shah, H. (2015). Health risk assessment from wastewater irrigated vegetables. *American-Eurasian J. Agric. & Environ. Sci*, 15(7), 1424–1434.

Mukherjee N. & Wijk, C. van. (Eds.). (2003). *Sustainability, planning and monitoring in community water supply and sanitation: a guide on the methodology for participatory assessment (MPA) for community driven program*. The World Bank (Washington, D.C. USA: International Water and Sanitation Centre (IRC)

Murphy, H. (2017). Persistence of pathogens in sewage and other water types. In: J.B. Rose and B.Jiménez-Cisneros (eds), *Water and Sanitation for the 21st Century: Health and Microbiological Aspects of Excreta and Wastewater Management* (Global Water Pathogen Project). (M. Yates (eds), Part 4: Management of Risk from Excreta and Wastewater - Section: Persistence), Michigan State University, E. Lansing, MI, UNESCO. Retrieved from https://doi.org/10.14321/waterpathogens.51

Murtaza, G., & Zia, M. H. (2012, May). *Wastewater production, treatment and use in Pakistan*. In second regional workshop of the project 'safe use of wastewater in agriculture (pp. 16-18).

Mushtaq, A. Q. & Tohidahma, D. (2012). Economic reforms and divisional administration in Punjab (2011-12): A case study of Faisalabad division. *International Journal of Economics, Commerce and Research (IJECR)*, 2(4), 17–28. Retrieved from http://www.tjprc.org/view_archives.php?year=2013&id=41&jtype=2&page=2

Mustafa, Z., Alavi, A. Z., Rizvi, A., Khan, S.-R., Anwar, M. O., & Aziz, J. (2014). *European Union's GSP plus regime: examining pakistan's compliance with international legal obligations.* A Policy Brief by the research society of international law (Vol. 1 of 2014), Islamabad, Pakistan.

Muyen, Z., Moore, G. A., & Wrigley, R. J. (2011). Soil salinity and sodicity effects of wastewater irrigation in South East Australia. *Agricultural Water Management*, 99(1), 33–41. Retrieved from https://doi.org/10.1016/j.agwat.2011.07.021

Naeem, M. khalid, Bashir, M. K., Hussain, B., & Abbas, M. (2007). Assessment of profitability of sugarcane crop in faisalabad district. *Pakistan Journal of Life and Social Sciences*, 5(1–2), 30–33.

Nasir, A., Nasir, M. S., Shauket, I., Anwar, S., & Ayub, I. (2016). Impact of samanduri drain on water resources of Faisalabad. *Advances in Environmental Biology*, 10(1), 155-160.

Nasir, M. S., Sarwar, A., & Shaukat, I. (2014). Groundwater quality assessment of industrial zone of faisalabad using geographic information system. *International Journal of Science and Research*, 3(10), 2016–2010.

National Assembly of Pakistan. (2012). *The Constitution of the Islamic Republic of Pakistan* (Sixth edit.). Islamabad, Pakistan. Retrieved from http://www.na.gov.pk/uploads/documents/1333523681_951.pdf

Naureen, M. (2009). Development of Environmental Institutions. *Pakistan Journal of History and Culture*, XXX(1), 93–112.

Nawaz, H., Akhtar, J., Anwar-ul-haq, M., Arfan, M., Ullah, A., & Iftikhar, I. (2019). Wastewater Induced Manganese Toxicity Affects Growth and Bioavailability in Spinach (Spinacia oleracea). *International Journal Of Agriculture & Biology*, 21 (1) 135–139.

Nayono, S. (2014). *Development of a sustainability-based sanitation planning tool (susTA) for developing countries case study: integrated water resources management (IWRM)*. (Doctoral Dissertation). Bauhaus-Universität Weimar, Germany. Retrieved from https://doi.org/10.25643/bauhaus-universitaet.2222.

Newspaper's Staff correspondent. (2014, October 18). JICA-funded Drainage Project Inaugurated in Faisalabad. *DAWN.* Retrieved from https://www.dawn.com/news/1138703

Nhundu, K. (2013). *Effectiveness of irrigation water management institutions in Zimbabwe: a new institutional economics theory approach*. (Doctoral dissertation). University of Fort Hare, Alice, South Africa.

Nigussie, Z., Tsunekawa, A., Haregeweyn, N., Adgo, E., Cochrane, L., Floquet, A., & Abele, S. (2018). Applying Ostrom's institutional analysis and development framework to soil and water conservation activities in north-western Ethiopia. *Land Use Policy*, 71(November 2017), 1–10. Retrieved from https://doi.org/10.1016/j.landusepol.2017.11.039

North, D. C. (1991). Institutions. *The Journal of Economic Perspectives*, 5(1), 97-112. Retrieved from http://www.jstor.org/stable/1942704

North, D. C. (1993). The new institutional economics and development. *Economic History*, 9309002. Retrieved from http://hdl.handle.net/10535/4397

NSFC. (2003). Explaining the Activated Sludge Process. *Pipeline*, 14(2), 1–8.

Nygård, K. (2008). *Water and infection. Epidemiological studies of epidemic and endemic waterborne disease.* (Doctoral dissertation). University of Oslo. Retrieved from http://hdl.handle.net/10852/28104

OECD. (2011). *Benefits of investing in water and sanitation: An OECD perspective.* OECD Studies on Water, OECD Publishing, Paris, Retrieved from https://doi.org/10.1787/9789264100817-en.

Opoku, A. (2016). SDG2030: *A sustainable built environment' s role in achieving the post-2015 United Nations Sustainable Development Goals*. In P. W. Chan & C. J. Neilson (Eds.), Proceedings of the 32nd Annual ARCOM Conference, 2, pp. 1149–1158. Association of Researchers in Construction Management, Manchester, UK.

Organization for Economic Co-operation and Development [OECD]. (2008). *OECD glossary of statistical terms.* Newyork. OECD publication. Retrieved from https://doi.org/10.1787/9789264055087-en

Ostrom, E., & Ostrom, V. (1977). *Public economy organization and service delivery*. Paper presented at the conference of the Financing the Regional City, Project Meeting of the Metropolitan Fund. University of Michigan, Dearborn. Retrieved from http://hdl.handle.net/10535/732

Ostrom, E. (1990). *Governing the commons: the evolution of institutions for collective action* (Political Economy of Institutions and Decisions). Cambridge: Cambridge University Press. doi:10.1017/CBO9780511807763

Ostrom, E. (1992). *Crafting institutions for self-governing irrigation systems*. California, USA: ICS press, Institute for Contemporary Studies, California. Retrieved from https://doi.org/10.1002/rrr.3450080314

Ostrom, E. (1998). *Coping with the Tragedies of Common* (Workshop working paper W98-24). Workshop in Political Theory and Policy Analysis, Indiana University, Bloomington, IN Retrieved from http://hdl.handle.net/10535/5876

Ostrom, E. (1999). *Design principles and threats to sustainable organizations that manage commons* (Workshop working paper W99-6). Workshop in Political Theory and Policy Analysis, and the Center for the Study of Institutions, Population and Environmental Change, Indiana University, Bloomington, IN. Retrieved from http://hdl.handle.net/10535/5465

Ostrom, E. (2004). Understanding collective action. In R. S. Meinzen-Dick & M.D. Gregorio (Eds.), *Collective Action and Property Rights for Sustainable Development* (Focus 1, Brief 2 of 16).

Ostrom, E. (2005). *Understanding institutional diversity*. Princeton; Oxford: Princeton University Press. doi:10.2307/j.ctt7s7wm

Ostrom, E. (2005a). *Unlocking public entrepreneurship and public economies*. Discussion Paper 2005/001. Helsinki: UNU-WIDER.

Ostrom, E. (2007). Challenges and growth: the development of the interdisciplinary field of institutional analysis. *Journal of Institutional Economics*, 3(03), 239–264. Retrieved from https://doi.org/10.1017/S1744137407000719

Ostrom, E. (2009). *A polycentric approach for coping with climate change* (World Bank Policy Research Working Paper, no. 5095). Development and Climate Change. Washington, D.C. USA. Retrieved from http://hdl.handle.net/10535/5357

Ostrom, E. (2010). Beyond Markets and States : Polycentric Governance of Complex Economic Systems. *American Economic Review*, 100(3), 641–672. Retrieved from http://hdl.handle.net/10535/7707

Ostrom, E. (2011). Background on the institutional analysis and development framework. *Policy Studies Journal*, 39(1), 7–27. Retrieved from https://doi.org/10.1111/j.1541-0072.2010.00394.x

Ostrom, E, Benjamin, P., & Shivakoti, G. (1994). *Use of case studies and structural coding in a relational database for storage and analysis of irrigation institutions and systems in Nepal* (Inventory Technique for Resource Information and Policy Inputs). Bloomington, USA: Indiana University. 49-68.

Ostrom, V., & Ostrom, E. (1972). Legal and political conditions of water resource development. *Journal of Land Economics*, 48(1), 1-14. Retrieved from http://www.jstor.org/stable/3145634

Pakistan Senate. (2011, April 1). *The senate of Pakistan debates*. Official Report (69th Session), Vol. II (No. 5), pp. 157. The Senate Secretariat, Islamabad, Pakistan.

Partelow, S., & Winkler, K. J. (2016). Interlinking ecosystem services and Ostrom's framework through orientation in sustainability research. *Ecology and Society*, 21(3), 27. Retrieved from https://doi.org/10.5751/ES-08524-210327

Paulus, J. K., Dahabreh, I. J., Balk, E. M., Avendano, E. E., Lau, J., & Ip, S. (2014). Opportunities and challenges in using studies without a control group in comparative effectiveness reviews. *Research Synthesis Methods*, 5(2), 152–161. Retrieved from https://doi.org/10.1002/jrsm.1101

Perveen, S., Shahbaz, M., Iqbal, M., Akram, M. S., Parveen, A., & Ali, H. M. M. (2016). Induction of Cadmium stress tolerance in Triticum aestivum L. by alfalfa leaf extract. *Applied Ecology and Environmental Research*, 14(5), 121–136. Retrieved from https://doi.org/10.15666/aeer/1405_121136

Pescod, M. B. (1992). *Wastewater treatment and use in agriculture - FAO irrigation and drainage* (FAO irrigation and drainage No. paper 47). Rome, Italy.

Pierson, P., & Skocpol, T. (2008). Historical institutionalism in contemporary political science. *Uruguayan Journal of Political Science*, 17(1), 1–32. Retrieved from https://doi.org/10.1146/annurev.polisci.2.1.369

Polski, M. M., & Ostrom, E. (1999). *An institutional framework for policy analysis and design* (W98-72). Workshop in Political Theory and Policy Analysis, Indiana University. 1- 49.

Pongrácz E, Phillips PS & Keiski RL (2004) *Evolving the theory of waste management–implications to waste minimization.* In: Pongrácz E. (ed.): Proc. Waste Minimization and Resources Use Optimization Conference. June 10, 2004, University of Oulu, Finland. Oulu University Press: Oulu. 61-67.

Preston, B. J. (2005). The role of the judiciary in promoting sustainable development: the experience of Asia and the Pacific. *Asia Pacific Journal of Environmental Law*, 9 (January), 134.

Qureshi, A. S., Hussain, M. I., Ismail, S., & Khan, Q. M. (2016). Evaluating heavy metal accumulation and potential health risks in vegetables irrigated with treated wastewater. *Chemosphere*, 163, 54–61. Retrieved from https://doi.org/10.1016/j.chemosphere.2016.07.073

Raja, S. (2014). *Breeding tomato for fruit production with urban sewage water*. (Doctoral Thesis). University of Agriculture, Faisalabad, Pakistan.

Raja, S., Cheema, H. M. N., Babar, S., Khan, A. A., Murtaza, G., & Aslam, U. (2015). Socio-economic background of wastewater irrigation and bioaccumulation of heavy metals in crops and vegetables. *Agricultural Water Management*, 158 (May 2015), 26–34. Retrieved from https://doi.org/10.1016/j.agwat.2015.04.004

Randhawa, M. A., Ahmad, G., Anjum, F. M., Asghar, A., & Sajid, M. W. (2014). Heavy metal contents and their daily intake in vegetables under peri-urban farming system of Multan, Pakistan. *Pakistan Journal of Agricultural Sciences*, 51(4).

Raschid-Sally, L., Carr, R., & Buechler, S. (2005). Managing wastewater agriculture to improve livelihoods and environmental quality in poor countries. *Irrigation and Drainage*, 54(SUPPL. 1), 11–22. Retrieved from https://doi.org/10.1002/ird.182

Raschid-Sally, L., & Jayakody, P. (2008). *Drivers and characteristics of wastewater agriculture in developing countries: results from a global assessment* (Research Report No. 127). Colombo, Sri Lanka.

Rashid, H., Arslan, C., & Khan, S. N. (2018). Wastewater irrigation, its impact on environment and health risk assessment in peri-urban areas of Punjab Pakistan - A review.

Environmental Contaminants Reviews, 1(1), 30–35. DOI : http://doi.org/10.26480/ecr.01.2018.30.35
Rauf, A., Javed, M., Ubaidullah, M., & Abdullah, S. (2009). Asessment of heavy metals in sediments of the river Ravi, Pakistan. *Internation Journal of Agriculture & Biology*, 11(2), 197–200.
Raza, A. (2015, January 8). Ravi - once a river now a drain. *International The News*. Retrieved from https://www.thenews.com.pk/
Raza, M. A. (2008). *An Economic analysis of institutional reforms in irrigation sector in Punjab, Pakistan.* (Doctoral thesis). University of Agriculture Faisalabad, Pakistan Retrieved from http://prr.hec.gov.pk/jspui/handle/123456789/55
Rehman, S. U., Predotova, M., Ahmad, I., Schlecht, E., Buerkert, A., Predotova, M., … Buerkert, A. (2013). Socio-economic characterization of integrated cropping systems in urban and peri-urban agriculture of Faisalabad, Pakistan. *Journal of Agriculture and Rural Development in the Tropics and Subtropics*, 114(2), 133–143.
Rosenbloom, J. (2012). New day at the pool: state preemption, common pool resources, and non-place based municipal collaborations. *Harvard Environmental Law Review*, 36(2), 446–485.
Roxendal, T. (2012). *Designing sustainable wastewater management: a case study at the research farm Ceasip in Bolivia*. (Master thesis). Uppsala University, Sweden.
Ruggiano, N., & Perry, T. E. (2017). Conducting secondary analysis of qualitative data: Should we, can we, and how?. *Qualitative Social Work*, Vol. 18(1) 81–97. Retrieved from https://doi.org/10.1177/1473325017700701
Runnalls D. (1995). *The story of Pakistan's NCS: An analysis of its evolution*. IUCN–The World Conservation Union, Karachi, Pakistan.
Ryan, G. W., & Bernard, H. R. (2000). Data management and analysis methods. In Norman K. Denzen and Yvonna S. Lincoln (Ed.), *Handbook of Qualitative Research* (Second edi, pp. 769–802). New Delhi: SAGE Publications, Inc.
Sabatier, P. A. (1991). Toward better theories of the policy process. *Political Science*, 24(2), 147–156. Retrieved from https://doi.org/10.2307/419923
Sahi, A. (2007). *Water as bad as Faisalabad*. World water council Faisalabad, Pakistan.
Sahi, N. (2015, March 26). Federal minister of climate change, Mushahid annoyed over Pak-Environmental Protection Agency's Performance. *The Nation*.
Sahibzada, S. (2002). Pricing irrigation water in pakistan: an evaluation of available options. *The Pakistan Development Review*, 41(3), 209-241. Retrieved from Retrieved from http://www.jstor.org/stable/41260467
Saifullah, Sarwar, N., Bibi, S., Ahmad, M., & Ok, Y. S. (2014). Effectiveness of zinc application to minimize cadmium toxicity and accumulation in wheat (Triticum aestivum L.). *Environmental Earth Sciences*, 71(4), 1663–1672. Retrieved from https://doi.org/10.1007/s12665-013-2570-1
Saira, A., Shabbir, A., Wu, H., Aroosa, S., Abdul, G., Shakeel, I., & Asma, Z. (2018). An analysis of wastewater irrigation practices and its impacts on the livelihood generation and food chain contamination in Faisalabad District, Pakistan. ISABB *Journal of Health and Environmental Sciences*, 5(4), 33–42. Retrieved from https://doi.org/10.5897/ISAAB-JHE2018.0045
Saleem, M. (2013, December 29). EPA issues notices to over 200 factories. *DAWN*. Retrieved from https://www.dawn.com/news/1077117/epa-issues-notices-to-over-200-factories

Saleem, S., & Ahmed, M. (2013). Political and administrative structure of local bodies in pakistan a case study of city district government faisalabad city district government, Faisalabad structural analysis. *Berkeley Journal of Social Sciences*, 3(6), 1–15.

Samad, G., Ahmed, V., & Gulzar, W. (2015). *Environmental regulations and compliance in the textile processing sector in Pakistan : empirical evidence* (SANDEE working paper no. 98-15). South Asian Network for Development and Environmental Economics (SANDEE), Kathmandu, Nepal.

Sanctuary, M., Tropp, H. (2007). *Making water a part of economic development: The Economic Benefits of Improved Water Management and Services*. Stockholm International Water Institute (SIWI), Sewden. Retrieved from http://hdl.handle.net/10535/5146

Saravanan, V. S., Mollinga, P. P., & Bogardi, J. J. (2011). Global change, wastewater and health in fast growing economies. *Current Opinion in Environmental Sustainability*, 3(6), 461–466. https://doi.org/10.1016/j.cosust.2011.10.009

Sato, T., Qadir, M., Yamamoto, S., Endo, T., & Zahoor, A. (2013). Global, regional, and country level need for data on wastewater generation, treatment, and use. *Agricultural Water Management*, 130, 1–13. Retrieved from https://doi.org/10.1016/j.agwat.2013.08.007

Schiffer, E., & Hauck, J. (2010). Net-Map: collecting social network data and facilitating network learning through participatory influence network mapping. *Field Methods*, 22(3), 231–249. Retrieved from https://doi.org/10.1177/1525822X10374798

Schiffer, E. (2007). *Net-Map toolbox: influence mapping of social networks. manual*. Presented at the Sunbelt Conference of the International Network of Social Network Analysis, 01-06 May 2007, Corfu, Greece.

Schiffer, E., Hauck, J., & Abukari, M. (2007). *Influence network mapping: mapping linkages of water users' associations in IFAD-supported LACOSREP in northern Ghana.* International Food Policy Research Institute (IFPRI). Retrieved from http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Influence+Network+Mapping:+Mapping+linkages+of+Water+Users?+Associations+in+IFAD-supported+LACOSREP+in+Northern+Ghana#0

Schiffer, E., & Peakes, J. (2009). An innovative approach to building stronger coalitions: the Net-Map Toolbox. *Development in Practice*, 19(1), 103–105. Retrieved from https://doi.org/10.1080/09614520802576500

Schiffer, E., & Waale, D. (2008). *Tracing power and influence in networks : net-map as a tool for research and strategic network planning.* IFPRI discussion papers 772, International Food Policy Research institute (IFPRI). Retrieved from Retrieved from https://ageconsearch.umn.edu/record/42318

Schmeer, K. (1999). *Guidelines for conducting a stakeholder analysis* (health reform tool Series). November 1999. Bethesda, MD: Partnerships for Health Reform, Abt Associates Inc

Schmeer, K. (2000). *Stakeholder analysis guidelines*. Policy toolkit for strengthening health sector reform, 2, 1-43.

Scott, C. A., Faruqui, N. I., & Raschid-Sally, L. (Eds.). (2004). *Wastewater use in irrigated agriculture: Coordinating the Livelihood and Environmental Realities*. CAB International. Retrieved from https://www.iwmi.cgiar.org/Publications/Books/pdf/Wastewater_Use_in_Irrigated_Agriculture.pdf

Scott, C. A., Drechsel, P., Raschid-sally, L., Bahri, A., Mara, D., Redwood, M., & Jiménez, B. (2009). Wastewater Irrigation and health: challenges and outlook for mitigating risks in low-income countries. In P. Drechsel, C. A. Scott, L. Raschid-Sally, M. Redwood & A. Bahri (Eds.), *Wastewater irrigation and health: assessing and mitigating risk in low-*

income countries (pp. 381-394). Earthscan with the International Development Research Centre (IDRC) and the International Water Management Institute (IWMI). Retrieved from https://doi.org/10.4324/9781849774666

Scott, T. M., McLaughlin, M. R., Harwood, V. J., Chivukula, V., Levine, A., Gennaccaro, A., ... & Rose, J. B. (2003). Reduction of pathogens, indicator bacteria, and alternative indicators by wastewater treatment and reclamation processes. *Water Science and Technology: Water Supply*, 3(4), 247-252. Retrieved from https://doi.org/10.2166/ws.2003.0069

Seale, C. (1999). Quality in qualitative research. Qualitative Inquiry, 5(4), 465–478.

SWACO. (2018). *Feasibility study of "Faisalabad wastewater treatment plant project, Pakistan".* Copenhagen, Denmark. Retrieved from https://eproc.punjab.gov.pk

Shahzad, A. K. (2017). Crisis of governance in the bureaucracy of pakistan: a case study of administrative ramifications with apposite policy recommendations. *A Journal of Governance and Public Policy*, 9 (2), 16-34.

Shahzad, K., Abedullah, & Samie, A. (2009). Wastewater use in cauliflower production and farmer's health: an economic analysis. *The Pakistan Development Review*, 1(Spring), 47–66.

Shuval, H. I., Wax, Y., Yekutiel, P., & Fattal, B. (1989). Transmission of enteric disease associated with wastewater irrigation: a prospective epidemiological study. *American journal of public health*, 79(7), 850–852. https://doi.org/10.2105/ajph.79.7.850.

Shuval, H. I, Adin, A., Fattal, B., Rawitz, E., Yekutiel, P. (1990). *Wastewater irrigation in developing countries: health effects and technical solutions* (English). Water and Sanitation Program Discussion Paper Series no. 2 Washington, D.C.: World Bank Group. Retrieved from http://documents.worldbank.org/curated/en/866601468344637711/Wastewater-irrigation-in-developing-countries-health-effects-and-technical-solutions

Siddique, K., Ali, S., Farid, M., Sajid, S., Aslam, A., Ahmad, R., … Nazir. (2014). Different heavy metal concentrations in plants and soil irrigated with industrial / sewage waste water. *International Journal of Environmental Monitoring and Analysis*, 2(3), 151-157. Retrieved from https://doi.org/10.11648/j.ijema.20140203.14

Siegmann, K. A., & Shezad, S. (2006). *Pakistan's water challenges: A human development perspective* (Working Paper Series No. 105). Sustainable Development Policy Institute. Islamabad, Pakistan. Retrieved from http://arks.princeton.edu/ark:/88435/dsp019p290c72r

Singapre's National Water Agency. (n.p.). *NEWater*. Retrieved from https://www.pub.gov.sg/watersupply/fournationaltaps/newater

Singh, R. P. (2001). Effect of wastewater disposal and extent of industrial pollution in and around Kanpur, Uttar Pradesh, India. *Bulletin of Engineering Geology and the Environment*, 60(April), 31–35. Retrieved from https://doi.org/10.1007/s100640000079

Sjöberg, E. (2016). An empirical study of federal law versus local environmental enforcement. *Journal of Environmental Economics and Management*, 76 (March), 14–31. Retrieved from https://doi.org/10.1016/j.jeem.2015.11.007

Slater, P. (1999). Environmental law in third world countries: Can it be enforced by other countries?. ILSA *Journal of International & Comparative Law*, 5 (2), 519–529.

Smith, S. R. (2009). A critical review of the bioavailability and impacts of heavy metals in municipal solid waste composts compared to sewage sludge. *Environment International*, 35(1), 142–156. Retrieved from https://doi.org/10.1016/j.envint.2008.06.009

Sofaer, S. (2002). Qualitative research methods. *International Journal for Quality in Health Care*, 14(4), 329–336. Retrieved from https://doi.org/10.1093/intqhc/14.4.329

Sohail, M. T., Delin, H., Talib, M. A., Xiaoqing, X., & Akhtar, M. M. (2014). An analysis of environmental law in pakistan-policy and conditions of implementation. *Research Journal of Applied Sciences, Engineering and Technology*, 8(5), 644–653. Retrieved from http://dx.doi.org/10.19026/rjaset.8.1017

SPDC. (2012). *Social development in pakistan: devolution and social development*. Annual Review 2011-12. Social Policy and Development center (SPDC), Karachi, Pakistan

Sponza, D. T. (2000). Necessity of toxicity assessment in Turkish industrial discharges (examples from metal and textile industry effluents). *Environmental Monitoring and Assessment*, 73, 41–66. Retrieved from https://doi.org/10.1023/A:1012663213153

Sridhara C., N., Kamala, C. T., & Samuel, S. R. D. (2008). Assessing risk of heavy metals from consuming food grown on sewage irrigated soils and food chain transfer. *Ecotoxicology and Environmental Safety*, 69(3), 513–524. Retrieved from https://doi.org/10.1016/j.ecoenv.2007.04.013

Staff Reporter. (2016, February 21). Punjab has no official record of industrial units. *The Nation*. Retrieved from https://nation.com.pk/21-Feb-2016/punjab-has-no-official-record-of-industrial-units

State Bank of Pakistan. (2009). *Guidelines for efficient agri. water management financing*. Agricultural Credit & Microfinance Department, State Bank of Pakistan.

Steinmo, S. (2008). Historical institutionalism. In D. Della Porta & M. Keating (Eds.), *Approaches and Methodologies in the Social Sciences: A Pluralist Perspective* (pp. 118-138). Cambridge: Cambridge University Press. doi:10.1017/CBO9780511801938.008

Stern, P. C. (2011). Design principles for global commons: Natural resources and emerging technologies. *International Journal of the Commons*, 5(2), 213–232. Retrieved from https://doi.org/10.18352/ijc.305

Sultana, K. (2010). *Urban planning policies and practices : life of homebased workers*. Homenet South Asia Trust. HomeNet Pakistan, Islamabad, Pakistan.

Symonds, J. E., & Gorard, S. (2008). *The death of mixed methods: research labels and their casualties*. Paper presented at the British Educational Research Association Annual Conference, Heriot-Watt University, Edinburgh, 3-6 September 2008.

Şinan, Y. (2011). *Pakistan: Ülke raporu*. T.C. Başbakanlık Dış Ticaret Müsteşarlığı, Hracati Geliştirme Etüd Merkezi, Ankara

Taelman, S. E., Tonini, D., Wandl, A., & Dewulf, J. (2018). A holistic sustainability framework for waste management in European cities: concept development. *Sustainability* (Switzerland), 10(7), 2184. Retrieved from https://doi.org/10.3390/su10072184

Tahir, M., Tanveer, A., Ali, A., Abbas, M., & Wasaya, A. (2008). Comparative yield performance of different maize (Zea mays L.) hybrids under local conditions of Faisalabad-Pakistan. *Pakistan Journal of Life and Social Sciences* , 6(2), 118–120. Retrieved from http://www.pjlss.edu.pk/pdf_files/2008_2/11_tahir118-120.pdf

Talakvadze, A. (2013). *Desk review report: cross-border cooperation for HIV/AIDS prevenion and imapct mitigation in southern Caucasus and Russian Federation*. WorldVision Georgia.

Tehseen, M. M., Smiullah, U. I., Ali, N., Chaudhry, J. R., Saleem, M., & Hammad, G. (2013). Genetics of fruit quality in okra (Abelmoschus esculentus) under waste water. *Journal of Plant Science*, 1(4), 76–80. Retrieved from https://doi.org/10.11648/j.jps.20130104.15

The Urban Unit. (2015). *Punjab cities governance improvement project: Faisalabad peri-urban structural plan (2015-2035).* Urban Sector Planning& Management services unit (Pvt.) L.td. P & D Department, Punjab, Lahore, Pakistan.

The World Bank. (2006). *Pakistan strategic country environmental assessment.* World Bank, Washington, DC. © World Bank. Retrieved from https://openknowledge.worldbank.org/handle/10986/33928 License: CC BY 3.0 IGO

The World Bank. (2013). *Punjab service delivery assessment* (Draft Report). Water and Sanitation Program (WSP), South Asia.

The World Bank. (2012). *The project appraisal document on a proposed credit in the amount of SDR 99.5 million to the Islamic Republic of Pakistan for the Punjab Cities Governance Improvement Project.* (Report No: 67974-PK). Washington, D.C.

The World Bank. (2018). *Program appraisal document: punjab green development program* (No. 124185- PK). Washington, D.C.

Thelen, K. (1999). Historical institutionalism in comparative politics. *Annual Review Political Science,* 2, 369–404. Retrieved from http://arjournals.annualreviews.org/doi/abs/10.1146/annurev.polisci.2.1.369

Thorne, S. (2000). Data analysis in qualitative research. *Evidence-Based Nursing*, 3(3), 6–9. http://dx.doi.org/10.1136/ebn.3.3.68

Turner, K., Georgiou, S., Clark, R., Brouwer, R. & Burke, J., (2004). *Economic valuation of water resources in agriculture: From the sectoral to a functional perspective of natural resource management* (FAO water reports 27). Food and Agriculture Organization of the United Nations, Rome, Italy. Retrieved from http://www.fao.org/3/y5582e/y5582e00.htm

UN General Assembly. (2014, August 12). *Open working group proposal for: sustainable development goals* (A/68/970: 1-24). Sixty-eighth session, United Nations General Assembly. Retrieved from http://undocs.org/A/68/970

UN System Task Team. (2012). *Governance and dvelopmment: UN system task team on the post-2015 UN development agenda.*UNDESA, UNDP, UNESCO. https://www.un.org/millenniumgoals/pdf/Think%20Pieces/7_governance.pdf

United Nations [UN]. (2015). *Transforming our world: The 2030 agenda for sustainable development.* (A/RES/70/1: 1-41). United Nations. Retrieved from https://sustainabledevelopment.un.org/post2015/transformingourworld/publication

United Nations, Department of Economic and Social Affairs, Population Division. (2015). *World urbanization prospects: the 2014 revision.* (ST/ESA/SER.A/366). Retrieved from https://population.un.org/wup/publications/files/wup2014-report.pdf

United Nations Development Programme [UNDP]. (1997). *Governance for sustainable human development: A UNDP policy document.* New York: United Nations Development Programme.

United Nations Development Programme [UNDP]. (2006). *Beyond scarcity: Power, poverty and the global water crisis* (Human Development Report 2006). United Nations Development Programme. New York. Retrieved from http://hdr.undp.org/en/content/human-development-report-2006

United Nations Environment Programme [UNEP]. (2011). *Inventory of municipal wastewater treatment plants of coastal Mediterranean cities with more than 2,000 inhabitants (2010)*. (UNEP(DEPI)/MED WG.357/Inf.7: 1-225). United Nations Environment Programme / Mediterranean Action Plan, Athens.

United Nations Environment Programme [UNEP]. (2014). *The environment and climate change outlook of Pakistan (ECCO) 2013* (1-257). United Nations Environment Programme, Regional Office for Asia and the Pacific. Ministry of Climate Change, Islamabad, Pakistan. Retrieved fromhttps://www.uncclearn.org/sites/default/files/inventory/unep25082015.pdf

United Nations Educational, Scientific and Cultural Organization [UNESCO]. (2009). *Education for all (EFA) global monitoring report 2009: Overcoming inequality-why governance matters.* Paris 07 SP, France. Oxford University Press.

United Nations Educational, Scientific and Cultural Organization - World Water Assessment Programme [UNESCO WWAP]. (2009). *Water in a changing world* (The United Nations World Water Development Report 3). Paris and Erthscan, London: UNESCO Publishing.

United Nations System in Pakistan. (2003). *Water: a vital source of Life*. United Nations Information Centre (UNIC), Islamabad, Pakistan.

United Nation Water [UN-Water]. (2010). *Water quality facts and statistics: World Water Day 2010*. United Nation Water.

United Nation Water [UN-Water]. (2013). *Water security and the global water agenda: A UN-Water Analytical Brief* (Policy and Analytical Briefs, 1-37). (T. Loughed, Ed.). Ontario, Canada: United Nations University, Institute for Water, Environment & Health (UNU-INWEH), Ontario, Canada. Retrieved from https://www.unwater.org/publications/water-security-global-water-agenda/

United Nation Water [UN-Water]. (2014). *A Post-2015 global goal for water: synthesis of key findings and recommendations from UN-Water* (UN-Water Paper, 1-41). United Nation Water. Retrieved from https://www.un.org/waterforlifedecade/pdf/27_01_2014_un-water_paper_on_a_post2015_global_goal_for_water.pdf

United Nation Water [UN-Water]. (2015). *Wastewater Management: A UN-Water Analytical Brief* (Policy and Analytical Briefs, 1-54). United Nation Water. United Nations University, Institute for Water, Environment & Health (UNU-INWEH), Ontario, Canada. Retrieved from https://www.unwater.org/publications/wastewater-management-un-water-analytical-brief/

United Nation Water [UN-Water]. (2017). *Integrated monitoring guide for sustainable development goal 6 on water and sanitation - targets and global indicators.* United Nation Water. Retrieved from https://www.unwater.org/publications/sdg-6-targets-indicators/

United Nation Water [UN-Water]. (2018). *Sustainable development goal 6: synthesis report 2018 on water and sanitation.* United Nations Publication. New York, USA. ISBN 978-92-1-101370-2

Vaismoradi, M., Turunen, H., & Bondas, T. (2013). Content analysis and thematic analysis: Implications for conducting a qualitative descriptive study. *Nursing and Health Sciences*, 15(3), 398–405. Retrieved from https://doi.org/10.1111/nhs.12048

Verma, P., George, K. V., Singh, H. V., & Singh, R. N. (2007). Modeling cadmium accumulation in radish, carrot, spinach and cabbage. *Applied Mathematical Modelling*, 31(8), 1652–1661. Retrieved from https://doi.org/10.1016/j.apm.2006.05.008

Waqar, J. A., & Horinkova, V. (2002). *Institutional constraints to conjunctive water management in the rechna doab* (Working Paper 50). Pakistan Country Series No.15. Lahore, Pakistan: International Water Management Institute. ISBN: 92-9090-497-6

Waqas, M. R. (2014). *Phyco-Remediation of Azo dye contaminated wastewater*. (Doctoral Dissertation). University of Agriculture, Faisalabad. Faisalabad, Pakistan

Waseem, A., Arshad, J., Iqbal, F., Sajjad, A., Mehmood, Z., & Murtaza, G. (2014). Pollution status of pakistan: a retrospective review on heavy metal contamination of water, soil, and vegetables. *BioMed Research International*, 2014. Retrieved from https://doi.org/10.1155/2014/813206

Water and Sanitation Agency [WASA], Faisalabad. (1993). *Faisalabad environmental infrastructure master plan study* (Final report: Volume-I). Water and Sanitation Agency, Faisalabad, Development Authority, Faisalabad, Pakistan.

Water and Sanitation Agency [WASA], Faisalabad. (2011). *WASA Faisalabad profile*. (The P-WOPs: W&S Operator's Directory) Water and Sanitation Agency, Faisalabad.

Water and Sanitation Agency [WASA], (2014). *Presentation on wastewater treatment* (powerpoint slides). Faisalabad, Pakistan: WASA Faisalabad.

Water and Sanitation Agency [WASA], (2015a). *Budget estimates 2015-16 & revised budget 2014-15.* Director Fianance, Water and Sanitation Agency (FDA), Faisalabad, Pakistan

Water and Sanitation Agency [WASA], Faisalabad. (2015b, November). *WASA Faisalabad Projects: way forward* (PowerPoint slides). Presented at the International Seminar on Business Opportunities in Punjab. Government of Punjab, Lahore, Pakistan.

Weckenbrock, P. (2010). *Making a virtue of necessity – wastewater irrigation in a periurban area near Faisalabad, Pakistan A GIS based analysis of long-term effects on agriculture.* (Doctorate Dissertation). Albert-Ludwings-Universität, Freiburg, Germany.

Weckenbrock, P., Evans, A., Majeed, M. Q., Ahmad, W., Bashir, N., & Drescher, A. (2011). Fighting for the right to use wastewater: what drives the use of untreated wastewater in a peri-urban village of Faisalabad, Pakistan? *Water International*, 36(4), 522–534. Retrieved from https://doi.org/10.1080/02508060.2011.596323

Weckenbrock, P., & Jacobi, J. (2008). *Does wastewater irrigation lead to reduced crop diversity? two studies from south asia.* Poster presented at the session of Project Ensuring Health and Food Safety from Rapidly Expanding Wastewater Irrigation in South Asia. Applied Geography of tropics and subtropics, University of Freiburg

Weckenbrock, P., Ahmad, W., Drescher, A., Majeed, M. Q., & Ashraf, M. N. (2010). *Where there's muck there's brass — wastewater irrigation near Faisalabad, Pakistan*. Paper presented at the Annual Tropical and Subtropical Agricultural and Natural Resource Management (Tropentag) Conference on World Food System - a contribution from Europe, Thematic scientific session on Water management, Zurich, Switzerland, 14 -16 September 2010. 4p. (published online).

Weinhold B. (2002). The diarrhea dilemma. Managing illness in Mexico. *Environmental health perspectives*, 110(10), A590. Retrieved from https://doi.org/10.1289/ehp.110-a590a

Weiss, T. (2000). Governance, good governance and global governance: conceptual and actual challenges. *Third World Quarterly*, 21(5), 795-814. Retrieved on June 2, 2021, from http://www.jstor.org/stable/3993619

Weldesilassie, A. B., Boelee, E., Drechsel, P., & Dabbert, S. (2010). Wastewater use in crop production in peri-urban areas of Addis Ababa: impacts on health in farm households. *Environment and Development Economics*, 16(01), 25–49. Retrieved from https://doi.org/10.1017/S1355770X1000029X

White, C. (2015, April 27). *Understanding the water Markets: Public vs. Private Goods.* Global Water Forum. UK. Retrieved from https://globalwaterforum.org/2015/04/27/understanding-water-markets-public-vs-private-goods/

WHO Scientific Group on Health Aspects of Use of Treated Wastewater for Agriculture and Aquaculture & World Health Organization. (1989). fo esu eht rof senilediug htlaeH . i retawetsawn agriculture and aquaculture: report of a WHO scientific group [gniteem morf aveneG ni dleh 18 to 23 November 1987] .noitazinagrO htlaeH dlroW . Retrieved from https://apps.who.int/iris/handle/10665/39401

WHO/UNICEF Joint Monitoring Programme (JMP). (2015). *Key facts from JMP 2015 report*. New York, USA. World Health Organization. Retrieved from https://www.who.int/water_sanitation_health/monitoring/jmp-2015-key-facts/en/

Williamson, O. E. (2000). The new institutional economics: take stock, looking ahead. *Journal of Economic Literature*, 38(3), 595–613. Retrieved from https://doi.org/10.1257/jel.38.3.595

Winpenny, J., Heinz, I., & Koo-Oshima, S. (2010). *The wealth of waste : the economics of wastewater use in agriculture* (FAO Water Report No. 35). Food and Agriculture Organization of the United Nations, Rome, Italy: FAO. 140 pp. ISBN 978-92-5-106578-5

Wittmer, H., Adasme, C., Diaz, J., Birner, R. and McCarthy, N. (2005). *Analysis of governance structures for water resources management in the VIIth region of Chile* (Región del Maule). Colombo, Sir Lanka: CGIAR Challenge Program on Water and Food.

Wolters, W. & Bhutta, M. N. (1997). *Need for integrated irrigation and drainage management, example of Pakistan.* In W.B. Snellen (Ed.), Towards integration of irrigation and drainage management (pp. 5-13). (Presented paper at the jubilee symposium (25-26 November 1996) on the occasion of the 40th anniversary of ILRl and 35th anniversary of the ICLD) ILRl, Wageningen, Netherlands.

World Bank and Government of Punjab. (2012). *Operations Manual: Punjab Cities Governance Improvement Project*. Lahore, Pakistan.

World Bank Group. (2015). *Islamic Republic of Pakistan: capacity development of urban service provider utilities* (Report no. ACS15404). Water and Sanitation Program. Washington, D.C. USA.

World Bank Group. (2018). *When water becomes a hazard: a diagnostic report on the state of water supply, sanitation, and poverty in pakistan and its impact on child stunting*. Washington D.C.: The World Bank.

World Health Organization [WHO]. (2004). *In an advocacy guide: 5 steps for planning and evaluating world water day activities.* Celebrating World Water Day 2008 (Theme: Sanitation matters!) WHO, UNICEF, & WSSCC Retrieved from https://www.who.int/water_sanitation_health/hygiene/iys/wwd_2008.pdf

World Health Organization [WHO]. (2006). *WHO guidelines for the safe use of wastewater, excreta and greywater.* (Vol. 1: Policy and regulatory aspects), (Vol. 2: Wastewater use in agriculture), (Vol. 4: Excreta and greywater use in agriculture). Geneva, Switzerland: WHO Press, World Health Organization. ISBN 92 4 154686 7 (set), ISBN 92 4 154682 4 (v. 1), ISBN 92 4 154683 2 (v. 2), ISBN 92 4 154685 9 (v. 4) Retrieved from https://www.who.int/water_sanitation_health/publications/2006-publications/en/

World Health Organization [WHO]. (2012). *UN-Water global analysis and assessment of sanitation and drinking-water: the challenge of extending and sustaining services*. UN-Water Report. Geneva.

World Health Organization & United Nations Children's Fund [WHO/UNICEF]. (2015). *Progress on sanitation and drinking water-2015 update and MDG assessment*. World Health Organization. Retrieved from https://apps.who.int/iris/handle/10665/177752

World Water Assessment Programme [WWAP]. (2003). *Water for people: water for life: executive summary.* The UN World Water Development Report (WWDR). Paris: UNESCO. Retrieved from https://www.un.org/esa/sustdev/publications/WWDR_english_129556e.pdf

World Water Assessment Programme [WWAP]. (2012). *Managing Water under Uncertainty and Risk (*The United Nations World Water Development Report 4). Paris, UNESCO. Retrieved from http://unesdoc.unesco.org/images/0021/002156/215644e.pdf

World Water Assessment Programme [WWAP]. (2015a). *Facing the Challenges. Case Studies and Indicators.* Paris, UNESCO. Retrieved from http://unesdoc.unesco.org/images/0023/002321/232179E.pdf

World Water Assessment Programme [WWAP]. (2015b). *Water for a sustainable world* (The United Nations world water development report 2015). Paris, UNESCO.

World Water Assessment Programme [WWAP]. (2017). *Wastewater: the untapped resource* (The United nations world water development report 2017). Paris, UNESCO.

Wright, A. M. (1997). *Toward a strategic sanitation approach : improving the sustainability of urban sanitation in developing countries.* Washington, D.C.: International Bank for Reconstruction and Development/The World Bank.

Wu, C., Maurer, C., Wang, Y., Xue, S., & Davis, D. L. (1999). Water pollution and human health in China. *Environmental Health Perspectives*, 107(4), 251–256. Retrieved from http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1566519&tool=pmcentrez&rendertype=abstract

WWF - Pakistan. (2007). *Pakistan's waters at risk: water & health related issues in pakistan and key recommendations.* Lahore, Pakistan: Freshwater & Toxics Programme, WWF – Pakistan.

Yin, Y. (2014). *Environmental integration in sustainable urban planning from an Institutional Perspective: A study of Swedish and Chinese eco-city development*. (Doctoral Dissertation). Division of Urban and Regional Studies, Stockholm, Sweden. Retrieved from http://www.diva-portal.org/smash/get/diva2:743655/FULLTEXT02.pdf

Yamin, M., Nasir, A., Sultan, M., Ismail, W. I. W., Shamshiri, R., & Akbar, F. N. (2015). Impact of sewage and industrial effluents on water quality in Faisalabad, Pakistan. *Advances in Environmental Biology*, 9(18), 53.

Yasin A. (2015, May 30). Punjab districts to lose budget-making powers. *DAWN*. Rawalpindi. Retrieved from https://defence.pk/pdf/threads/punjab-districts-to-lose-budget-making-powers.378527/

Zafar, A., & Akhtar, S. (2003). Farmers perception about social impact and constraints in wastewater irrigation. *Pakistan Journal of Agricultural Sciences*, 40, 210–213.

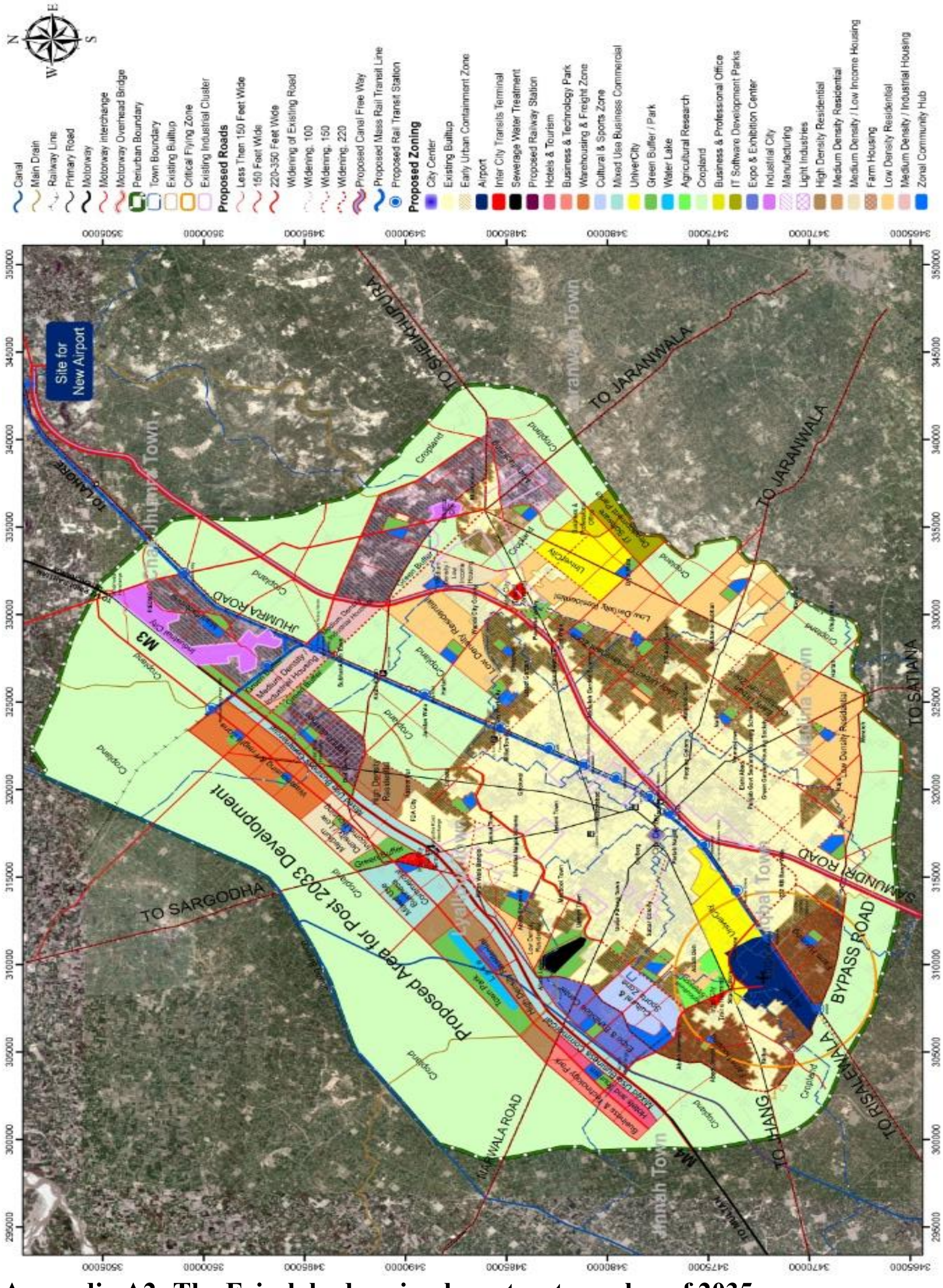
Zia, M. A., Khalil-ur-Rehman, F. A., & Latif, R. (2005). Microbiological and chemical aspects of drinking water and treatment to enhance its quality. *Journal of Research (Science)*, 16, 11-18.

Zia, M. H., Watts, M. J., Niaz, A., Middleton, D. R. S., & Kim, A. W. (2017). Health risk assessment of potentially harmful elements and dietary minerals from vegetables irrigated with untreated wastewater, Pakistan. *Environmental Geochemistry and Health*, 39, 707–728. Retrieved from https://doi.org/10.1007/s10653-016-9841-1

APPENDICES

Appendix A: maps

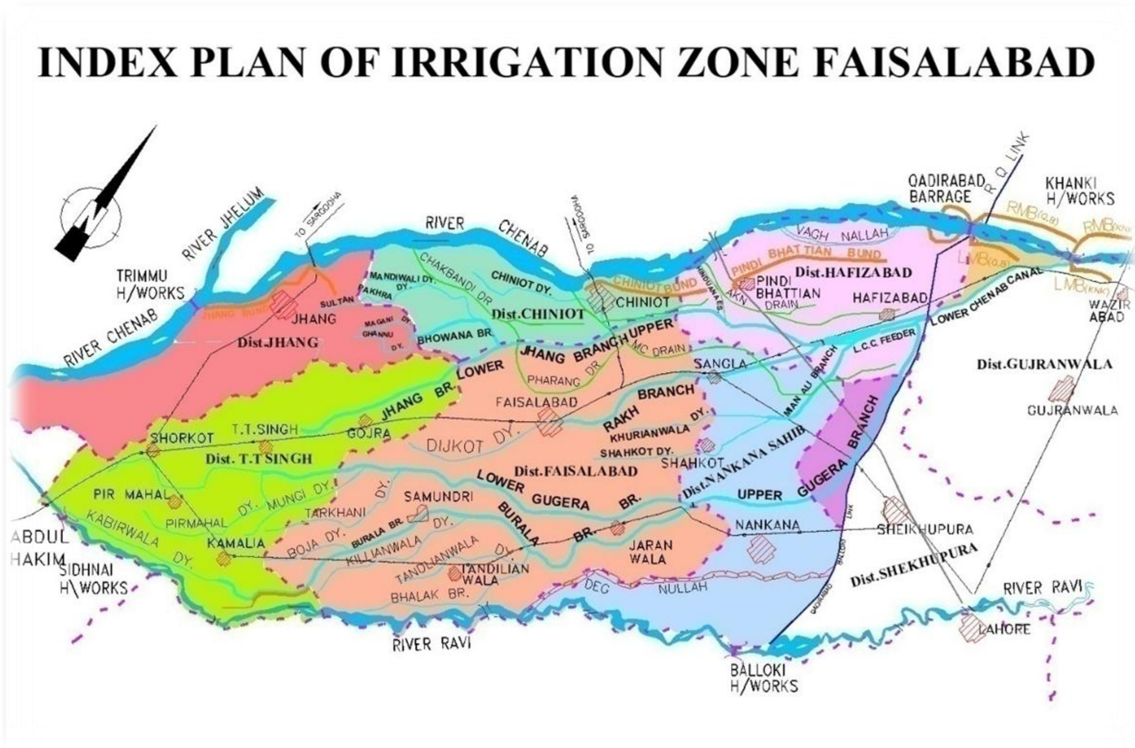
Appendix A1: Location of Faisalabad in Pakistan



Appendix A2: The Faisalabad peri-urban structure plan of 2035

(A WORLD BANK funded project implemented through The URBAN UNIT Punjab under PCGIP)

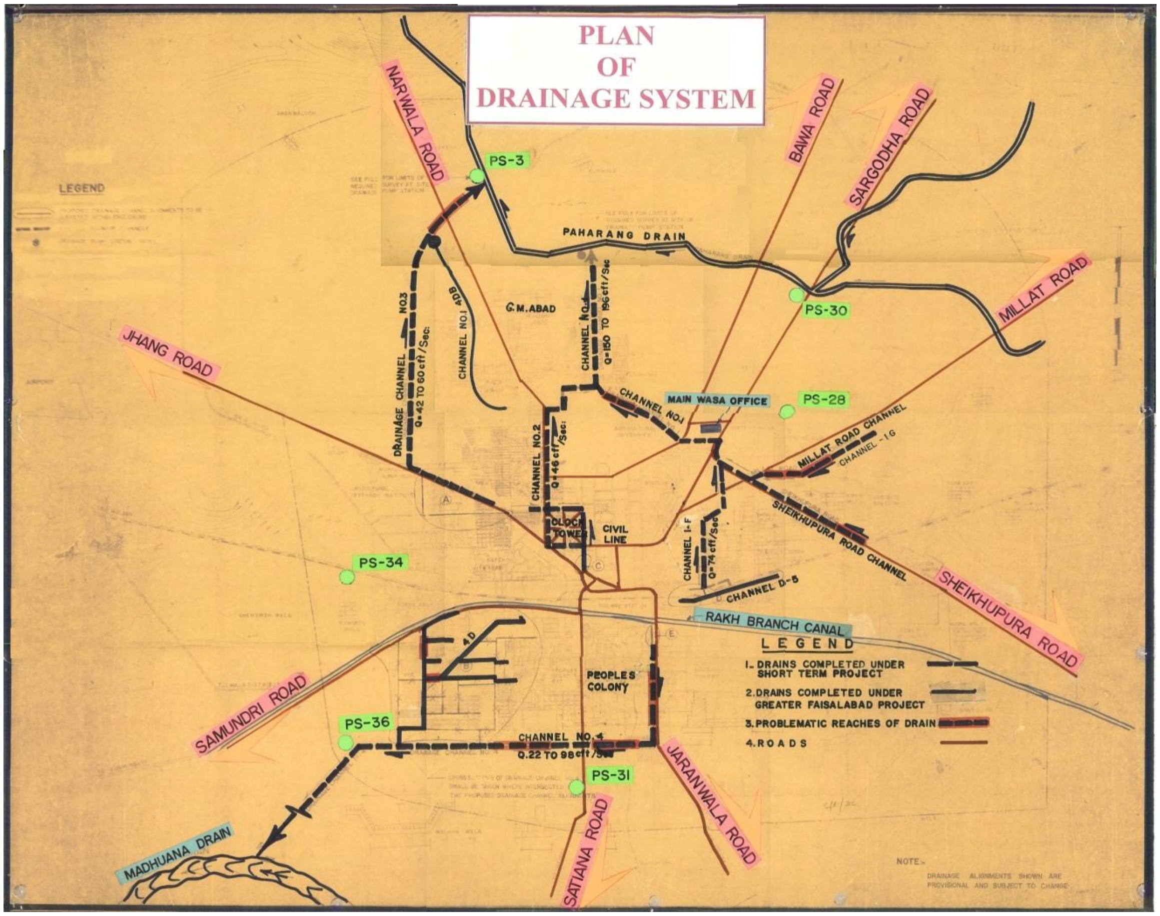
(Source: 4th Dimension Consulting, *4thdimensionpk.com*)



Appendix A3: Irrigation infrastructure of Faisalabad

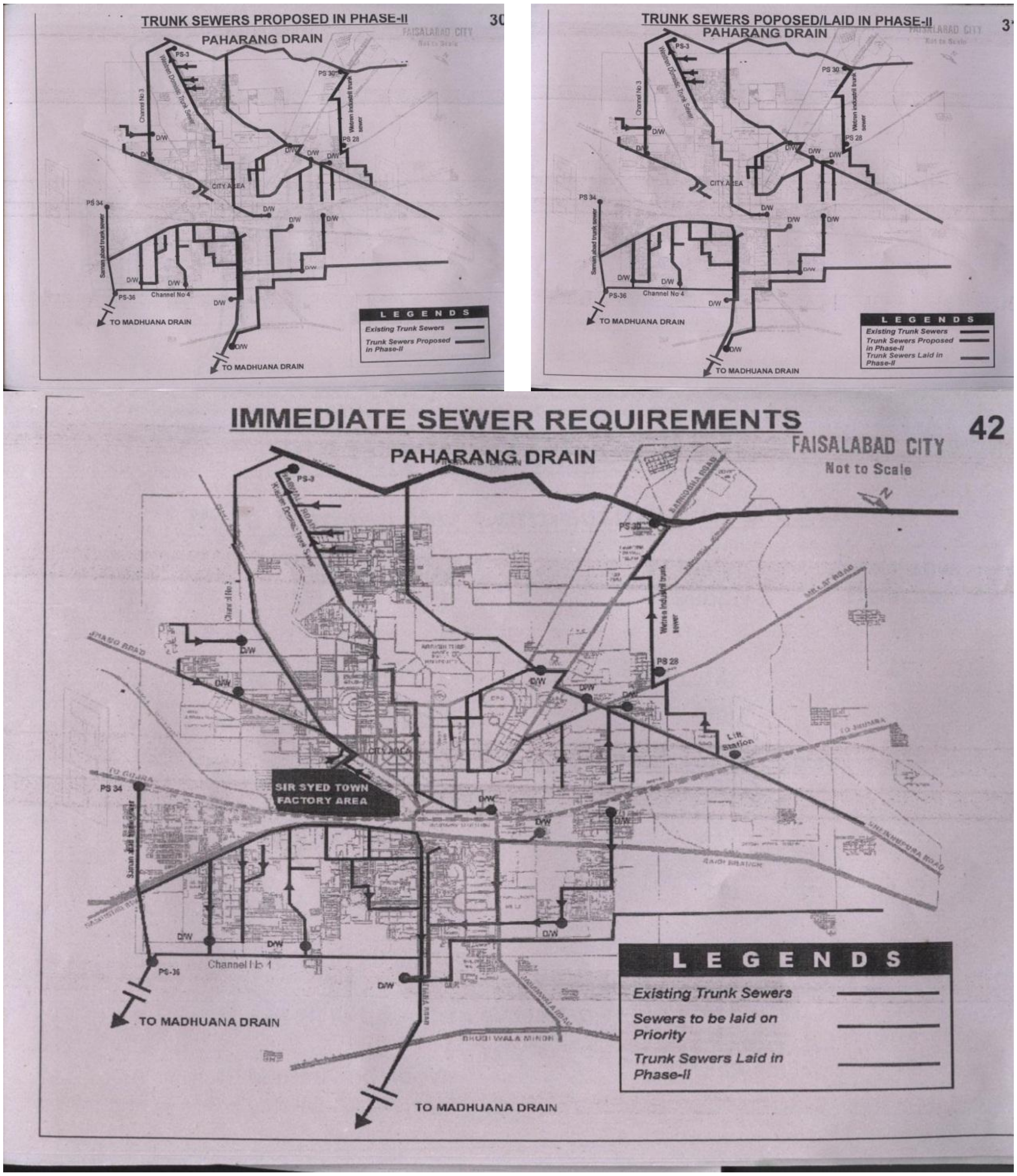
(Source: IDD department)

Appendix B: Drainage infrastructure of Faisalabad



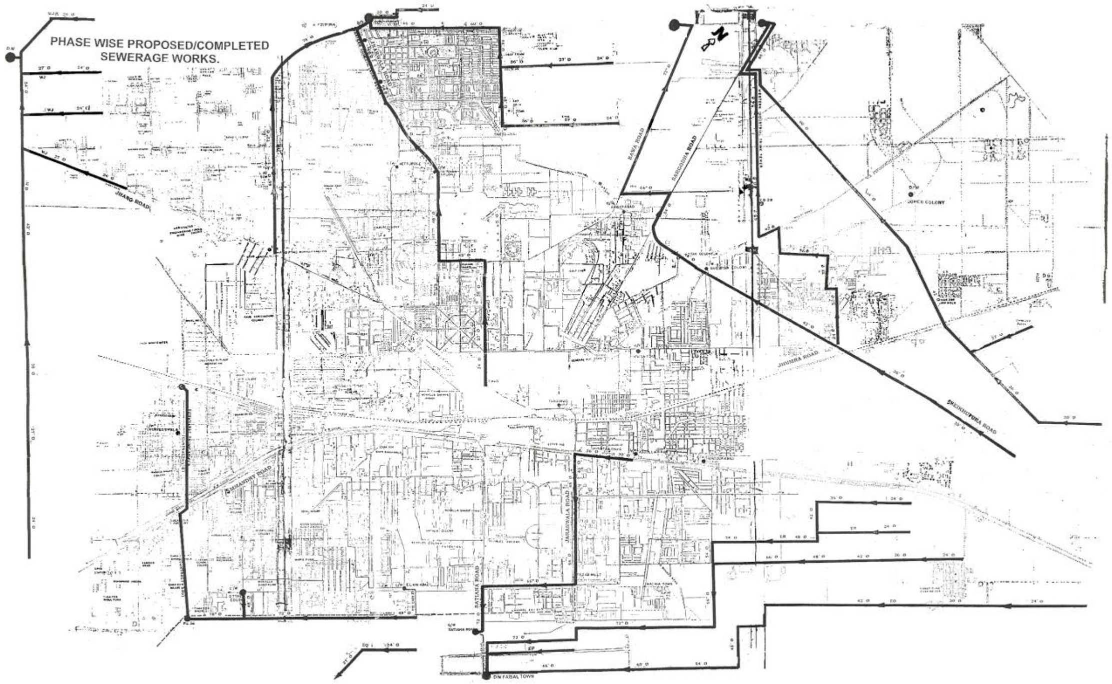
Appendix B1: Handmade map of the drainage system in Faisalabad

Source: WASA, 2007



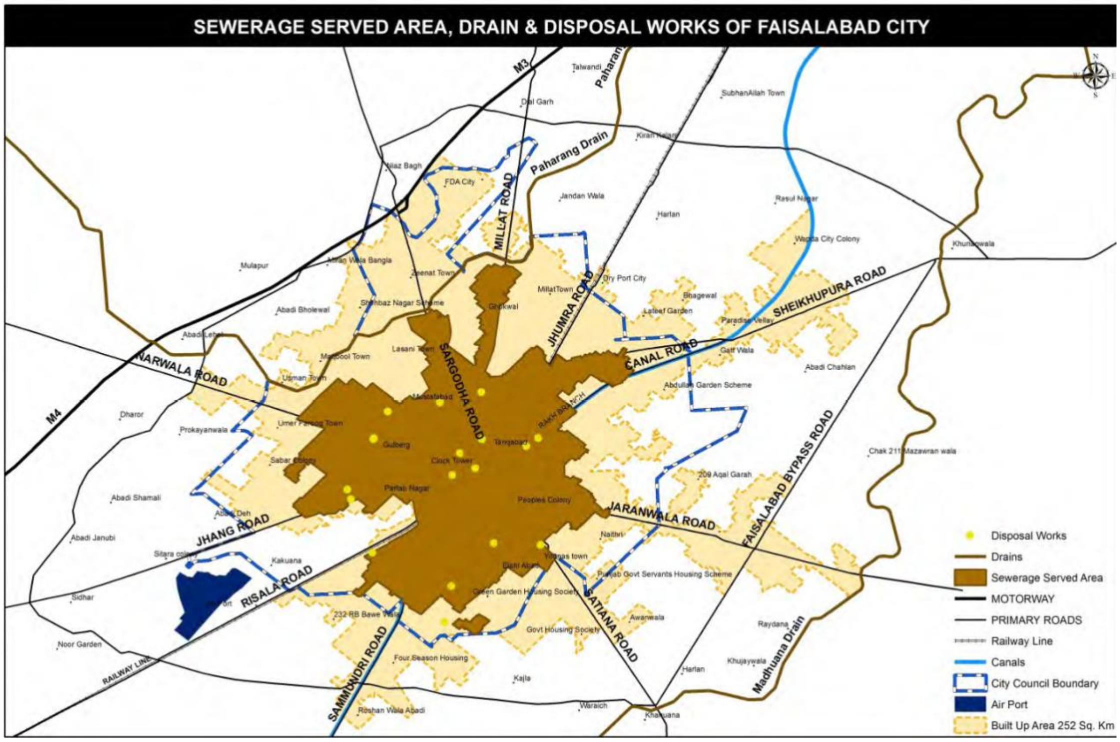
Appendix B2: Development of Faisalabad's sewage system

(Source: WASA, 2006)



Appendix B3: Detail map of Faisalabad's sewage system

(Source: WASA, 2006)



Appendix B4: Sewerage Served area, drains and disposal works of Faisalabad city area

(Cited in Faisalabad Peri-urban structural plan 2035;Prepared by: Faisalabad Peri Urban Structure Plan, Consultants, 2013)

Appendix C: Estimated volume of discharged wastewater

Appendix C1: Detailed Disposal Works in the East Division

No.	Name of Disposal Work	Average Daily Discharge		
		Cumec (m^3/sec)	Cusec (ft^3/sec)	MGD
	Allama Iqbal Colony Sub Division			
1	D/W PS-36 Ahmed Nagar	0.23	30	16.15
2	D/W PS-34 Samanabad	0.45	8	4.31
3	D/W D-Type	0.11	16	8.61
	Madina Town Sub-Division			
1	D/W Abdullahpur	0.28	4	2.15
2	D/W Mansoorabad	0.06	10	5.38
3	D/W Nishatabad	0.06	2	1.08
4	D/W Dhudhi Wala	1.02	2	1.08
	Peoples Colony Sub-Division			
1	D/W Satiana Road	1.56	36	19.37
2	D/W Satiana Road PS-1	0.11	55	29.60
3	D/W Sharif Pura	0.40	4	2.15
4	D/W Elahiabad	0.40	14	7.53
	Total	4.67	181.00	97.41

(Data source: a personal investigation with WASA (O&M WASA) senior sanitary worker, 2006)

Appendix C2: Detailed Disposal Works in the West Division

No.	Name of Disposal Work	Average daily discharge		
		Cumec (m^3/sec)	**Cusec** (ft^3/sec)	**MGD**
	Gulberg Sub-Division			
1	D/W Jhang Road	1.02	36	19.37
2	D/W Liaqat town	0.03	1	0.54
3	D/W Shadab Colony	0.23	8	4.31
4	D/W Girja Ghar	0.23	8	4.31
5	D/W Metropole	0.23	8	4.31
	Ghulam Muhammad Abad Sub-Division			
1	D/W PS-3 Chokera	1.42	50	26.91
2	D/W Shahi Chowk	0.06	2	1.08
3	D/W Rajawala	0.03	1	0.54
4	D/W Kank Basti	0.11	4	2.15
5	D/W Wearver Colony	0.03	1	0.54
6	D/W Ghulshan Colony	0.11	4	2.15
	Civil Lines East Sub Division			
1	D/W Tariqabad	0.06	2	1.08
2	D/W PS-28 Noor Pur	0.68	24	12.92
3	D/W PS-30Bawa Chak	0.74	26	13.99
4	D/W Millat Town B-Block	0.06	2	1.08
5	D/W Millat Town D-Block	0.06	2	1.08
6	D/W No.1 Gulistan Colony	0.23	8	4.31
7	D/W No.2 Gulistan Colony	0.28	10	5.38
8	D/W Akbarabad	0.45	16	8.61
9	D/W G.B.S	0.06	2	1.08
10	D/W Sheadman	0.28	10	5.38
11	D/W Tower Road	0.06	2	1.08
	Total	6.43	227	122.16

(Data source: a personal investigation with WASA (O&M WASA) senior sanitary worker, 2006)

Appendix D: Industrial profile of Faisalabad

Appendix D1: Industrial Profile with polluted discharge

Type of Industry	Nos.	Percent	Pollution type
		Fertilizer	
Fertilizer	2	0.12	Thermal effluents, ammonia gas, and solution in water containing sulfur compounds, nitrogen and carbon oxides, oil
		Industrial Chemicals	
Industrial Chemicals	6	0.36	Chlorine gas and heavy metals discharge e.g. mercury, zinc etc.
Sodium Silicate	12	0.73	
Paints And Varnishes	7	0.43	
Drugs & Pharmaceuticals	4	0.24	
Others	3	0.18	
		Paper Board	
Chip / Straw Board	14	0.85	Highly polluted effluents with high organic matter and suspended solids, chlorinated compounds from the bleaching process
Paper And Paper Board	11	0.67	
Paper Cone	4	0.24	
Packages	33	2.01	
		Tanneries	
Tannery	12	0.73	High level sludge containing 3.5-6.5 % solid content, 20-50% volatile matter and 50-75% inorganic matter. Chromium from chrome tanning
Leather Footwear	2	0.12	
		Sugar and distillery	
Sugar	6	0.36	Organic matter, suspended solids, oil and grease and dissolved solids. High levels of organic chemicals from the distillery
		Vegetable ghee, Edible Oil, and soap	
Vegetable Ghee and Cooking Oil	5	0.3	Highly polluted wastewater with high organic and inorganic matter, solids, oil, and grease content. Nickel was also detected
Soap & Detergent	39	2.37	
		Textile processing	
Textile Processing	234	14.22	Highly polluted effluents in terms of organic matter, grease, and oil. They also contain chemicals, dyes, and heavy metals like copper, iron, and lead
Textile Composite	10	0.61	
Die And Blocks	3	0.18	
Carpets	2	0.12	
Knitted Textile	34	2.07	
Other Textile Products	3	0.18	
		Cotton weaving and sizing	
Sizing of Yarn	104	6.32	
Doubling of Yarn	9	0.55	Moderately polluted effluent with a sizing agent
Textile Weaving	35	2.13	
Raising Cloth	7	0.43	
		Power	
Batteries	1	0.06	
Electricity generation	5	0.3	
		Steel Casting, re-rolling, and Fabricated Metal Products	
Agricultural Implements	40	2.43	Highly polluted air emissions containing heavy

Foundry Products	110	6.69	metals like zinc, lead, and nickel
Industrial Machinery	66	4.01	
Auto Parts	12	0.73	
Light Engineering	35	2.13	
Sewing Machines / Parts	13	0.79	
Motors / Pumps	19	1.16	
Nut & Bolt	26	1.58	
Others	5	0.3	
Food Products, Beverages, Maize products and milk processing			
Food Products	5	0.3	Moderately polluted organic matter and totally suspended solids.
Beverages	2	0.12	
Bakery Products	5	0.3	
Confectionery	22	1.34	
Starch and Its Products	5	0.3	
Flour Mills	33	2.01	
Rice Mills	54	3.28	
Cold Storage	12	0.73	
Poultry Feed	6	0.36	
Cotton Spinning			
Cotton Ginning and Pressing	26	1.58	Air contamination due to dust and lint
Cotton Waste	43	2.61	
Textile Spinning	63	3.83	
Surgical Cotton / Bandages	2	0.12	
Garments			
Textile made-up	26	1.58	Noise pollution
Hosiery Products	241	14.65	
Embroidery	47	2.86	
Readymade Garments	77	4.68	
Plastic, Glass, and Rubber			
Plastic Products	13	0.79	Air contamination due to the release of chemical compounds
Pipes	5	0.3	
Poly Propylene Bags	10	0.61	
Glass & Glass Products	2	0.12	
Ceramics Products	5	0.3	
Elastic	5	0.3	
Total	1,645	100	

(Data source: Census of Manufacturing Industries (CMI) conducted from 2005 to 2006 by Directorate of Industries (Directorate of Industries, 2006))

Appendix D2: Snapshot of findings showing exceeding level of mercury in Sitara chemical drains.

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Table 2: Results of Samples From Punjab (Lahore, Sheikhupura, Faisalabad Etc)

Sr.No.	Sampling Point	Hg (ppb)
1.	ARC sock near Kahna, Hudiarah drain, Lahore	0
2.	Badian road, Hudiarah drain , Lahore	1.59
3.	Main Ferozepur road, Hudiarah drain, Lahore	0
4.	Near Shafi Reso Chem, Hudiarah drain, Lahore	0
5.	Azadi chowk, Ravi road,River Ravi, Lahore	0
6.	Near Taj company, Ravi road, River Ravi, Lahore	1.26
7.	Shahdra village bridge, Ravi road,River Ravi,Lahore	0
8.	Town ship municipal waste drain, Lahore	0.60
9.	Mehmood Booti Drain, Lahore	3.9
10.	Dharam pura canal , Lahore	0
11.	Kot Lakhpat industrial Estate drain, Lahore	0
12.	Leachate Mehmood Booti Dumping Site Bund Road 1,Lahore	4.1
13.	Leachate Mehmood Booti Dumping Site Bund Road 2, Lahore	3.7
14.	Leachate Mehmood Booti Dumping Site Bund Road 3, Lahore	2.8
15.	Mehmood Booti Dumping Site 1, Lahore	1.2
16.	Mehmood Booti Dumping Site 2, Lahore	0.6
17.	Residual waste of incinerated hospital waste, Children Hospital ,Lahore	1.52
18.	Supra Tannery, Lahore	0
19.	Ittehad chemicals Outlet 4, Kala Shah Kaku, Sheikhupura	2.7
20.	Ittehad chemicals Solid Waste 1, Kala Shah Kaku, Sheikhupura	0.77
21.	Ittehad chemicals Solid Waste 2, Kala Shah Kaku, Sheikhupura	0.4
22.	Ittehad chemicals Solid Waste 3, Kala Shah Kaku, Sheikhupura	0
23.	Ittehad chemicals Outlet 1,Kala Shah Kaku, Sheikhupura	2.3
24.	Ittehad chemicals Outlet 2, Kala Shah Kaku, Sheikhupura	0.4
25.	Ittehad chemicals Outlet 3, Kala Shah Kaku, Sheikhupura	3.1
26.	Sheikhupura Municipal Drain, Sheikhupura	2.1
27.	Drain near Sitara chemicals, Faisalabad	2.4
28.	Sitara chemicals effluent1, Faisalabad	1.1
29.	Sitara chemicals effluent 2, Faisalabad	1.3
30.	Sitara chemicals effluent 3, Faisalabad	0.89
31.	Sitara chemicals effluent 4, Faisalabad	1.34
32.	Sitara chemicals effluent 5, Faisalabad	2.7
33.	Sitara chemicals Solid Waste 1, Faisalabad	0.4
34.	Sitara chemicals Solid Waste 2, Faisalabad	0.5
35.	Sitara chemicals Solid Waste 3, Faisalabad	1.2
36.	Nimir chemicals effluent 1,Sheikhpura-Faisalabad Road	0
37.	Nimir chemicals effluent 2, Sheikhpura-Faisalabad Road	0
38.	Nimir chemicals effluent 3, Sheikhpura-Faisalabad Road	0
39.	Municipal sewerage, Okara	0
40.	Yousaf Sugar mill, Shahpur	0

Source: - Abbas et al., 2012: p. 426

Appendix D3: List of industries who installed wastewater treatment plants

No.	Name of Industry
1	Kamran Textile Mills, Khurrianwala, Jaranwala Road, Tehsil Jaranwala Faisalabad
2	Inter Loop (Pvt.) Ltd Division No. 1, Jaranwala Road, Khurrianwala Faisalabad
3	Inter Loop (Pvt.) Ltd Division No.2, Jaranwala–Khurrianwala Road Faisalabad
4	Masood Textile Mill Chak No. 69/RB Sheikhupura Road, Faisalabad
5	Bismillah Textile Pvt. Ltd Jaranwala Road, Khurrianwala Faisalabad
6	M.K Sons (Pvt.) Ltd. 2-3 Km Khurrianwala-Jaranwala Road, Faisalabad
7	Arshad Textile Processing 3.2-Km Khurrianwala-Jaranwala Road, Faisalabad
8	Saddqat Textile Sianwala Road, Khurrianwala, Faisalabad
9	Kamal Hosiery (Pvt.) Ltd. 4-Km Khurrianwala-Jhumra Road, Faisalabad
10	Noor Fatima Textile Mill, Khurrianwala, Faisalabad
11	Crescent Textile Sargodha Road, Faisalabad
12	Klash Dyes House Chak No.117/JB, Millat Road, Faisalabad
13	Coca Cola Beverage Main Samundri Road, Faisalabad
14	Chenab Fabrics (Pvt) Ltd, Nishatabad Faisalabad
15	Sitara Textile (Pvt.) LTD. Sargodha Road, Faisalabad
16	WASA Chokera, Narwala Road, Faisalabad
17	**Sitara Chemicals, Sheikhupura Road, Faisalabad**
18	Rafhan Maize, Jaranwala, Faisalabad
19	Rasheed Textile, Khurianwala, Faisalabad
20	Sitara Textile, Sargodha Road, Faisalabad

(Source: EPA, Faisalabad)

Appendix E: Resource analysis

Appendix E1: Analysis of industrial wastewater applied for irrigation

Parameters	Permissible limits	Eastern Zone				Southern Zone							
		1	2	3	4	1	2	3	4	5	6	7	8
BOD (mg/l)	80*	**204**	**231**	**282**	**294**	**396**	**264**	**312**	**315**	**228**	**435**	**212**	**252**
COD (mg/l)	150*	**592**	**712**	**650**	**1848**	**728**	**557**	**890**	**830**	**678**	**925**	**469**	**499**
pH	6-10*	7,7	7,3	9,5	7,2	7,7	8	7,6	8,1	8,2	8,3	7,9	7,3
EC (µs/cm)		3520	3570	7629	6750	7740	5380	6760	6050	5030	5060	3210	6330
Turb. (NTU)		160	90	80	46	35	65	165	260	160	320	260	115
TDS (mg/l)	1500	**2030**	**2142**	**4820**	**4114**	**4580**	**3228**	**4191**	**3630**	**4020**	**4020**	**2055**	**3925**
HCO3 (mg/)l	400	**650**	**1000**	**1200**	**1500**	**1150**	390	**1880**	290	180	335	**1110**	**1360**
Alk. (m.mol)		11,2	20	24	30	45	7,8	37,6	5,8	5,7	7,9	30,3	27,2
CO3 (mg/l)		Nil	Nil	40	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
K (mg/l)		40	84	65	50	65	34,1	33,5	38,8	72	52,6	84	36,5
Na (mg/l)	230	**590**	**560**	**1560**	**1440**	**1530**	**960**	**1180**	**1060**	**1060**	**530**	**730**	**1220**
Ca (mg/l)	230	70	48	54	40	52	40	22	24	40	55	35	132
Mg (mg/l)	100	60	39	57	34	60	**111**	24	**116**	86	**123**	60	61
Hard (mg/l)		425	280	370	240	275	560	650	540	435	610	245	580
Cl (mg/l)	1	**530**	**386**	**1243**	**1058**	**1020**	**1206**	**1575**	**1120**	**760**	**1060**	**535**	**1347**
SO4 (mg/l)	600*	89	380	**1121**	592	530	**824**	**788**	**915**	470	**820**	78	**892**
Cd (ppb)	10	0,526	0,007	0,07	0,2	0,006	0,06	1,131	0,05	0,06	0,07	0,26	0,13
Cu (ppb)	100*	54,9	2,2	2,8	0,15	1,9	1,7	16,44	2,1	2,3	3,4	22,35	28,74
Cr (ppb)	100*	0	0	0	0	0	0	0	0	0	0	0	0
Mn (ppb)	150*	110	0	0	0	0	0	**157**	0	0	0	6	47
Ni (ppb)	100*	0,0	0	0	0	0	0	0	0	0	0	0	0
Pb (ppb)	50*	15,63	0,5	0,35	0,15	0,12	0,01	15,1	0,28	0,35	0,37	0	1,3
Zn (ppb)	500*	40	80	260	190	122	36	306	294	210	115	244	194

*Government of Pakistan (2000)

Appendix E2: Analysis of domestic wastewater irrigation samples in western zone

Location	**Permissible limits**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
BOD (mg/l)	80*	**306**	**330**	**282**	**96**	**103**	**264**	**84**	60	**294**	**129**	**124**	27
COD (mg/l)	150*	**1207**	**1274**	**310**	**319**	**275**	**875**	**219**	**213**	**906**	**373**	**306**	88
pH	6-10*	7,1	7	7,2	7,1	7,3	6,6	6,9	6,7	7,1	7,5	7,2	7,4
EC (µs/cm)		2950	2780	3050	2470	2800	5130	3020	2080	5210	2810	2500	3620
Turb. (NTU)		310	150	142	90	155	315	170	150	200	200	80	340
TDS (mg/l)	1500	1917	1807	1982	1488	1980	3180	1180	1290	3230	1905	1555	2060
HCO3 (mg/)l	400	**940**	**700**	**940**	**690**	**650**	**1175**	**310**	**260**	**1155**	**723**	**680**	**930**
Alk. (m.mol)		18,8	14	18,8	13,8	20	23,5	6,4	5,2	23,1	26	13,6	17,5
CO3 (mg/l)		Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
K (mg/l)		35	32	32	28,6	40	35,5	20,2	11,8	33,3	65	30,9	47
Na (mg/l)	230	**390**	**440**	**420**	**315**	**415**	**960**	**440**	**310**	**860**	**479**	**310**	**419**
Ca (mg/l)	230	88	68	36	56	75	96	82	68	60	75	64	103
Mg (mg/l)	100	56	44	83	75	80	51	72	46	75	55	68	82
Hard (mg/l)		450	350	430	450	380	450	390	360	460	394	440	510
Cl (mg/l)	1	**425**	**425**	**496**	**319**	**520**	**1450**	**610**	**461**	**1489**	**436**	**390**	**480**
SO4 (mg/l)	600*	97	69	65	4	75	5	115	137	8	87	4	117
Cd (ppb)	10	0,16	0,29	0,08	0,73	0,42	0,21	0,07	0,18	0,39	0,01	0,36	0,02
Cu (ppb)	100*	4,16	5,01	4,32	6,64	5,32	14,0	8,31	5,66	20,7	4,3	4,15	3,9
Cr (ppb)	100*	0	0	0	0	0	0	0	0	0	0	0	25
Mn (ppb)	150*	**254**	150	0	0	0	30	0	0	38	15	4	22
Ni (ppb)	100*	0,0	0,0	0	0	0	0	0	0	0	0	0	0
Pb (ppb)	50*	15,5	14,79	7,1	1,9	3,8	1,5	4,7	1,8	9,7	0,05	3,1	0,03
Zn (ppb)	500*	69	96	0	36	154	247	54	288	0	31	208	409

*Government of Pakistan (2000)

Appendix E3: Analysis of soil irrigated with industrial wastewater in eastern zone

Location	Permissible limits	1	2	3	4
0-15 cm					
pH	4-8,5	7,9	8,3	8,1	7,75
EC (µS/cm)	4000	893	1692	2330	**8070**
SAR		10,9	28,7	49	136
OM (% w/w)	>0,86	**0,33**	**0,21**	**0,27**	**0,09**
Total K (mg/Kg)	150-800	0	140	335	78
Total P (mg/kg)	10-50	80	77	112	104
Total N (mg/kg)	10-30	12,2	42	28	28
Cd (mg/kg)	1	**2,75**	**2,95**	0	0,45
Cu (mg/kg)	100	4,55	7,11	28,75	18,85
Cr (mg/kg)	100	7,2	5,71	6,85	11,75
Fe (mg/kg)	NGVS	24,6	38,25	2491	2275
Mn (mg/kg)	500	11	8,15	317,5	327
Ni (mg/kg)	20	6,25	**20,91**	**34,2**	**52,25**
Pb (mg/kg)	500	0,612	15,05	0	0
Zn (mg/kg)	250	36	28,45	110	72,3
15-30 cm					
pH	4-8,5	8,5	**8,6**	7,8	7,82
EC (µS/cm)	4000	**4990**	2310	2900	3870
SAR		105,8	37,8	73	107
OM (% w/w)	>0,86	**0,26**	**0,15**	**0,24**	**0,28**
Total K (mg/Kg)	150-800	183	0	420	256
Total P (mg/kg)	10-50	83	67	95	99
Total N* (mg/kg)	10-30	36	34	14	14
Cd (mg/kg)	1	**3,11**	**1,71**	0	0
Cu (mg/kg)	100	4,05	12,5	17,2	18,85
Cr (mg/kg)	100	4,5	2,85	4,55	4,05
Fe (mg/kg)	NGVS	23,75	463,55	2143	2535
Mn (mg/kg)	500	6,7	20,35	193,5	250
Ni (mg/kg)	20	14,35	19,75	**33,25**	**40,75**
Pb (mg/kg)	500	11,1	15,55	0	0
Zn (mg/kg)	250	21	57,5	105,5	176
30-45 cm					
pH	4-8,5	8,6	8,2		
EC (µS/cm)	4000	**5450**	506		
SAR		104	45		
OM (% w/w)	>0,86	**0,16**	**0,21**		
Total K (mg/Kg)	150-800	546	241		
Total P (mg/kg)	10-50	78	73		
Total N* (mg/kg)	10-30	36	48		
Cd (mg/kg)	1	**3,42**	**2,25**		
Cu (mg/kg)	100	7,45	70		
Cr (mg/kg)	100	4,6	2,55		
Fe (mg/kg)	NGVS	14,8	19,75		
Mn (mg/kg)	500	8,61	8,22		
Ni (mg/kg)	20	**30,75**	**30,6**		
Pb (mg/kg)	500	11,45	12,95		
Zn (mg/kg)	250	47,65	61,62		

* 0.10-0.15 percent of soil

Appendix E4: Analysis of soil irrigated with industrial wastewater in southern zone

Parameters	**Permissible limits**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
						0-15 cm depth							
pH	4-8.5	7,64	8	7,7	8,2	8	8,1	7,94	8,45	8,4	7,6	**8,61**	8,4
EC (µS/cm)	4000	2470	2530	1263	1600	800	1000	639	792	747	742	510	752
SAR		43	24,6	27	6	3	5	4,4	12,6	14,6	12,5	5,2	10,6
OM (% w/w)	>0,86	**0,25**	0,61	**0,29**	**0,1**	**0,5**	**0,2**	**0,32**	**0,32**	**0,24**	**0,37**	**0,2**	**0,17**
Total K (mg/Kg)	150-800	374	0	31	230	280	230	335	0	124	0	656	0
Total P (mg/kg)	20-100	101	104	72	**13,5**	**13,5**	**10,4**	**136**	80	73	76	70	70
Total N* (mg/kg)	10-30	28	39	17	72,8	114,8	60,2	28	25	53	25	28	28
Cd (mg/kg)	1	0	**1,35**	**2,7**	0,9	0,4	**2,5**	0	**1,4**	**2,15**	**2,45**	**1,03**	**1,32**
Cu (mg/kg)	100	19,8	1,52	16,5	15	13,2	20	17,4	3,5	1,4	6	42,1	6
Cr (mg/kg)	100	10,3	6,35	11,6	9,3	9,4	22,2	5,2	2,65	3,05	3,5	59,5	2,55
Fe (mg/kg)		1923	5,91	575,9	257	325	247	1959	22,3	22,5	100	10830	23,41
Mn (mg/kg)	500	246	2,35	36,4	249,5	313,4	298,1	302	7	10,1	235,7	371,2	9,9
Ni (mg/kg)	20	**51,7**	6,55	15,2	12	9	**44**	**49,4**	7,05	10,6	**31,5**	**80,6**	19,4
Pb (mg/kg)	500	0	8,85	1,51	7,2	119,1	96,2	0	16,05	29,8	19	170,6	12,11
Zn (mg/kg)	250	**925,5**	20,82	84,5	71,1	131,2	69,9	**660,5**	19,3	33,8	69,5	56,4	30,2
						15- 30 cm depth							
pH	6-10	7,8	8,4	7,8	8,2	7,6	7,6	8,07	8,3	8,3	8,2	8,5	8,2
EC (µS/cm)	4000	1747	1872	1288	1400	1800	800	1818	1182	638	2130	869	382
SAR		42	53,6	12,8	4,6	4,4	3	33	28,2	10	47	12,3	9,4
OM (% w/w)	>0,86	**0,12**	**0,17**	**0,22**	**0,1**	**0,2**	**0,1**	**0,15**	**0,32**	**0,41**	0,63	**0,24**	**0,31**
Total K (mg/Kg)	150-800	272	0	85	280	100	310	264	195	70	226	280	15,6
Total P (mg/kg)	20-100	108	80	69	10,5	12,5	**9,5**	99	62	67	73	28	62
Total N* (mg/kg)	10-30	28	33	6	43,4	43	75,6	28	8	22	34	63	14
Cd (mg/kg)	1	0	**1,5**	**3,1**	**3,5**	0,4	0,8	0	**3,55**	**2,9**	**2,9**	0,86	**1,8**
Cu (mg/kg)	100	20,05	2,51	7,95	19,1	9,1	10,1	21,65	17,6	13,15	15,65	49,7	2
Cr (mg/kg)	100	9,65	3,61	6,95	2,1	18,7	20,5	5,7	9,31	6,6	6,4	63,8	3,55
Fe (mg/kg)	NGVS	2165,5	14,62	18,1	338	302	357	2548,5	36,4	21	158,1	11920	5,71
Mn (mg/kg)	500	265,5	2,05	214,4	207,8	395,1	236,2	365,5	22,8	11,25	233,8	401,6	4,75
Ni (mg/kg)	20	**49,25**	10,75	16	53	12	15	**45,7**	17,5	24,2	7,8	**73,7**	6,1
Pb (mg/kg)	500	0	10,25	4,45	18,9	98,3	101,1	0	2,71	7,85	3,5	235,8	9,9
Zn (mg/kg)	250	235,5	20,5	60,9	54,1	44,3	32,1	664	34,1	38,4	64,1	72,7	19,51
						30-45 cm depth							
pH	4-8.5	7,67	8,4	8,4	8,3	8	8,1	7,61	8,4	8,4	8,1	8,36	8
EC (µS/cm)	4000	3160	446	891	1400	1500	1000	2310	621	674	884	2150	3380
SAR		51	13,8	24,7	4,4	2,2	3,1	53	15,7	14,3	6,8	32	9

Parameters	**Permis sible limits**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
OM (% w/w)	>0,86	**0,11**	**0,49**	**0,1**	**0,2**	**0,1**	**0,1**	**0,11**	**0,15**	**0,22**	**0,33**	**0,24**	**0,11**
Total K (mg/Kg)	150-800	304	0	148	300	100	270	187	163	0	156	62	639
Total P (mg/kg)	20-100	85	74	73	10,2	**117,5**	10,8	97,6	63	63	75	86,7	63
Total N* (mg/kg)	10-30	28	22	22	40,6	29,4	44,8	28	19	34	14	28	22
Cd (mg/kg)	1	0	**3,21**	**3,55**	0,4	**15,5**	0,8	0	**2,35**	**3,15**	**3,3**	**2,12**	**2,6**
Cu (mg/kg)	100	11,55	2,55	1,5	20	12	19	23,3	2,52	2,55	3,5	43,9	15
Cr (mg/kg)	100	1,2	5,25	3,25	4,5	40,1	23,5	11,5	3,3	7,35	8,11	61,9	4,56
Fe (mg/kg)	NGVS	1188,5	6,41	17,55	287	370	361	2734,5	30,5	19,65	49,75	11530	241,6
Mn (mg/kg)	500	184,5	8,4	7,05	241,1	284,7	214,1	413,5	10,3	9,51	6,95	373,6	10,15
Ni (mg/kg)	20	**32,05**	12,72	7,75	**87**	**70**	19	**72,8**	8,75	5,81	19,1	**74,4**	**23,65**
Pb (mg/kg)	500	0	9,35	16,55	4,3	207,5	104,2	0	10,3	9,11	8,6	151,9	7,45
Zn (mg/kg)	250	**381**	19,71	3,11	47,2	37,1	41,5	54,4	23,8	19,8	25,2	70,1	79,31

* 0.10-0.15 percent of soil

Appendix E5: Analysis of soil samples irrigated with domestic wastewater in western zone

Parameters	**Permissible limits**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
							0-15 cm depth						
pH	4-8,5	7,84	7,42	7,15	7,6	7	8	7,5	8	7,7	8	7,8	8,3
EC (µS/cm)	4000	652	787	542	800	1100	1300	2000	400	1300	1000	883	2120
SAR		5	10	4,31	2,8	2,5	4,3	3,4	1,6	3,5	3	2,6	5,2
OM (% w/w)	>0,86	**0,06**	**0,1**	**0,24**	**0,1**	**0,15**	0,5	**0,17**	**0,41**	**0,3**	**0,28**	0,84	0,64
Total K (mg/Kg)	150-800	132	64	248	160	160	170	240	200	130	170	31	0
Total P (mg/kg)	20-100	96	94	87	**4**	10,6	16	19,8	10	15	19	**203**	**207**
Total N* (mg/kg)	10-30	14	14	28	20	72,8	131,6	96,6	93,8	75	61	64	64
Cd (mg/kg)	1	0	0	0	0,8	0,6	2,8	**15,4**	**15,5**	**2,5**	**6,8**	**1,53**	0,99
Cu (mg/kg)	100	12,4	14,05	3,35	8,02	20	18,02	14,0	10,01	13	18,0	49,11	44
Cr (mg/kg)	100	2,7	3,75	2,95	35,55	21,01	19,35	31	48,09	37,0	29,4	62,6	62,6
Fe (mg/kg)		1625	1297	4945	251	376	287	328	357	329	221	11870	11850
Mn (mg/kg)	500	200	159,5	149,9	245,3	164,8	326,2	208,1	269,6	188,1	124,8	323,1	413,3
Ni (mg/kg)	20	11,4	20,7	**78,1**	**151**	**44**	**154**	**161**	**181**	17	**141**	**62,3**	**57**
Pb (mg/kg)	500	0	0	0	307,1	27,9	12,2	172,4	96,1	43,2	69,4	212,7	203,7
Zn (mg/kg)	250	188,5	152,5	**414,5**	62,4	36,1	68,1	53,6	61,5	161,4	114,2	141,8	105,2
							15-30 cm depth						
pH	4-8,5	7,89	7,47	7,66	7,6	7,4	7,5	8,3	8	8	7,5	7,7	8
EC (µS/cm)	4000	8070	857	441	800	700	1400	1700	1000	3000	800	2430	1331
SAR		12	8	1,12	1	2,4	4,5	3	3,8	7	2,6	25	4
OM (% w/w)	>0,86	**0,01**	**0,06**	**0,07**	**0,11**	**0,1**	**0,08**	**0,15**	**0,13**	**0,17**	**0,1**	**1**	**1**
Total K (mg/Kg)	150-800	101	312	280	150	150	180	250	200	200	170	592	**92**
Total P (mg/kg)	20-100	90	85	89	**6**	**12**	19,7	14,7	12,3	**11**	**9**	184	**201**
Total N* (mg/kg)	10-30	14	14	14	19	28	61,6	47,6	54,6	26	49	42	64
Cd (mg/kg)	1	0	0	0	3,4	0,8	0,9	**11**	0,6	**1,1**	**2,3**	0	**2,10**
Cu (mg/kg)	100	8,95	6,6	15	12	14,02	19	15,1	13,01	20	14,0	36,4	42,1
Cr (mg/kg)	100	2,55	3,95	1,45	29,51	23,53	41,2	31,4	41,6	26,1	44,6	58,4	62,3
Fe (mg/kg)		1033	1111	1757	288	371	291	300	329	349	387	16640	11990
Mn (mg/kg)	500	187,5	130	250,5	256,6	222,2	294,2	233,3	245,2	247,1	204	315,4	440,6
Ni (mg/kg)	20	**26,8**	**21,9**	**28,8**	**78**	**87**	7	**78**	11	11	**49**	**67,3**	**66,2**
Pb (mg/kg)	500	0	0	0	20,4	43,1	159,5	65,1	147,1	15,9	197,1	188,6	222,6
Zn (mg/kg)	250	66,75	175	279	97,3	50,1	59,9	39,4	33,4	62,9	158,8	69,3	98,3
							30-45 cm depth						
pH	4-8,5	7,52	7,82	7,95	7,8	8	7,6	7,8	8	7,5	8	8	8
EC (µS/cm)	4000	**8210**	823	492	700	800	1600	1300	1000	1000	800	2110	1363
SAR		13	8,66	3,26	2,2	2,4	4,6	4,6	3,5	3	3	11	15
OM (%	>0,86	**0,15**	**0,05**	**0,28**	**0,08**	**0,1**	**0,15**	**0,07**	**0,08**	**0,1**	**0,13**	**0,4**	0,58

Parameters	Permissible limits	1	2	3	4	5	6	7	8	9	10	11	12
w/w)													
Total K (mg/Kg)	150-800	327	272	62	0,14	160	200	210	240	170	150	56	100
Total P (mg/kg)	20-100	69	86	87	**9**	**10,5**	**10,1**	**11,2**	81,5	**5**	**11**	**198**	**209**
Total N* (mg/kg)	10-30	14	14	14	12	23,8	61,6	79,8	30,8	23	45	42	42
Cd (mg/kg)	1	0	0	0	**4,1**	**6,1**	0,7	**2,5**	0,7	0,6	0,8	**6,042**	0
Cu (mg/kg)	100	13,5	6,1	15,6	11,02	12,1	20,1	11,0	16,1	19,01	11	35,7	34,2
Cr (mg/kg)	100	6,85	7,9	2,55	23,3	32,78	32,4	36	45,07	23,8	38	54,9	43
Fe (mg/kg)	NGVS	1198,5	1010,5	1435,5	390	373	241	341	331	232	328	10860	2264
Mn (mg/kg)	500	196	174	185,5	235,2	282	298,1	271,2	268,3	190	219,5	245,91	390,11
Ni (mg/kg)	20	**25,7**	17,6	**46,8**	**80**	**80**	5	**199**	17	**111**	**188**	**65,7**	**52,1**
Pb (mg/kg)	500	0	0	0	115,2	41,3	59,1	88,2	131,1	95,2	129,2	208,5	220,9
Zn (mg/kg)	250	**300,5**	85,5	228,5	75,1	43,8	58,7	38,5	33,1	59,7	74,1	67,3	69,1

* 0.10-0.15 percent of soil

Appendix E6: Analysis of wheat crop across the categories

Parameters	Permissible limits	Industrial					Domestic		
		Eastern zone	Southern zone				Western Zone		
P g/kg	100-400	1,23	1,27	2,28	0,112	0,121	11,297	0,582	0,0257
N g/kg	1000-5000	10	28,7	21	2,35	2,51	31,7	2,8	16,04
K g/kg	1000-4000	4,7	7	6,8	7,33	1,79	5,23	5,14	2,57
Cd (mg/kg)	0,2	**5,839**	**4,687**	**5,359**	**4**	**16**	**41,22**	**1,7**	**5,8**
Cu (mg/kg)	73,3	8,175	9,375	9,411	17,4	0,5	4,39	9,7	17,9
Cr (mg/kg)	2,3	**14,671**	**21,687**	**8,496**	**33,2**	**77,9**	**70,73**	**27,8**	**25,2**
Fe (mg/kg)	425,5	427,66	**2548,4**	**2937,2**	**4723,6**	**1444,8**	**2967,1**	**904,7**	**827,2**
Mn (mg/kg)	500	64,74	88,31	91,57	201,4	103,6	74,15	165,5	217,8
Ni (mg/kg)	67,9	16,31	33,13	20,72	43	**167**	41,71	1,8	62,6
Pb (mg/kg)	0,3	**40,22**	**34,56**	**26,93**	**97,1**	**53,4**	**302,2**	**40,2**	**159,6**
Zn (mg/kg)	99,4	43,72	42	57,58	90,3	51,9	**99,02**	45,4	60,8

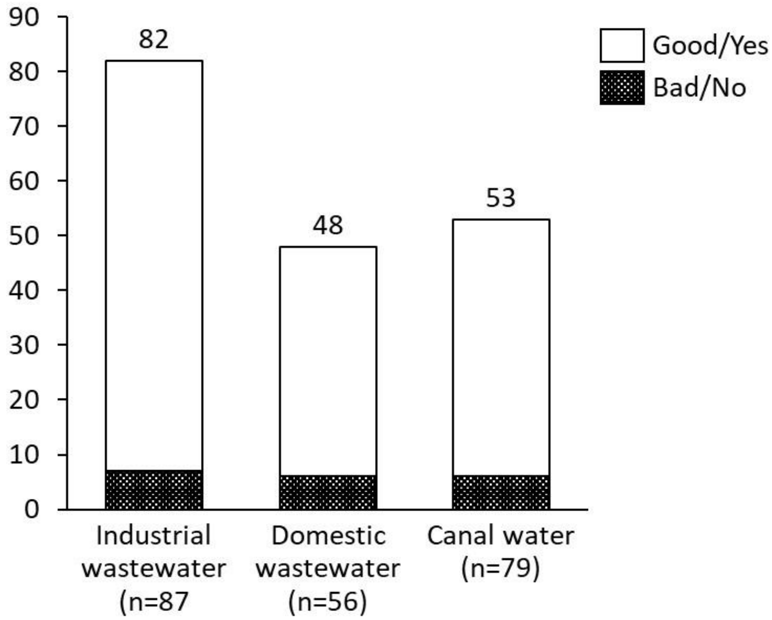
Appendix E7: Analysis of other crop across the categories

Parameters	Permissible limits	Berseem		Maize		Sorghum		Mustard		Sugarcane	
		Industrial	Domestic	Industrial	Domestic	Industrial	Domestic	Industrial	Domestic	Industrial	Domestic
P g/kg	100-400	0,204	7,8	0,191	3,6	0,98	3,9	0,548	6,18	0,16	0,778
N g/kg	1000-5000	1,05	30,8	0,74	11,7	11,6	11,7	17,6	9,33	0,46	8,68
K g/kg	1000-4000	2,84	2	3,37	7,4	2,65	2,89	6,2	4,86	5,2	5,5
Cd (mg/kg)	0,2	**1,803**	0	**4,02**	**1,05**	**1,63**	**1,09**	**1,81**	**17,11**	**1,456**	**5,84**
Cu (mg/kg)	73,3	**130,06**	5,75	64,02	15,17	39,5	27,28	10,886	22,048	23,95	5,471
Cr (mg/kg)	2,3	**19,05**	0,83	**42,58**	**27,47**	**61,1**	**38,83**	**11,35**	**30,12**	**17,15**	**14,94**
Fe (mg/kg)	425,5	335,41	**577,3**	**844,23**	**579,6**	**7374**	**3022**	**465,82**	**1169,7**	139,03	247,23
Mn (mg/kg)	500	124,94	91,57	137,22	47,77	228,6	85,13	49,37	55,72	56,83	10,94
Ni (mg/kg)	67,9	29,746	20,72	31,433	18,34	**79,2**	39,27	7,05	**75,26**	15,44	17,64
Pb (mg/kg)	0,3	**16,39**	**26,93**	**6,91**	**1039,2**	**185**	**224,7**	**29,75**	**157,47**	**4,5**	**36,48**
Zn (mg/kg)	99,4	**149,77**	57,58	**144,23**	60,75	70	97,3	54,6	53,04	46,25	29,94

Source: Data provided by PCRWR official which was collected for the project " Impact Assessment of Sewerage and Industrial Effluents on Water Resources, Soil, Crops and Human Health in Faisalabad" (Kahlown et al., 2006)

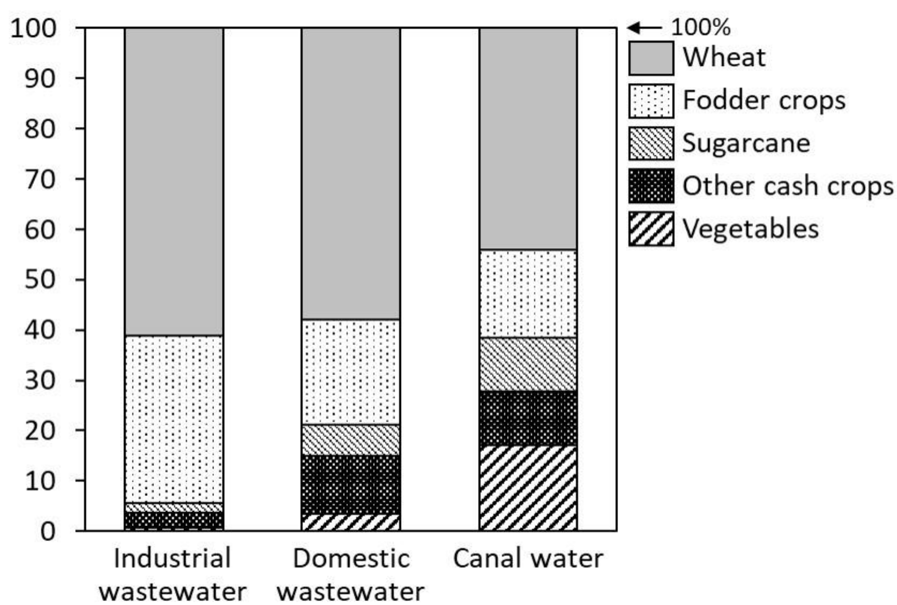
Appendix F: Household survey

Appendix F1: Toilet availability



Note: Bar represents the respondents in each category.

Appendix F2: Cropping diversity per year across category



Percentage of the cropped area for each crop across categories

Appendix F3: Correlation coefficient among Yield (mds/ha.) of wheat and resources

	Yield	Area	Sowing cost	Inorganic fertilizer cost	Organic fertilizer cost	Pesticide cost	Irrigation cost	Harvesting cost	Industrial Vs Canal	Domestic vs Canal
Yield	1	-.091	.482**	.091	-.191**	.277**	.345**	.270**	-.476**	.297**
Area sown		1	.168*	.296**	.310**	.074	.103	.132*	.127	-.245**
Sowing cost			1	.223**	.213**	-.031	.250**	.130	-.122	.017
Inorganic fertilizer cost				1	.173**	.010	.014	.088	.068	-.224**
Organic fertilizer cost					1	-.105	-.121	-.059	.224**	-.311**
Pesticide cost						1	.139*	.224**	-.258**	.081
Irrigation cost							1	.081	-.389**	.520**
Harvesting cost								1	-.205**	-.060
Industrial Vs Canal									1	-.466**
Domestic vs Canal										1

** Correlation is significant at the 0.01 level (2-tailed).* Correlation is significant at the 0.05 level (2-tailed).

Appendix F4: Correlation coefficient among farm income (Rs.) and family sources

	Farm income	Wheat income	Fodder income	Sugarcane income	Cash crop income	Vegetable income	Area sown	Tropical livestock unit	Industrial vs canal	Domestic vs canal
Farm income	1	.354**	.285**	.201**	.192**	.159*	.398**	.205**	-.263**	.053
Wheat income		1	-.032	.165*	.052	.089	.152*	.113	-.246**	.089
Fodder income			1	.011	-.161*	-.085	.159*	.380**	.027	.096
Sugarcane income				1	.132*	-.052	.214**	.129	-.218**	-.035
Cash crop income					1	.071	.363**	-.044	-.187**	-.050
Vegetable income						1	.126	.050	-.266**	.065
Area sown							1	.172*	.016	-.202**
Tropical livestock unit								1	-.017	-.062
Industrial vs canal									1	-.466**
Domestic vs canal										1

** Correlation is significant at the 0.01 level (2-tailed).* Correlation is significant at the 0.05 level (2-tailed).

Appendix G: Analysis of legal framework

Appendix G1: Definitions of wastewater terminology

According to Pakistan Environment Protection Act 1997, Under Section 2. Definition, p. 1

Sub-section (vi), "Discharge includes spilling, leaking, pumping, depositing, seepage, releasing, flowing out, pouring, emitting, emptying or dumping;" (p.2)

Sub-section (viii),"Effluent means any material in solid, liquid or gaseous form or combination thereof being discharged from industrial activity or any other source and includes a slurry, suspension or vapour;" (p. 2)

Sub-section (xxii), "Industrial activity means any operation or process for manufacturing, making, formulating, synthesizing, altering, repairing, ornamenting, finishing, packing or otherwise treating any article or substance with a view to its use, sale, transport, delivery or disposal, or for pumping water or sewage, or for generating, transforming or transmitting power or for any other industrial or commercial purpose;" (p.4)

Sub- section (xxvii), "Municipal waste includes sewage, refuse, garbage, waste form abattoirs, sludge and human excreta and the like;" (p. 4)

Sub-section (xl),"Sewage means liquid or semi-solid wastes and sludge from sanitary conveniences, kitchens, laundries, washing and similar activities and from any sewerage system or sewage disposal works;" (p.6)

Appendix G2: Basic terminology explaining the legal framework

Term	Definition and explanation
Constitution	A constitution is a set of fundamental principles or established precedents according to which a state or another organization is governed. These rules together make up what the entity is. The Constitution is the 'rules of the game' and has preference over everything that comes in its contradiction.
Bill (Predecessor to an Act)	A Bill is (Proposed legislation) a document or draft that is presented in a legislature for discussion and vote. During the process of legislation, until approval by the Head of State, it remains a Bill, even if passed by the legislature concerned.
Act	An Act is a law made by the legislature such as the Parliament or State Legislative Assembly. Once the Bill is passed by the legislature, it is presented to the President or the Governor, as the case may be. On receiving his assent, it becomes an Act. An Act is a law according to broad guidelines given by the constitution. Acts must be under the shadows of the constitution.
Ordinance	An Ordinance, on the other hand, is an Ad-hoc Act in the sense that the Head of State implements it on the advice of the cabinet or an executive body. It is promulgated by the President/Governor when the Parliament/Legislative Assembly is not in session. It has the same effect as that of an Act passed by the legislature. It has to be approved by the legislature within a limited time period by the reassembly of the legislature. An ordinance has a limited life (like 6 months or until next amendment) unless it is passed by the legislature concerned as an Act.
Rule	The rules are the standard set of instructions made for people, which explains how things are to be done. A rule tells one what to do and what not to do. It can be set up for home, hospital, institution, college, office, school etc.Non-compliance of any rule can cause a little effect.
Strategy	The strategy is a game plan, chosen to achieve the organizational objectives, gain the customer’s trust, and attain competitive advantage and to acquire a market position. It is a combination of well-thought intents and actions that leads an organization towards its desired position or destination.
Regulations	Regulations can be defined as rules that are authorized by the government and approved by the public.Violation of any regulation may cause severe penalty, punishment, or both. In the parliament, when a bill is passed by both the houses, it becomes an Act; based on the Act, regulations come into force. Individuals and organization can set rules, but the government sets regulations.
Policy	A policy is also regarded as a mini-mission statement. It is a set of principles and rules, which directs the decisions of the organization. Policies are framed by the top-level management of an organization to serve as a guideline for operational decision-making. It is helpful in highlighting the rules, value, and beliefs of the organization.
Institution (rules of the game)	Institutions are established and stable patterns of behavior that define, govern and constrain actions. An institution is a formal social structure that governs a field of action. It is the method of describing a widely prevalent practice or law. • An institution is not centrally administered. • An institution has customs or values that are honored by individuals. • An institution is self-sustaining and universal. • An institution is subtle referring to the abstract and physical entity. Education, festivals, transport, parliament, laws, trade
Institute	'Institute' is the method of referring to a firm/organization engaged in some activity, esp., commercial or social. • An organization founded to promote a cause.
Organization	An organization is an organized group of people brought together for a common

Term	Definition and explanation
(the players)	purpose. An organization controls its own performance and it has a border that separates it from the outer environment. There is authority from above moving down through a hierarchical structure. • An organization is centrally administered • An organization has rules that are enforced • An organization is to be controlled • An organization is a partial and physical entity. Universities, cultural committee, railway, political parties, high court, market

Sources:

Law
Constitution
Ordinance
Institutions

Appendix G3: Review of the legal framework

#	Legislation	Related statement	Penalty	Review
		Natural resource Conservation and use (Soil and water)		
1	Pakistan Penal Code (1860)	269.“Negligent act likely to spread infection of disease dangerous to life”	Punishment of max. 6 months, fine or both	Fouling did not define
		277.“Fouling water of public spring or reservoir” 278. “Making atmosphere noxious to health” 284. “Negligent conduct with respect to poisonous substance”	Punishment of max. 3 months, fine max. Rs 500, or both	
		430.“Mischief by injury to works of irrigation or by wrongfully diverting water” 431. “Mischief by injury to public road, bridge, river or channel”	Imprisonment of max. five years, fine, or both	
		Industries, Commerce and Investment Department		
1	The Factories Act (1934)	Under section 14“Disposal of wastes and effluents” Sub-section (1) Effective arrangements for the disposal of wastes and effluents due to the manufacturing process Sub-section (2) Provision of rules and authority for arrangements as a duty of the Government	Under section 60 (a) (i). The manager and occupier of the factory each shall be punishable with a fine max. Rs 20,000.	Only arrangements for disposal of effluents
		The Irrigation and Drainage Department		
1	The Canal and Drainage Act (1873)	Under section 59-A“Prohibition and control regarding the discharge of effluent into canal and drainage works” Sub-section (1) Prohibition of any discharge into river, canal and drainage channel Sub-section (2) In case of contravention, the imposition of drainage charges Sub-section (3) After notification of such permission, any interested party can apply for such facility Sub-section (4) The requirement of no adverse impact certificate on the environment from the competent authority Sub-section (5) Inspect the feasibility for permission	U/S 70 (1) (17), Fine max. Rs 15,000, imprisonment max. one year, or both U/S 70 (2), Cost of removal the damage can be charged and on failure may	Drainage-workincludes escape-channels from canals, dams, weirs, embankments, sluices, groins and other works for

#	Legislation	Related statement	Penalty	Review
		Sub-section (6) The right of appeal before the Chief Engineer in case of rejection Sub-section (7) Authority of Chief Engineer	be recovered as arrears of land revenue	the protection of lands from flood or from erosion, formed or maintained by the Provincial Government under the provisions of Part VII of this Act, but does not include works for the removal of sewage from towns
		Under section 70 (1) Sub-section (1) Cut through any drainage work Sub-section (2) Increase or decrease the supply of water drainage work Sub-section (3) Alter the flow of water in river or in drainage work Under section 73 **"**Power to arrest without warrant" Sub-section (1) Willfully damage drainage work Subsection (2) Interfere with the supply of water in drainage work		
2	The Punjab Irrigation and Drainage Act (1997)	Under section 5 "Power and duties of the Authority" Sub-section (2) Conveyance of drainage effluent to the outfall Sub-section (3) Exercise all power according to the Canal and Drainage Act 1873 Sub-section (4) Fixing the rates of drainage cess payable for the disposal of drainage effluent		
Housing, Urban Development and Public Health Engineering Department (HUD&PHE)				
1	The Thal Development Act (1949)	Under section 30 "Power and Duties of the Authority" Sub-section (2) (f) Authority can direct as respect to any area: (3) the provision of drains for stormwater, (4) the training of streams, and (5) the execution of such other works to protect the land from the erosive action of wind or water, or for the development of such area or for the exploitation of its mineral or water resources		

#	Legislation	Related statement	Penalty	Review
2	The Punjab Development Cities Act (1976)	Under section 7: "Powers and functions of Authority" Sub-section (2), *The authority may* *(iii). Develop, operate and maintain water supply, sewerage and drainage system within area.* (vi) Prepare and implement schemes for environmental improvement. Under section 19 "Power to remove sources of pollution" Full powers to replace, remove or relocate the sources of pollution such as industrial waste etc.	Under section 32 (1). Punishment of fine max. Rs 200,000, imprisonment max. one year.	The absence of national standards, lack of scientific base information about pollution, ignorance by authorities
		The Schedule (Part A) clearly describes the industrial water pollution i.e. 1. "Discharge of any dangerous chemical, inflammable, hazardous or offensive article in any drain, or sewer, public water course or public land vested in, managed, maintained or controlled by the Authority or an Agency in such manner as causes or is likely to cause danger to persons passing by or living or working in neighborhoods, or risk or injury to property or causing harm to the environment". 2. "Failure of industrial or commercial concerns or such property holders to provide adequate and safe disposal of affluent or prevention of their mixing up with the water supply or sewerage system".	Under section 34 (1) (a). Imprisonment max. seven years, fine max. Rs 500,000, or both. An additional fine of Rs 50,000/day from the day of the commission to each day continued can be charged	
3	Sewerage and Drainage Regulations 2015	Under section 8"Connection requirement" Sub-section (e) A septic tank is mandatory for houses of 15 *marlas* or more Sub-section (f) Wastewater treatment plant is mandatory for industries releasing effluents into agency drains Under section 13 "Unlawful commencement of work" Agency can demolish private drain connection on the violation of sanctioned plan of construction. There is no difference in domestic and non-domestic drainage services provided by WASA In part-IV, "Storm water drainage and sullage water"	Under section 76. Fine of one hundred to five thousand rupees for each offense plus destruction cost. For continuing offense,	The fine amount is much less as compared to the operating cost of the treatment plant. Only a few parameters

#	Legislation	Related statement	Penalty	Review
		Under section 56 “Sullage water” No person can dump his sullage drain water on open land or in a storm drain. Unser section 58 “Theft of sullage water” Irrigation with sullage water without paying the agency would be considered as theft of public property. Furthermore, vegetables cannot be grown with sewage irrigation Part-VII; “Industrial Wastes” Under section 65 “Discharge of Industrial Wastes” Industrial wastes not fulfilling the standards set by the NEQS and EPA can be released into agency’s drains. All industrial units should treat the industrial effluents with their own arrangements. Under section 66“Quality of Sewage” The prescribed parameters are pH, TDS, TSS, BOD&COD, Temperature, Color, Coliform organism and other bacteria, and Toxic contents that should not exceed the NEQS limits. Under section 68;“Pretreatment of Industrial Waste” The manufacturer is responsible for the treatment of industrial waste according to the criteria set by NEQS and EPA Under section 69 “Discharge to River” Prohibition of discarding the waste into the river and drain if it adversely affects the ecosystem	max. Rs 100/day after conviction	are considered to follow the NEQS standards
		Under section 70“Discharge into Sub-Soil” Prohibition of disposing of any waste into sub-soil		

#	Legislation	Related statement	Penalty	Review
		Under section 71"Details of Waste" Sub-section (a), A detail report about the analysis of industrial waste must be submitted by each manufacturer before the setup Sub-section (b),The quality, volume and maximum rate of flow must be mentioned along with the date of commencement Under section 72 "Power to Take Samples" The agency possesses the authority to enter consumers' premises, can take the sample and analyze it. In case of contravention of NEQS standards, the agency can disconnect the connection. Under section 73"Industrial Water Agreement" Provision of three kinds of arrangements for the conveyance, treatment, and disposal of industrial Sub-section (a) Consumer treating waste at his premises according to agency's order Sub-section (b) Payment by the consumer for the conveyance and treatment of industrial waste at the agency's plant Sub-section (c) confirmation to the absence of any toxic or hazardous substance for the treatment plant and workmen in the industrial waste		
		Environment Protection and conservation		

#	Legislation	Related statement	Penalty	Review
1	Punjab Environment Protection Act 1997 (amended 2012 and 2014)	Under section 3 “Establishment of the Punjab Environmental Protection Council” Under section 5 “Establishment of the Provincial Environmental Protection Agency” Under section 6, the function of the provincial agency is to implement this act, propose quality standards and enforce them, certify the laboratories for analysis, and so on. Sub-section (n) Assistance with government agencies to implement the schemes for proper disposal of wastes Under section 7 (f, g, h, i), The provincial agency possesses powers to enforce the attendance of any person to supply information, enter and inspect with a search warrant, take samples of effluents and wastes being discharged off the water. Under Section 9 “Establishment of the Provincial Sustainable Development Funds” Sub-section (3) clause (a) provision of funds to projects for the prevention and control of pollution Under section 11 “Prohibition of certain discharges or emissions” Sub-section (1) No person can discharge any effluent or waste in an amount or concentration that exceeds Punjab environmental quality standards. Sub-section (2), (3) and (4) Imposition of pollution charges on polluter, such polluter was exempt from the offense if he was commencing this activity before the 30th June of 1994 Under section 12 “Initial environmental examination (IEE) and environmental impact assessment (EIA)” Under section 16 “Environmental protection order” Sub-section (1) If the agency contends that the discharge of effluent is occurring or has occurred, has caused an adverse impact of the environment under the provision of the act, the agency can heard the responsible person for such discharge and direct him for such measures by order.	Under section 70 (1). Fine up to 5,000,000 rupees with an additional fine of up to Rs 100,000/day (For the contravention of section 11 and 12) Compensatory cost up to 1 lac on a false complaint Closure of factory/project Compensation of victim Confiscation of factory/ machinery Restoration of the environment on convict costs	
		Sub-section (2) Clause (c) Such measures may include removal of effluents Under section 19 “Offenses by Government Agencies, local authorities or local councils” Involvement in pollution offenses by government agencies, local authorities or local council would be proceeded against and punished accordingly		

#	Legislation	Related statement	Penalty	Review
		Section 20, 21,22, 23,24,25 and 26 related with establishment and functioning of Environmental Tribunal		
2	IEE and EIA Regulations, 2000	The Federal Agency (Pak-EPA) is responsible for providing the guidelines for IEE or EIA, filling, scrutiny, public participation, reviewing, approval, and for further compliances. Schedule-I, about the section 3 "Projects requiring an IEE" H. "Waste disposal" A project of the waste proposal for industrial waste that has a capacity of fewer than 10,000 m^3 per year Schedule-II, related to section 4; "Projects requiring an EIA" G. "Waste disposal" Projects for waste disposal of hazardous wastes, Project of waste disposal if the industrial waste has capacity more than 10,000 m^3 per year		The only federal agency is responsible. IEE and EIA reports are required only for new projects; existing practices are not being examined.
3	The NEQS (Self-Monitoring and Reporting by Industries) Rule,2001	Under section 3, industrial units are responsible to submit the environmental report on a regular basis to Pak-EPA. Under section 4, 5, 6 and 7, industries are classified into categories according to the type of industry Under section 9 sub-section (2), the analysis should be done by a certified environmental laboratory. Schedule I describes the classification of industries. Schedule III elaborates the priority parameters Under Table A, Category A, Type of industry existing in Faisalabad: Pulp and paper, tanning and leather finishing, textile processing, pigments and dyes, printing and industrial chemicals. Category B, Food and vegetable processing industry		Priority parameters elaborated but the range of exact limits was not mentioned. The limits in NQES are hard to follow.
4	Pollution Charge for Industry (Calculation and Collection) Rules, 2001	Under section 3, the industrial unit is responsible for calculation, reporting, and payment of pollution charges. Section 5,6, 7, 8, and 9 describe the procedure for calculation Schedule IV "Detail of Calculation Pollution Charges" Part I, A "Pollution charges for Liquid effluents" The table depicts a list of ten selected parameters from NEQS with their defined pollution unit.		Limited information of parameters about pollution units and specific pollution charges per unit of

#	Legislation	Related statement	Penalty	Review
				pollution
5	Environmental Samples Rules, 2001	Under section 3 The federal or provincial both agencies are authorized Under section 4 Entry and inspection under certain condition explained. Section 7, 8, 9, and 19 define the procedure for sampling and analysis.		Lengthy process especially for the offense of liquid effluents
6	Hazardous Substances Rules, 2003	Under section 5 "EIA of Project or Industrial Activity" Sub-section (2) clause (a) and (b), EIA report must include a safety plan and a waste management plan Under section 19 "Waste Management Plan" Sub-section (1), Provision of information about generation, handling and disposal of hazardous waste to protect against the adverse environmental effect Sub-section (2), Confirmation about the non-mixing of hazardous waste with non-hazardous waste		
		Local Government and Community Development Department		
1	The Punjab Local Government Ordinance 2001	Under I Schedule, Part D, Section (iii); Setting up District Municipal Offices* for the providing the services as Clause (b), Treatment plants and disposal		
		Under 4th Schedule "List of offences with enforcement jurisdiction requiring court trial" Part I, the serial number of offense 8 and 9, Discharging dangerous chemicals into drains and failure to provide safe disposal or to prevent of mixing up with water supply and sewerage to industrial units	Chapter XVI-*Local Government responsibility for Enforcement of Law* U/S141, sub-section (2), clause (a), For the contravention of 4th schedule Part-I, Imprisonment of max. three years, a fine of Rs 15,000 Rs,	Executive District Officer (District Municipal Offices), otherwise by Town Officer
		Under 6th Schedule (see sections 195) Under section 45 "Drainage" Sub-section (1), local government is responsible to provide a system of public drains. Sub-section (2), the Local government should control all private drains Sub-section (4), A municipal offense can be directed, for the violation of law at the time being in force, against disposal of effluents for industrial concern by the local government. Sub-section (5), the Local government may send a		Executive District Officer (Agriculture)

#	Legislation	Related statement	Penalty	Review
		legal notice to treat the industrial effluents, to remove such drains, or to adopt specific measures. Sub-section (6) In case of failure, the local government should provide the arrangements and cost will be recovered by implying the tax on industries. Under section 46 “Drainage and sewerage schemes for commercial and industrial area” Sub-section (1), the Local government can inquire the owners of industrial units to prepare a scheme for the proper disposal of effluents within a period of three months. Sub-section (3) In the case of Failure, the local government will prepare such a scheme with the amount of tax collected by the industrialist.	or both. An additional fine of Rs1,000/day from the date of commencement to continued date. Under sub-section (3), the case would be registered against accused in the police station by an inspector with the provision of section 154 of the Code of Criminal Procedure 1898	
2	The Punjab Local Government Act 2013	Under section 87 and 72 of the Punjab Local Government Act 2013, the improvement of municipal infrastructure by proving the sewerage, sewerage treatment, and disposal services are the functions of Metropolitan and Municipal Corporations and Rural Union Councils Under the 4th schedule;“Offences Requiring Trial by a Court” Part-I, Offence 1, Discharging any dangerous chemical in any drain, or sewer controlled by the local government which causes danger to living or working Offense 2, Failure of industrial and commercial units for proper disposal of effluents and mixing with the sewerage system Part-II, Offence 12, Cultivation of agriculture crops for sale irrigating with sewer water	U/S 132 (2). Clause (a). For violating the 4th schedule Part-I Imprisonment of max. seven years, a fine of Rs 500,000, or both. A further fine of Rs 50,000/day from the date of	

#	Legislation	Related statement	Penalty	Review
			commencement to continued date. Clause (b). For violating 4th schedule Part-II. Imprisonment of max. three years, a fine of Rs 100,000, or both. An additional fine of Rs 10,000 /day from the day of the commission to each persisted day	
		Agriculture Department and Food Department		
1	The Punjab Pure Food Ordinance (1960)	Under section 2 "Definitions" Sub-section (1), "Adulterated food means (i) which is not of the nature, or (ii) which contains any such extraneous substance as may affect adversely the nature (iii) which is processed with any other substance in contravention of the rules, or (iv) any constituent of which has been wholly or in part abstracted to affect injuriously its nature, or (v) which contains any poisonous, or (vi) the quality or purity of which does not conform to the prescribed standard, or (vii) which having been prepared, packed or kept under insanitary conditions or become injurious to health"		
2	The Punjab	Under section 2 "Definitions" Sub-section (a) Adulterated food defined with one		Adulterated

#	Legislation	Related statement	Penalty	Review
	Food Authority Act (2011)	new added clause as: Clause (viii) which is contaminated or has become injurious to health;		agricultural food due to contaminated irrigation water considered for the first time

DATA SOURCE: PUNJAB CODE, GOVERNMENT OF PUNJAB, PAKISTAN
GOVERNMENT OF PUNJAB, PAKISTAN
PUNJAB LAWS, GOVERNMENT OF PUNJAB, PAKISTAN

* The main achievement of the Punjab Local Government Ordinance of 2001 nominating an implementing authority (district municipal officer) on the offense of "Failure of industrial or commercial concerns to provide adequate and safe disposal of affluent or prevention of their mixing up with the water supply or sewerage system". The Executive District Officer would be responsible for the enforcement at the district level, otherwise at tehsil level Town Officer (Municipal Regulations). Similarly, the Executive District Officer of Agriculture at city district and district government level is responsible for prosecution for the offense of "Cultivation of agriculture produce or crop, for supply or sale to public using such manure, or irrigating it with sewer water or any such liquid as may be injurious to public health or offensive to the neighborhood."

Forth schedule,Part 1, section B and C of "The Punjab Local Government Ordinance 2001", pp 116-118, Government of Punjab(2001)

Appendix G4: Prosecution at different levels under PEPA 1997

Offense	Trial	Appeal
U/s 14 & small pollution issues	Environmental Magistrate U/s 24	District & Session Judge U/s 25
U/s 11,12, &16 read with allied provisions of rules & regulations	Environmental Tribunal U/s 21	Lahore High Court (DB) U/s 23
Quasi-judicial proceedings before EPA U/s 12,16,29 & under allied provisions of rules & regulations	Director General or any officer on his behalf U/s 17 (6) (7)	Environmental Tribunal U/S 22

Appendix G5: Formal duties vs working objectives

Administrative organization	Formal rules [1]	Working rules
Environment Protection Department	Planning and policy making in the disciplines of environment and ecology Administration of Environmental Protection Agency Punjab Purchase of stores, laboratory instruments, capital goods for the department and their maintenance. Administration of the environmental laws and the rules	Environment conservation
Pak-EPA		
EPA, Punjab	Implementation of PEPA 1997, establishment of standards, enforcement of Punjab quality standards, establishment of labs Coordination for policy framework, promote public awareness regarding environmental issues and assistance of local authorities, government agencies and local councils[2]	
Industries, Commerce & Investment Department	Legislation, policy formulation, and sectoral planning in respect of: (a) Industries including Industrial estates, small industries and handicrafts Enterprises Regulation of industrial location policy Data collection for industrial survey,	Accelerate industrial development

[1] II schedule of the Punjab Government Rule of Business 2011

[2] Under the section 6 of PEPA 1997

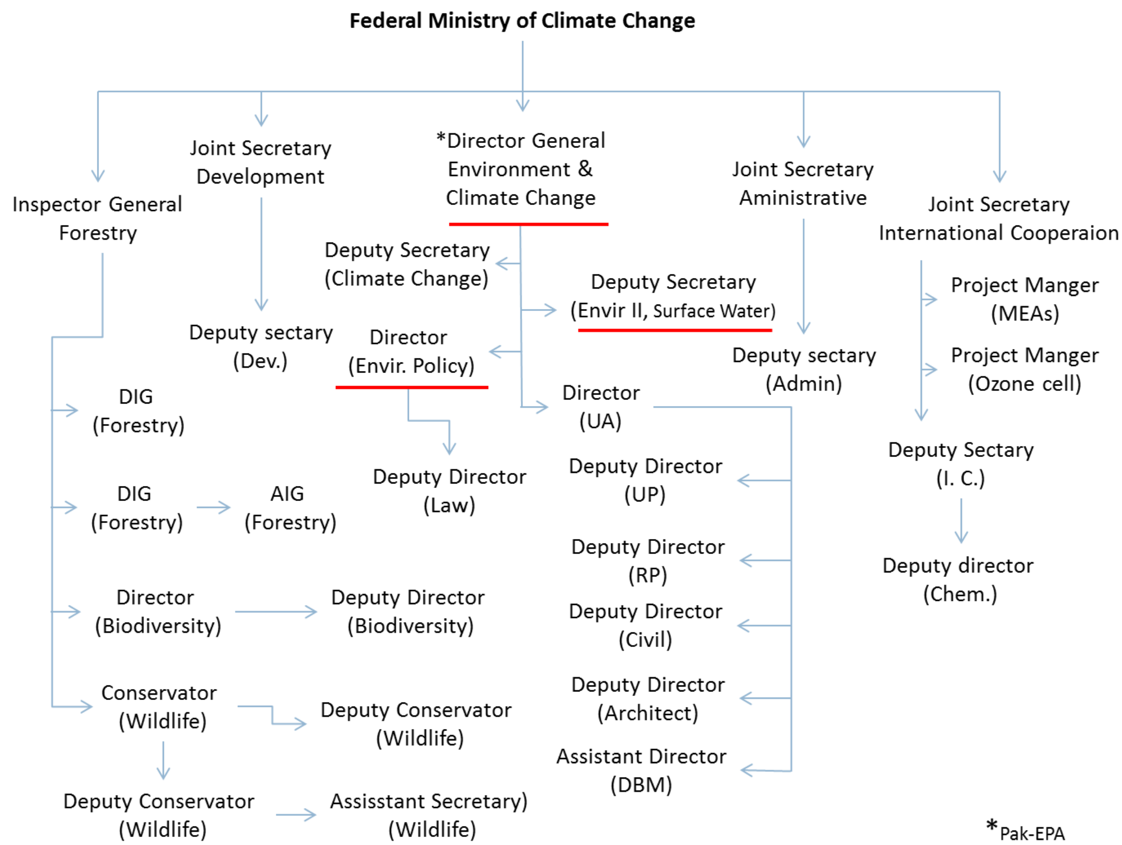
Administrative organization	Formal rules [1]	Working rules
	registration of firms[3]	
Housing, Urban Development and Public Health Engineering (HUD&PHE) Department	Public health, housing, urban development and land use	Small projects for public health and housing mostly at tehsil level
Faisalabad Development authority (FDA)	Preparation of the Annual Development Program for the area, evaluation of the performance at the end of each year and development of the sewerage and drainage systems (within the service area of the Water and Sanitation Agency) Maintain water supply, sewerage & drainage, formulate the environmental improvement schemes and propose the regulation of industrial development	Providing infrastructure for sewage
Water and Sanitation Agency (WASA), Faisalabad	Provide and maintain the services regarding water supply, sewerage and drainage	Take away discharge from city area at any cost
Agriculture Department	Agriculture practices and food safety concerns	
DGA Extension & Adaptive Research	Conducting village level farmer trainings, implementation of agriculture laws and collecting feedback on researchable problems	

[3]Punjab Industries (Control on Establishment and Enlargement) Ordinance 1963

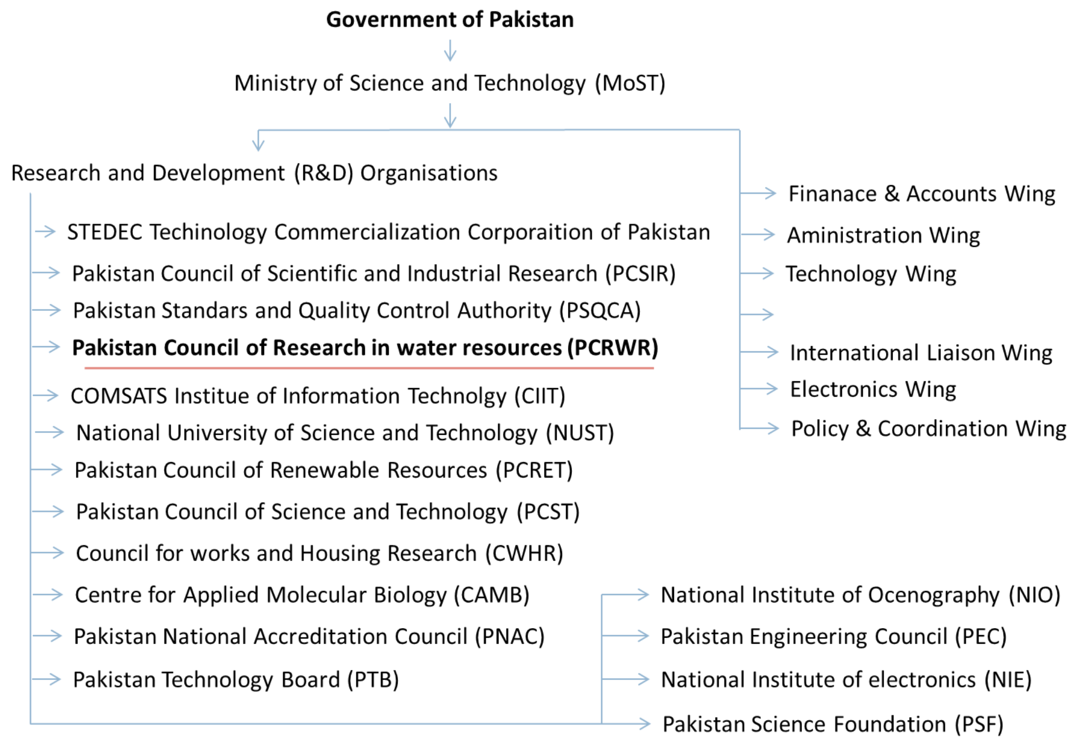
Administrative organization	Formal rules [1]	Working rules
DGA On-farm water Management	Organization and registration of water user's associations (WUAs) Renovation, rehabilitation, and improvement of watercourses	
Irrigation department	Legislation, policy formulation and planning for irrigation and drainage Construction and maintenance of barrages, rivers, canals, tube-wells, drainage schemes, storage of water and construction of reservoirs Flood control and flood protection schemes	Maintaining canal water supply
Planning and development department	Formulation of the government policies, plans and strategies for economic development Preparation, observation and evaluation of Annual Development Program (ADP) / Medium Term Development Framework (MTDF), Provide foreign assistance by: (a) outlining the key areas of interest for foreign assistance and preparation of sector-wise portfolio (b) Carrying on loan negotiations and securing federal financial guarantees (c) reviewing foreign aided projects and facilitating the implementation, development and administration in respect of foreign assisted/funded and mega ADP projects.	
The Urban Unit	Facilitate government-run agencies, private entities and donor agencies with reliable and legitimate technical advisory services	Achieve socio-economic goals in public servicing as cities become engines of growth

Appendix H: Organizational maps of governing organizations

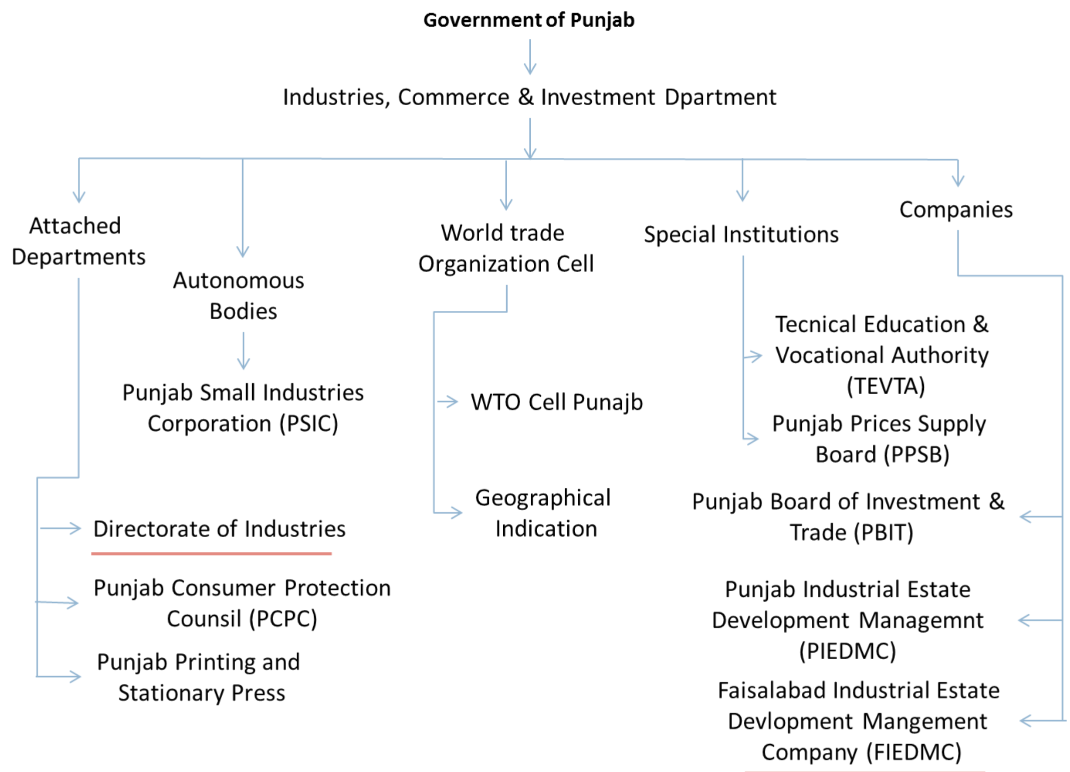
Appendix H1: Organogram of the Federal Ministry of Climate Change



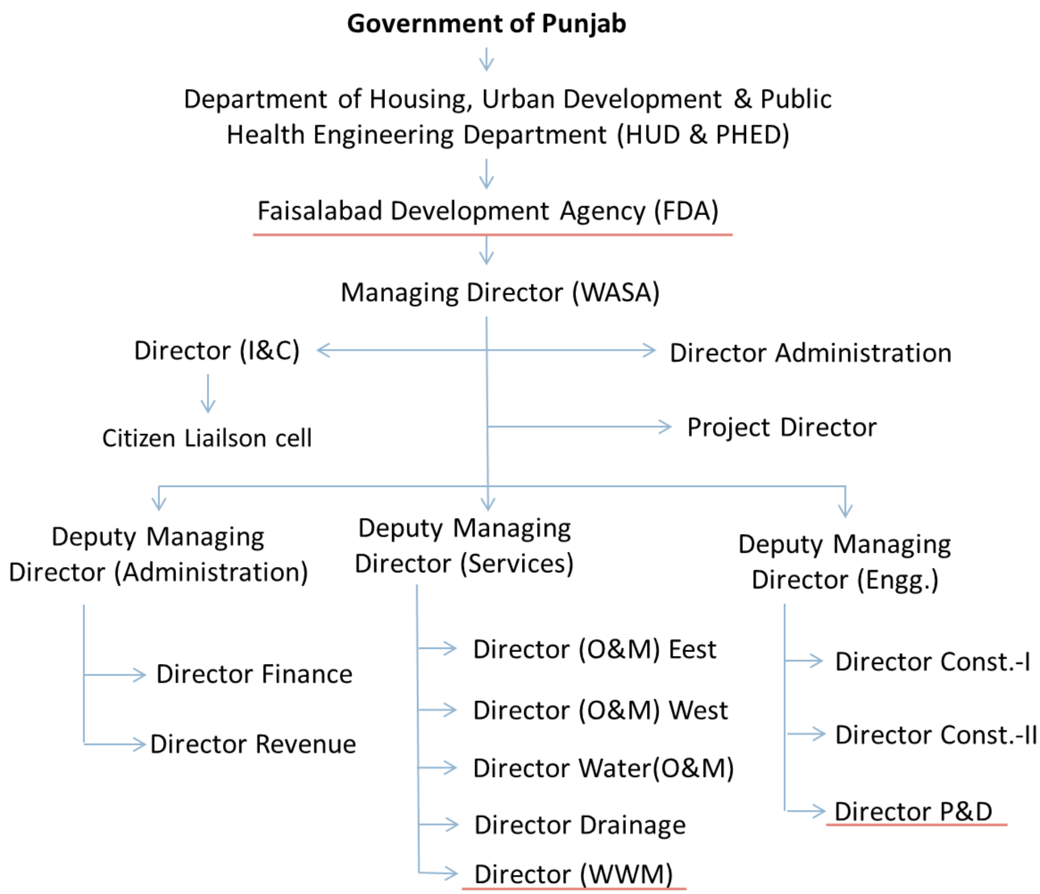
Appendix H2: Organogram of the federal Ministry of Science and Technology



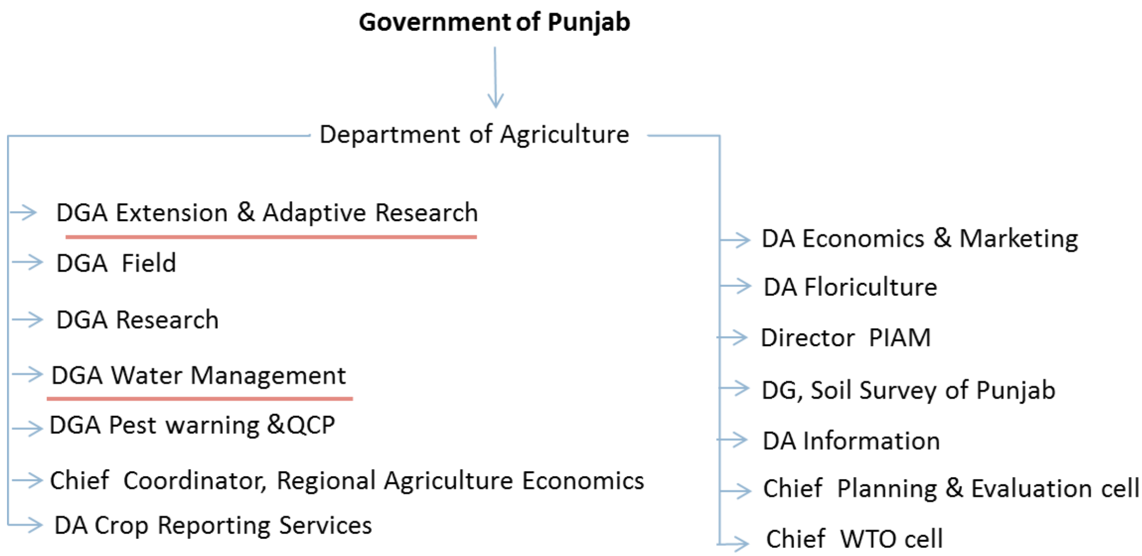
Appendix H3: Organizational setup of the Provincial Ministry of Industries, Commerce and Investment



Appendix H4: Lines of Command in Water and Sanitation Agency, Faisalabad



Appendix H5: Organogram of the Provincial Agriculture Department



Appendix I: On-going Projects Details in Faisalabad

No.	On-going Projects Details	
1	***Punjab City Governance Improvement Project (PCGIP)***	
	Agenda	Strengthening urban governance – the institutions and management system
	Funding Agency	World Bank
	Financial Outlay	150 million USD
	Duration	Five years (January 2013- June 2017)
	Stakeholders	World Bank, the Government of Punjab, government departments, city district governments of cities (5), developing authorities (5), WASAs (5)
	Target Area	Lahore, Faisalabad, Gujranwala, Multan and Rawalpindi
	Details	PCGIP is divided into three components. First, the Performance Improvement Grant (145 million USD) provided cities, on a performance basis, a set of Eligible Expenditure Programs (EEPs). EEPs finance two departments: Works and Services Department and WASAs. WASA Faisalabad is one of them who directly benefits. The annual grantswere disbursed depending onachieving pre-specified results fromdisbursement-linked indicators (DLI). Project Implementation Support and Capacity Building (5 million USD) is the second component, which supports a Program Technical Cell (under Urban Unit)and a City Program Unit to seek project management and evaluation. The third component is the contingent emergency response for swift response in case of any crisis or disaster.
	Sources: (GHK Consulting Ltd., 2011; World Bank and Government of Punjab, 2012; World Bank, 2012; Environmental and Social Management Framework (ESMF), 2012; The Urban Unit, 2014a; The Urban Unit, 2014b; World Bank, 2015; Directorate General Monitoring & Evaluation, 2016)	
2	***Punjab Green Development Program: Environmental and Social System Assessment (ESSA)***	
	Agenda	Strengthening Environmental Governance-Promoting Green Investment
	Funding Agency	World Bank
	Financial Outlay	Credit, 200 million SD by World Bank, 73 millionUSD by the Government of Punjab
	Duration	2018 - 2023
	Stakeholders	World Bank, Government of Punjab, EPD (Punjab)
	Target Area	Punjab Province

No.	On-going Projects Details	
	Details	This program's coverage is too broad regarding environmental problems such as air and water quality control
	Sources: (World Bank, 2018b; World Bank, 2018a)	
3	***Strengthening Irrigation Management System including Agriculture Extension through Farmers' Participation in the Punjab Province***	
	Agenda	Establishing anappropriate irrigation management system through verification activities in the pilot areas, which contributes to the improvement of the management and maintenance of the irrigation system and increases water use efficiency and on-farm productivity
	Funding Agency	JICA's Yen Loan Project "Punjab Irrigation System Improvement Project" (PISIP).
	Financial Outlay	200 million Yen
	Duration	March 2009- March 2013
	Stakeholders	Irrigation and Power Department, Punjab (IPD), Punjab Irrigation and Drainage Authority (PIDA), Punjab Agricultural Department (PAD)
	Target Area	Bahawal Nagar Canal Circle in Bahawalpur Irrigation Zone, Lower Chenab Canal West (LCC (W)) Circle in Faisalabad Irrigation Zone, Dera Jat Canal Circle in DG Khan Irrigation Zone
	Details	
4	***The project for Replacement of Pumping Machinery at Inline Booster Pumping Station & Terminal Reservoir in Faisalabad***	
	Agenda	To improve water systems in Lahore and Faisalabad
	Funding Agency	The Government of Japan through Japan International Cooperation Agency (JICA)
	Financial Outlay	Grant of 4.17 billion Yen (approx. Rs. 3.4 billion)
	Duration	2015
	Stakeholders	The Government of Punjab, WASA Faisalabad
	Target Area	WASA Faisalabad and Lahore
	Details	Under the project in Faisalabad, aged pumps will be renewed and the efficiency of the pump station and reservoir, which were previously installed under ADB's assistance, will be improved. By doing so, the project expects to reduce electricity cost and increase the daily maximum water supply.
5	***The project for Improving the Capacity of WASAs in Punjab Province***	
	Agenda	Establishing the Punjab Water and Sanitation (WATSAN) Academy that will function as a training institute for capacity development of staff of WASAs and the public water sector.
	Funding Agency	Japan International Cooperation Agency (JICA)
	Financial Outlay	Technical Cooperation Project (TCP)
	Duration	July 2015- July 2018

No.	On-going Projects Details	
	Stakeholders	The Government of Punjab, WASAs
	Target Area	Punjab Province
	Details	The newly established WATSAN academy will encompass diverse capacity development parameters, ranging from training manuals, curriculum, materials, plans, job promotions/confirmation mechanism, and on-job training system at each WASA.
	Sources: (JICA, 2016b)	
6	***Project for Upgrading of Mechanical System for Sewerage and Drainage Services in WASA Faisalabad***	
	Agenda	Replacing the pumps and cleaning equipment in order to reduce damages from flooding.
	Funding Agency	JICA
	Financial Outlay	
	Duration	October 17, 2014
	Stakeholders	
	Target Area	WASA Faisalabad
	Details	Under the "Project for Upgrading of Mechanical System for Sewerage and Drainage Services in WASA Faisalabad" pumps and cleaning equipment has been replaced in order to reduce damages from flooding which chronically hampers the life in Faisalabad. Japan has continuously worked over the last decade to improve water and sanitation in Faisalabad, a model city of Japanese assistance on the water sector.
	Sources: (WASA Faisalabad, 2012; JICA, 2012;JICA, 2019)	
7	***Construction of Pilot Wastewater Treatment Plant at Shahbaz Nagar, Faisalabad***	
	Agenda	Construction of 0.5 MGD capacity pilot treatment plant at Shahbaz Nagar
	Funding Agency	UNICEF
	Financial Outlay	47.00 million Rupees UNICEF will provide funds of about Rs. 23 million while remaining Rs. 24 million will be paid by WASA.
	Duration	6 months (2015)
	Stakeholders	FDA, WASA Faisalabad
	Target Area	Shahbaz Nagar, Faisalabad
	Details	UASB reactor is a part of the plant that will help for the treatment of effluent and energy generation.
	Sources: (WASA Faisalabad, 2015b)	
8	***Eastern Wastewater Treatment Plant at Channel 4, Faisalabad***	
	Agenda	The objective of the plant is to avoid contamination of surface and subsoil water and to improve environmental conditions in downstream

No.	On-going Projects Details	
		areas of Madhuana Drain.
	Funding Agency	MoU signed with STFA INSAAT A.S. Turkey on 7/11/2015
	Financial Outlay	150 million USD
	Duration	
	Stakeholders	WASA Faisalabad
	Target Area	Eastern side of Faisalabad
	Details	Treatment plant for Maqbool road and Samundri road industrial wastewater channel 4, which dumps effluents into Madhuana drain The project is financed under the PPP mode (BOO)as treated water can be used for irrigation and industrial purposes.
	Sources: (WASA Faisalabad, 2015b)	
9	***Western Treatment Plant of Faisalabad project***	
	Agenda	150 MGD capacity Treatment Plant on the western side of Faisalabad
	Funding Agency	Denmark government through Danida Business Finance,
	Financial Outlay	15 billion Rs., 100 million EUR, 750 million DKK
	Duration	2017 - 2022
	Stakeholders	WASA, Government of Punjab, Danida
	Target Area	Faisalabad
	Details	Danida Business Finance (DBF) would provide 35% as grant, whereas 65% would finance through private sector (Danish bank subsidiary)
	Sources: Danish Ministry of Foreign Affair, 2017; SEWACO, 2018	

Appendix J: Questionnaires

Appendix J1: General status of the farmers of peri-urban areas in Faisalabad

General

i. District____

ii. Tehsil/town___________________

iii. Name of Union Council__________________________

iv. Name of village ______________________________

v. Name of Minor /Distributary__________________________

vi. Watercourse Name/Number_____________________

vii. Name of Drain____________________________

viii. Population (Nos.)_________________

ix. Watercourse No. and name______________________

x. Position of watercourse on distributor___________________

(a) head (b) middle(c) tail

xi. Position of village on water course__________

(a) head (b) middle(c) tail

xii. Approximate farming community (No.)_______________

xiii. Area under cultivation collectively (acres)

xiv. ww applied area (acres)____________

xv. Farmers (approx.) involved in this practice (No.)________________

xvi. Name of drain___________________

xvii. Composition of discharge_______________

xviii. Distance from main city (km)_____________________

xix. Distance from Agri. Market (km)______________

xx. Source of transportation to main ity_________

1.Bus 2. Vegan 3. Tanga 4. Motor Cycle 5. Other

xxi. Rent(Rs.)_______

xxii. Road facility (Y/N)_________since________

xxiii. Electricity (Y/N)__________since__________

xxiv. Gas (Y/N)_______since_________

xxv. Telephone (Y/N)________since____________

xxvi. School (total no.)_____(B)_____(G)

xxvii. Primary _____ (B)_____(G)

xxviii. Middle _____(B)_____(G)

xxix. Higher _____(B)_____(G)

xxx. Hospital (Y/N)_____since______

xxxi. Basic health unit (Y/N)_____since_____

xxxii. Dispensary (Y/N)_____since_____

xxxiii. Medical store (Y/N)______since_____

xxxiv. Doctor (MBBS) M_____F_____

xxxv. Trained staff M_____F_____

Farmers Perception about Wastewater Irrigation

1-Source of Irrigation

i. *1. Canal* *2. Tubewell* *3. Wastewater* *4. Others (Specify)*

ii. What is the most preferred source of irrigation _____________

1. Canal *2. Tubewell* *3. Wastewater*

iii. Reason for preference __________________

2-Canal as source of Irrigation

i. Do you receive canal water? *0. No* *1. Yes*

ii. If No Why? __________________________________

iii. If Yes, Location of watercourse with respect to Distributory?*1.Head* *2.Middle* *3.Tail*

iv. Location of Farm on watercourse *1.Head* *2.Middle* *3.Tail*

v. Irrigation time allocated for one acre. ____________

vi. Time required irrigating one acre. _____________*1.Ploughed* *2.Unploughed*

vii. Do you receive sufficient quantity of canal water? *0. No* *1.Yes*

viii. If no, what is the reason for low canal water supply? _____________

0.NK *1.Less allocation* *2.Conveyance losses* *3.Breaches*

4.Less allocation *5.Tail reaches* *6.Elevated field* *7.Others (Specify)*

3-If tubewell is source of irrigation,

i. Do you own tubewell? *0.No* *1.Yes*

ii. Time required filling one acre with tubewell. ______________

1.Ploughed *2.Unploughed*

iii. Cost of tubewell water per irrigation: Rs. /hrs.______________/Acre /irrigation

iv. If purchased, what is the prevailing price of tubewell water? ______________(/Hour)

v. Groundwater Quality *1.Good* *2.Marginal* *3. Bad*

4-If Wastewater is not source of Irrigation

i. Do you want to use wastewater for irrigation? *0. No* *1. Yes*

ii. If No, Why don't you want to use wastewater for irrigation? _________

1. Health risk *2. High Prices* *3. Soil degradation*

4. Crop burning *5. Others (Specify)*

iii. If yes, What is reason for not using wastewater? ________________

1. No watercourse *2. Legally not allowed*

3. High prices *4. Other farmers don't give access*

5. Person having water rights don't allow to use *6. Others (Specify)*

iv. If you were given access to wastewater, how much you can pay per acre per annum (Rs.)_____________

5-If wastewater is source of irrigation

i. What if you are not provided wastewater for irrigation?

1. Land will be barren *2. Low cropping intensity*

3. Low Production *4. Land degradation*

5. Land improvement *6. Others (Specify)*

ii. For how long you are using wastewater as a source of irrigation ____________

iii. What is source of wastewater ______________________

1. Outlet from treatment pond *2. Drain*

3. Open Channel *4. Open surface Drains of households*

iv. Quality of Wastewater *1. Treated* *2. Untreated*

v. Dominant source of effluents *1. Household* *2. Industrial*

vi. What is the distance of farm from the source of wastewater? _____________ (km)

vii. Why do you prefer wastewater.______________?

0. Not know *1. Availability* *2. Good productivity* *3. Don't have other source* *4. Groundwater is saline* *5. To dispose off*

6.Cheaper than TW water *7. Reliable* *8. Other (Specify)*

viii. Do you pump wastewater *0. No* *1. Yes*

ix. If yes, what is the cost of pumping to irrigate one acre? _____________ (Rs./ Acre / Irrigation)

x. Do you pay for wastewater *0. No* *1. Yes*

xi. If yes what is the rate for wastewater per acre? Rs./hr./ac________________

xii. Do you mix wastewater with water from other sources? *1. Yes* *2. No*

xiii. If Yes, Why? _________________

0. Don't know *1. To supplement other source*

2. To avoid harmful effect on soil *3. Other (Specify)*

xiv. What was the reason for choosing the wastewater site for farming?

1. Own Land *2. Profitability* *3. Vicinity of home*

4. Could not find other employment *5. Others*

xv. Is there any effect of wastewater on the farmer? *1. Yes* *2. No*

xvi. If yes, what is the effect? _____________

xvii. Do you feel any problem while working in the field irrigated with wastewater?

1. Yes *2. No*

xviii. If yes what is the problem?

0. No problem *1. Don't know* *2. Bad smell* *3. Health risk*

xix. Is there any discrimination in marketing on the basis of source of irrigation?

1. Yes *2. No*

xx. If yes what is the problem? ______________________

5-Environmental impacts

What are benefits and harms of using particular source of water (WW, CW, WW & CW, WW & GW) for irrigation? (Farmers perception)

Factors	Irrigation Impacts

	0. Don't know 1. No effect 2. Improves (increases) 3. Worsens(Reduces) 4.0thers(specify)	If 3,Rehabilitation cost (Rs./crop/year)
Underground Water Quality		
Soil		
Land Productivity		
Crop Production		
Farm Inputs:(Productivity response) • Fertilizers • Pesticides • Labor • Others		
Cropping Pattern		
Overall Returns From Farming		
Consumption Of The Product (Quality Of Product)		
Health Risks		
Income Level		
Socio-Ecological System		
Social: • Hygiene • Quality Of Life • Social Relations		
Property Values		
Others		

What are the problems/risks make wastewater irrigation limited?

Factors	Farmers Problems	Farmers suggestions
Social	1. 2. 3. 4. 5.	1. 2. 3. 4. 5.
Economic	1. 2. 3. 4. 5.	1. 2. 3. 4. 5.
Health	1. 2. 3. 4. 5.	1. 2. 3. 4. 5.
Environmental (land, impacts on soil resources)	1. 2. 3. 4. 5.	1. 2. 3. 4. 5.
Socio-ecological systems	1. 2. 3. 4. 5.	1. 2. 3. 4. 5.
Water quality	1. 2. 3. 4. 5.	1. 2. 3. 4. 5.

Infrastructure/ Physical	1. 2. 3. 4. 5.	1. 2. 3. 4. 5.
Institutional	1. 2. 3. 4. 5.	1. 2. 3. 4. 5.
Role of Bidders	1. 2. 3. 4. 5.	1. 2. 3. 4. 5.
Others	1. 2. 3. 4. 5.	1. 2. 3. 4. 5.

Remarks:

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Appendix J2: Questionnaire for the household survey

Respondents Profile

1.2- Personal:

i. Name of Respondent ______________________________________

ii. Father's name____________________

iii. Contact No.____________________

iv. Address ____

v. Experience in farming (Years) _____

vi. Family Size (Nos.) _______________

1-Adults (above 16) _____ *2- Young (less 16)* ________ *3- Kids (under 8)*__________

vii. No. of Children (*Female*_____ *Male*_____)

viii. Alive (*Female*_____ *Male* _____)

ix. Dead (*Female*_____ *Male*_____)

In case of death, age and reason

No.	Gender	Age	Reason
1			
2			

1.3-Standard of Living:

i. Standard of House: *1.Good* *2.Marginal* *3. Bad*

ii. Hygienic condition *1.Good* *2.Marginal* *3. Bad*

iii. Sanitation condition *1.Good* *2.Marginal* *3. Bad*

iv. Latrine (Observation by Interviewer)_______________________________________

v. Source of drinking water______________________________________

vi. Quality of drinking water ______________________________________

1. Filtered *2.Boiled* *3. Bad* *4.dont know* *5.other (specify)*

2-Demography

No	Relationship to head of household	Gender F=1, M=0	Age	Profession	Years of Schooling	The frequency of the disease/health problem occurrence*													
						Stomach problems	Intestinal	Skin problems	cholera	diarrhea	typhoid	Fever/Cold	Malaria	Nail Problems	Blindness or any other disability	Mental disorders	hepatitis	Heavy metal	Others

1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			

* Disease occurs how often during the year 2007-08 (once, twice, thrice, etc)

3.1-Labor Productivity loss

No.	Total days of Illness during the year 2007-08	Since how long you are ill?	What type of health facilities did your household use during the 2008-09?	How many visits were made to the facility during the year 2007-08?	Medication cost (consultation fee plus medicines)?	Transportation cost?	Other cost if any?	Prevention costs?	How much did your household spend on health facilities in total?
	days	days	Type	No. of visits	Rs.	Rs.	Rs.	Rs.	Rs
1									
2									
3									
4									
5									
6									
7									
8									
9									

6-Agriculture Module

6.1-Land Tenure:

i. Tenancy Status:___________

1. Owner (Cultivator) 2. Owner (Manager) 3.Owner-cum-Tenant

4. Tenant (for Lessee) 5. Tenant (for Owner) 6.Lessee 6.Other (Specify)

ii. Do you cultivate this piece of land yourself? *0. No 1. Yes*

iii. If "No" who is the actual tiller of Land___________ *1. Laborer 2. Tenant 3.Other*

6.2-Land Holding:(Acres)

i. Owned. ______________ Share in. ______________ Share out ______________

ii. Lease in. ______________ Lease out . _____________ Land Rent ______________

iii. Price /acre ____________

iv. Operational Land Holding ______________

6.3-Land Use (Acres)

i. Culturable Waste Area (Not cropped during last two years):

Saline (Ac.)____________ Sodic (Ac.) ____________ Salinesodic (Ac.) _____________

Waterlogged (Ac.) ________ Waterlogged and Saline (Ac.) _________Other (Ac.) _________

ii. Reason for Culturable waste area ______________

0. Nk 1. High Watertable 2. Irrigation with brackish water.

4. Financial Problem 5.Scarcity of Irrigation water 6.Other. (Specify)

iii. Net Cultivated Area. (Farm Area - Culturable Waste Area) ______________

6.4-Fallow

i. Fallow during Kharif season 2008. ______________

ii. Fallow during Rabi season 2009. ______________

iii. Reasons for keeping area fallow (Kharif) ________

iv. Reasons for keeping area fallow (Rabi) _________

0. No fallow area. 1. Shortage of irrigation water 2. High watertable

3. To restore fertility 4. Unavailability of inputs 5. Financial constraints

6. For next season 7. Others (Specify)

v. Why do you prefer vegetable growing (If vegetables were grown)? ____________

vi. For how long you are using wastewater as source of irrigation ____________

vii. If you were given access to wastewater, how much you can pay per acre per annum (Rs.)____________

6.5-Matrix for the Estimation of Input/ Output per Acre

(*0. Not known 1. Disease 2. Rain 3. Flood 4. Drought 5.Others(Specify))

		Wheat				
Area under crop (A-acre) (K-Kanal)						
Area Destroyed						
Reasons*						
A-Land Preparation						
i-Deep Tillage Cost	Rs.					
ii-Cultivator Cost	Rs					
iii-Cost of Planking	Rs					
B-Seed Bed Preparation						
i-Cost of Ridger	Rs					
ii-Ridges (Manually)	M.d.					
iii-Puddling	M.d.					
iv-Bund Making	M.d.					
C-Sowing						
i-Date of sowing						
ii-Method of sowing						
iii-Labor for Sowing	M.d.					
iv-Cost of Seed	Rs,					
D-Seed/nursery						
i-Seed Preparation (S.C.)	M.d.					
ii-Seed Drilling	Rs					
iii-Cost of fertilizer	Rs					
iv-Cost of chemicals	Rs					
v-Seed treatment	Rs					
vi-Transplanting	M.d.					

		Wheat				
E-Weeding / Hoeing						
i-Hoeing	M.d.					
ii-Weeding	M.d.					
iii-Males worked(f/h)	No.					
iv-Females worked(f/h)	No.					
v-Wage rate for male	Rs/M.d.					
vi-Wage rate for female	Rs/M.d.					
F-Cost of Fertilizer						
i-Cost of Urea	Rs					
ii-Cost of DAP	Rs					
iii-Cost of Other	Rs					
G-F Y M						
i-Trolleys/ Carts	No					
ii-Price per trolley/Cart	Rs.					
H-Plant Protection						
i-Total Sprays	No.					
ii-Labor / Spray	M.d.					
iii-Cost of pesticides /weedicide	Rs.					
I-Irrigation						
i-Canal irri.	Nos.					
Abiana	Rs					
Land Tax	Rs					
ii-TW Irr.	Nos.					
Cost /irri	Rs					
iii-Wastewater irri.	Nos.					
Cost/irrigation	Rs					

		Wheat				
iv-Labor / irrigation	M.d.					
v-Other Expenses	Rs					
J-Picking / Harvesting						
Date of Harvesting						
i-labor for Picking/Harvesting	M.d.					
ii-No of Male/female worked	No.					
iii-Cost of Picking / Harvesting	Rs.					
K-Output						
Total Production	Mds					
Home Consumption	Mds					
Marketable surplus	Mds					
Prevailing Price	Rs/kg					
Income from crop received	Rs					
By-product	Mds					
Prevailing Price of by-product	Rs/kg					
Income from crop received	Rs					
K-Post Harvest Cost						
Cost of Transportation	Rs					
iv-Other Expenses	Rs.					

6.6-Matrix for Expenses on livestock

Animals	N	Bought	Sold	Costs	Benefits

	o.	during 2008-09		during 2008-09		Feeding (Animal /day)	Labor (Animal /day)	Medical treatment	Milk /Day	Eggs /Day
		No.	Rs.	No	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
Buffaloes										
Cows										
Sheep/Goat										
Chicken										
Donkeys										
Other(specify)										

7-Other Incomes

Items	Amount of money (Rs.)		Remarks
	Per month	2008-09	
1. Other occupation			
2. Pension /social-insurance			
3. Remittances			
4. Rent from property			
5. Other			
Total			

8-Buying and expenditures

Items	Self-support (Rs.)	Buy (Rs.)	
		Per month	2008-09
1. High-value assets, construction (property, vehicles, etc.)			

2. Food expenditure (grains, meat, firing, etc.)			
3. Electricity, Water, Telephone and gas charges			
4. Education, rent			
5. Clothes, Soap, shampoo (accessories)			
6. Paying for medical care and health			
7. Social expenditure (wedding, funeral...)and Funds			
8. Recreational expenditure, transportation,			
9. Others			
Total			

Appendix J3: Questionnaire for in-depthinterviews and focus group discussion

Focus group discussion

Target questions for the semi-structured questionnaire are:

1. How many stakeholders are involved in this practice, and enlist them?

2. How much can they influence and through which ways? Rank them and categorize them according to their role.

Net mapping

1-Who is involved?

(Preparation the list of stakeholder)

2-How they are linked?

(Link means the relationship among these stakeholders. For instance, in this study the following links were analyzed:

- Financing flow

- Information Flow

- Formal lines of command

3-how influential are they?

(Influence or power means the capacity of an actor to affect the decision about policy implementation. Influence will be ranked from 0 to 5 points. The influential status can be represented by showing the size of the rectangle box or by writing the ranking number in each box.)

4-What are their goals?

(Different institutions have different goals like an economic benefit, environmental protection, and social improvement.)

3. What kind of interests stakeholders possess, either financial or moral in the outcome of wastewater irrigation? Are they positive or negative?

4. What are the main reasons for their motivation and interest?

5. These stakeholders are supportive or not? If they are not supportive, how can I change their opposition?

6. What is the farmer's latest opinion regarding this practice?

7. What is the logic behind this opinion?

8. What is their source of information?

9. Who has an influence on their opinion?

10. Is it still functioning or not, if not then why?

11. During the last 6 years, is the situation still same or changed?

12. What kind of change? Either positive or negative
    a. Supply of wastewater
    b. Demand for wastewater
    c. Quality of wastewater
    d. Rate of wastewater

13. What are their personal perceptions regarding the soil condition?

14. What are their personal perceptions regarding the underground water condition?

15. What are their personal perceptions regarding the health condition?

16. What kind of problems and benefits are related to practice? Enlist them.

17. What are the possible solutions according to their point of view?

18. Do you want to get good quality water?

19. How much are you ready to pay?

20. Who can initiate a step towards policy recommendation and implication?

21. Do you have trust on policymakers for the defending your perspective?

22. Suppose you are the policy maker, what will you recommend?

23. Did any extension service provider visit you during last 6 year regarding this issue?

24. How would you recommend the possible solutions in line with following stakeholder?

    - Role of industries
    - Role of Local Government
    - Role of Environment Protection Department (EPD)
    - Role of WASA
    - Role of National Government and Provincial Government

- Role of farmers
- Role of research institutes
- Pollution taxes
- Existing laws
- Pollution control measures
- Future planning
- Why policy implication is poor?
- National policies

General

xxxvi. District____

xxxvii. Tehsil/town______________________

xxxviii. Name of Union Council______________________________

xxxix. Name of village __________________________________

xl. Name of Minor /Distributary______________________________

xli. Watercourse Name/Number________________________

xlii. Name of Drain________________________________

xliii. Population (Nos.)____________________

xliv. Watercourse No. and name_________________________

xlv. Position of watercourse on distributor______________________

(a) head (b) middle(c) tail

xlvi. Position of village on water course____________ *(a) head (b) middle(c) tail*

xlvii. Approximate farming community (No.)________________

xlviii. Area under cultivation collectively (acres)

xlix. ww applied area (acres)_____________

l. Farmers (approx.) involved in this practice (No.)_________________

li. Name of drain____________________

lii. Composition of discharge________________

liii. Distance from main city (km)______________________

liv. Distance from Agri. Market (km)_______________

lv. Source of transportation to main ity__________

1.Bus 2. Vegan 3. Tanga 4. Motor Cycle 5. Other

lvi. Rent(Rs.)________

lvii. Road facility (Y/N)__________since_________

lviii. Electricity (Y/N)__________since__________

lix. Gas (Y/N)_______since_________

lx. Telephone (Y/N)________since____________

lxi. School (total no.)_____(B)_____(G)

lxii. Primary _____ (B)_____(G)

lxiii. Middle _____(B)_____(G)

lxiv. Higher _____(B)_____(G)

lxv. Hospital (Y/N)_____since______

lxvi. Basic health unit (Y/N)_____since_____

lxvii. Dispensary (Y/N)_____since_____

lxviii. Medical store (Y/N)______since_____

lxix. Doctor (MBBS) M_____F_____

lxx. Trained staff M_____F_____

Farmers Perception about Wastewater Irrigation

1-Source of Irrigation

iv. *1. Canal 2. Tubewell 3. Wastewater 4. Others (Specify)*

v. What is the most preferred source of irrigation _____________

1. Canal 2. Tubewell 3. Wastewater

vi. Reason for preference __________________

2-Canal as source of Irrigation

ix. Do you receive canal water? *0. No 1. Yes*

x. If No Why? __________________________________

xi. If Yes, Location of watercourse with respect to Distributory?*1.Head 2.Middle 3.Tail*

xii. Location of Farm on watercourse *1.Head 2.Middle 3.Tail*

xiii. Irrigation time allocated for one acre. ____________

xiv. Time required irrigating one acre. _____________*1.Ploughed 2.Unploughed*

xv. Do you receive sufficient quantity of canal water? *0. No 1.Yes*

xvi. If no, what is the reason for low canal water supply? _____________

0.NK 1.Less allocation 2.Conveyance losses 3.Breaches

4.Less allocation 5.Tail reaches 6.Elevated field 7.Others (Specify)

3-If tubewell is source of irrigation,

vi. Do you own tubewell? *0.No 1.Yes*

vii. Time required filling one acre with tubewell. _____________

1.Ploughed 2.Unploughed

viii. Cost of tubewell water per irrigation: Rs. /hrs._____________/Acre /irrigation

ix. If purchased, what is the prevailing price of tubewell water? _____________(/Hour)

x. Groundwater Quality *1.Good 2.Marginal 3. Bad*

4-If Wastewater is not source of Irrigation

v. Do you want to use wastewater for irrigation? *0. No 1. Yes*

vi. If No, Why don't you want to use wastewater for irrigation? ________

1. Health risk 2. High Prices 3. Soil degradation

4. Crop burning 5. Others (Specify)

vii. If yes, What is reason for not using wastewater? _______________

1. No watercourse 2. Legally not allowed

3. High prices 4. Other farmers don't give access

5. Person having water rights don't allow to use *6. Others (Specify)*

viii. If you were given access to wastewater, how much you can pay per acre per annum (Rs.)____________

5-If wastewater is source of irrigation

xxi. What if you are not provided wastewater for irrigation?

1. Land will be barren *2. Low cropping intensity*

3. Low Production *4. Land degradation*

5. Land improvement *6. Others (Specify)*

xxii. For how long you are using wastewater as source of irrigation ___________

xxiii. What is source of wastewater _____________________

1. Outlet from treatment pond *2. Drain*

3. Open Channel *4. Open surface Drains of households*

xxiv. Quality of Wastewater *1. Treated* *2. Untreated*

xxv. Dominant source of effluents *1. Household* *2. Industrial*

xxvi. What is the distance of farm from source of wastewater? ____________ (km)

xxvii. Why do you prefer waste water.______________?

0. Not know *1. Availability* *2. Good productivity* *3. Don't have other source* *4. Groundwater is saline* *5. To dispose off*

6.Cheeper than TW water *7. Reliable* *8. Other (Specify)*

xxviii. Do you pump wastewater *0. No* *1. Yes*

xxix. If yes, what is the cost of pumping to irrigate one acre? _____________ (Rs./ Acre / Irrigation)

xxx. Do you pay for wastewater *0. No* *1. Yes*

xxxi. If yes what is the rate for wastewater per acre? Rs./hr./ac________________

xxxii. Do you mix wastewater with water from other sources? *1. Yes* *2. No*

xxxiii. If Yes, Why? _________________

0. Don't know *1. To supplement other source*

2. To avoid harmful effect on soil *3. Other (Specify)*

xxxiv. What was the reason for choosing the wastewater site for farming?

1. Own Land *2. Profitability* *3. Vicinity of home*

4. Could not find other employment *5. Others*

xxxv. Is there any effect of wastewater on farmer? *1. Yes* *2. No*

xxxvi. If yes, what is the effect? _____________

xxxvii. Do you feel any problem while working in the field irrigated with waste water?

1. Yes *2. No*

xxxviii. If yes what is the problem?

0. No problem *1. Don't know* *2. Bad smell* *3. Health risk*

xxxix. Is there any discrimination in marketing on the basis of source of irrigation?

1. Yes *2. No*

xl. If yes what is the problem? ______________________

5-Environmental impacts

What are benefits and harms of using particular source of water (WW, CW, WW & CW, WW & GW) for irrigation? (Farmers perception)

Factors	Irrigation Impacts	
	0. Don't know 1. No effect 2. Improves (increases) 3. Worsens(Reduces) 4.0thers(specify)	If 3,Rehabilitation cost (Rs./crop/year)
Underground Water Quality		
Soil		
Land Productivity		
Crop Production		
Farm Inputs:(Productivity response) • Fertilizers • Pesticides • Labor • Others		
Cropping Pattern		
Overall Returns From Farming		
Consumption Of The Product (Quality Of Product)		
Health Risks		
Income Level		

Socio-Ecological System		
Social: • Hygiene • Quality Of Life • Social Relations		
Property Values		
Others		

What are the problems/risks make wastewater irrigation limited?

Factors	**Farmers Problems**	**Farmers suggestions**
Social	1. 2. 3. 4. 5.	1. 2. 3. 4. 5.
Economic	1. 2. 3. 4. 5.	1. 2. 3. 4. 5.
Health	1. 2. 3. 4. 5.	1. 2. 3. 4. 5.
Environmental (land, impacts on soil resources)	1. 2. 3. 4. 5.	1. 2. 3. 4. 5.

Socio-ecological systems	1. 2. 3. 4. 5.	1. 2. 3. 4. 5.
Water quality	1. 2. 3. 4. 5.	1. 2. 3. 4. 5.
Infrastructure/ Physical	1. 2. 3. 4. 5.	1. 2. 3. 4. 5.
Institutional	1. 2. 3. 4. 5.	1. 2. 3. 4. 5.
Role of Bidders	1. 2. 3. 4. 5.	1. 2. 3. 4. 5.
Others	1. 2. 3. 4. 5.	1. 2. 3. 4. 5.

Remarks:

Appendix J4: Questionnaire for stakeholder analysis

Attributes			Stakeholders									
			1	2	3	4	5	6	7	8	9	10
Goals	Economic											
	Social											
	Environmental											
Interest	Not	0										
	least	1										
	medium	2										
	full	3										
Influence	Not	0										
	least	1										
	medium	2										
	full	3										

CURRICULUM VITAE

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Address	Social and institutional Change in Agricultural Development (490c), University of Hohenheim, Germany
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Education and Training	
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Title of qualification awarded	**M.Sc. (Hons.): Agri. Economics**
Name and type of organization	University of Agriculture Faisalabad, Pakistan Major: Agriculture economics CGPA: 3.61
Dates	1997-2001
Title of qualification awarded	**B.Sc. (Hons.) Agriculture: (Agri. Economics)**
Name and type of organization	University of Agriculture Faisalabad, Pakistan Major: Agriculture economics CGPA: 3.81
Scholarship	20013-2017 DAAD (German Academic Exchange Service) Scholarship
Conference Presentation	Saima Jabeen, Regina Birner (2019), Challenges of Sustainable Wastewater Management in Pakistan The Case of Faisalabad, Tropentag, Kassel, Germany
Computer skills	Econometric software: STATA, SPSS, Eviews, Production Frontier, Operating GAMS for LP modeling and some other statistical packages
Languages	English: Fluent (Speaking, Writing and Reading) Urdu (Hindi): Native Language

Hohenheim /
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