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Strengthening Groundwater Governance in Pakistan

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ABSTRACT

Pakistan is highly dependent on irrigated agriculture for employment, income generation and food security—around 90 percent of all food production relies on either surface or groundwater irrigation. The growing dependence of agriculture but also industries and the drinking water sector on groundwater has led to the overexploitation of groundwater resources and, in some areas, to the deterioration of groundwater quality. Fiscal incentives for solarization of irrigation/drinking water pumps are likely to further increase water withdrawals and make water governance more complex. To understand the perspectives of groundwater users, a qualitative study was conducted in the alluvial groundwater systems of Punjab as well as the hard rock systems of Balochistan. Interviews with key informants at federal, provincial, and district level were also conducted to capture insights from additional decisionmakers affecting groundwater management and governance.

The study identified a series of challenges around groundwater management and use, including overexploitation of groundwater resources, worsening groundwater quality raising serious health challenges, lack of communities' participation in decision making, particularly women, non-availability of actionable data, weak enforcement of laws and regulations relating to groundwater governance, and partisan decision-making driven by political influentials and local bureaucracies. Solarization of irrigation pumps without proper regulatory and monitoring framework is expected to exacerbate groundwater extraction and accelerate water stress. The study strongly suggests an urgent need for not only integrated water management at all levels with equitable distribution of water resources but also to engage local communities and other stakeholders, including women in water conservancy awareness campaigns, groundwater quality monitoring, and decision-making. Moreover, the management and governance of water, particularly groundwater, must be insulated from political and partisan decision making. It is equally important to look at the quality of groundwater from a wider prism, considering health and water supply, sanitation and hygiene to address the increase in water borne diseases.

ACKNOWLEDGMENTS

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ACRONYMS

AWBs	Area Water Boards
bcm	Billion cubic meters
FOs	Farmer Organizations
HP	Horsepower
IBIS	The Indus Basin Irrigation System
IRS	Indus River System
IRSA	Indus River System Authority
Mha	Million hectares
MNFS&R	Ministry of National Food Security and Research
NCCP	National Climate Change Policy
NWP	National Water Policy
PBS	Pakistan Bureau of Statistics
PCRWR	Pakistan Council of Research in Water Resources
PIDA	Provincial Irrigation and Drainage Authorities
PKR	Pakistani Rupee
RYK	Rahim Yar Khan
SIDA	Sindh Irrigation and Drainage Authority

INTRODUCTION

The Indus Basin Irrigation System (IBIS) is the backbone of Pakistan's agricultural economy carrying an average of 63 percent of surface water (182 billion cubic meters, or bcm) annual flows through 7 tributaries, 19 barrages, 12 inter-river canals, 45 command canals and more than 120,000 km of water courses (Watto et al., 2021). The current live storage capacity of water through 3 water reservoirs is around 13 percent of annual flows equivalent to 30 days water requirement. The country produces 94,121 GWh of electricity with hydel share of 28.6 percent, of which household consumption is 46.6 percent and agriculture consume 8.2 percent while rest is industrial and commercial consumption.¹

Pakistan is the third-largest user of groundwater consuming about 9 percent of the global groundwater abstraction (Giordano, 2009) and occupying 4.6 percent of the total groundwater-irrigated area of the world (Siebert et al., 2010). Groundwater has emerged as an essential, reliable and indispensable freshwater source because of seasonal fluctuations, challenging regulations of surface water resources throughout the country, uncertainty in surface water availability, particularly for the tail enders, due to climate change and droughts, and inefficiency of the IBIS due to lack of maintenance (Watto and Mugeru 2016; Young et al. 2019).

The pivotal role of groundwater is increasingly threatened by over-abstraction, water logging, and contamination due to lowering water tables in various parts of the country, particularly Balochistan². The on-demand extraction of water in the face of rainfall variability and shortfalls in canal delivery enabled farmers to earn higher income through higher yields and increased cropping intensity (Qureshi et al., 2010; Ahmad et al. 2004; Meinzen-Dick 1996; Janjua et al., 2021). Nevertheless, it has resulted into other challenges such as lowering water tables³, declining quantity and quality of groundwater (Qureshi & McCornick, 2010) and health challenges. Further, an estimated 4.5 million hectares of land across the Indus Basin is affected by salinity, according to the Water and Power Development Authority, with about 40,000 hectares abandoned annually due to salinity (Ashraf et al., 2022). However, variation in estimates by different researchers and government bodies emphasizes a need for updated and regular assessment of the presence of salinity across the basin. Accumulation of salts in soil and plants is exacerbated by irrigation using marginal groundwater quality.

Multiple jurisdictions and structures govern the water resources in Pakistan. While transboundary water between Pakistan and India is regulated under Indus Water Treaty of 1960, the Indus River System Authority (IRSA) under the Federal Government is responsible for regulating and apportioning available surface water amongst the provinces in accordance with the Apportionment

¹ Energy Year Book 2022

² Agriculture sector uses 97% of the water in Balochistan (Khair et al., 2010)

³ Steenbergen et al., (2014), alluvial aquifer in Kuchlugh, Balochistan³ was depleted after three decades of intensive use.

of the Water of Indus River System Between the Provinces Accord, 1991, generally referred to as Water Accord of 1991. Intra-province surface water distribution, canals, and barrages are governed by the respective province. Groundwater management is also under the domain of the provinces but are largely unregulated in Pakistan. There are many stakeholders and perspectives to manage and govern the water sector, particularly, the groundwater. This complexity is cited by many in government during KIIs to argue that government agencies alone have the system-wide understanding needed to manage water. Nevertheless, Punjab's Khal Panchayat Act of 2019, as well as the longstanding experience of *karez* system management by communities in Balochistan or farmers organizations at water course level in Sindh suggest that local communities can be empowered to govern water at the local level.

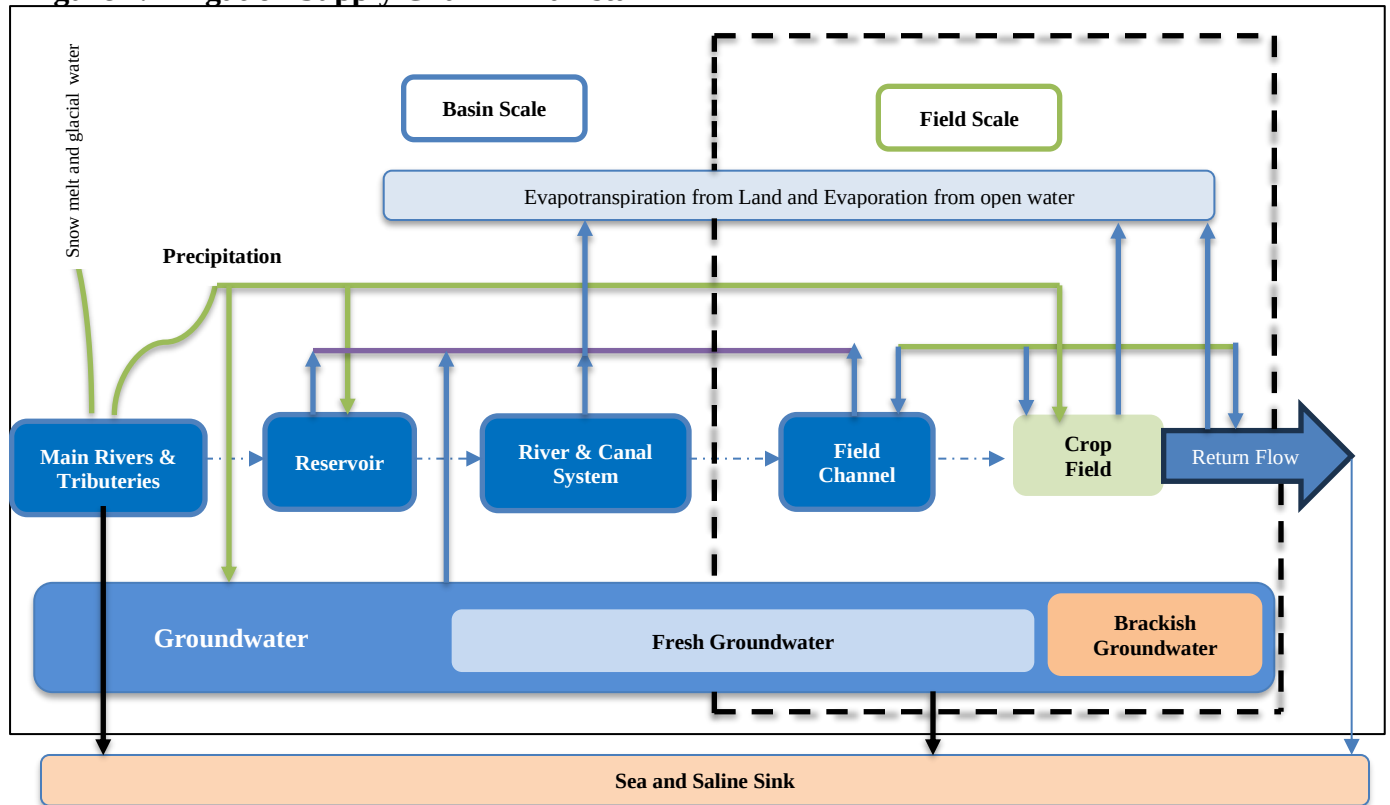
This paper addresses the perspectives of government and communities on groundwater governance in two contrasting contexts: Pishin District (Balochistan), a hard rock aquifer with a longstanding tradition of community management, and Rahim Yar Khan (RYK) District, (Punjab), a large-scale alluvial aquifer heavily influenced by the Indus Basin Irrigation System. This qualitative study is based on community-level focus group discussions (FGDs) to explore groundwater usage, particularly by women, quantity and quality at the community level, community understanding of the legislation and institutional mechanisms to regulate and manage groundwater, and how the 2022 flood affected the selected population. These community-level perspectives are complemented and contrasted with key informant interviews (KIIs) with professionals involved in water management at the federal, provincial and district level on their views. This paper specifically looks at the perspective of groundwater users and government stakeholders as to its extraction, perceived benefits, challenges, quality, local norms, legislation and institutions in place to manage and govern groundwater. It also provides an insight into institutional arrangements for aquifer recharge, water storage and quality of groundwater as well as related health issues. The purpose is to lay out the critical groundwater issues in the different contexts and provide initial assessment on the scope for improved groundwater governance for developing linkages in water-food-energy ecosystems.

The paper is organized as follows: section 2 provides a brief background of water resources including groundwater of Pakistan and existing jurisdictions and institutional arrangements for water governance; section 3 highlights the characteristics of study areas; section 4 elaborates the methodology adopted for this study; section 5 presents the community perspectives on groundwater in the context of local livelihoods and gender roles; and section 6 presents the perspectives of official stakeholders on the challenges of groundwater. The paper concludes with the way forward to strengthening groundwater governance as well as to ensure its sustainability.

BACKGROUND

The Indus River, along with various basins in Balochistan, and growing groundwater extraction through private tubewells, together deliver water to farms and other productive uses including hydropower and domestic, commercial and industrial needs. The surface water infrastructure includes natural and man-made water supply chains forming a complex network from the source at the basin level to the crop field (Figure 1). Return flows from the surface system then feed the groundwater.

Figure 1. Irrigation Supply Chain in Pakistan



Source: Adopted from Abdul Wahab Siyala, et al., 2023

Punjab's surface water share as per 1991 Accord is 69 bcm annually. The groundwater recharge is estimated to be 69.67 bcm (rainfall 9.73, canal system 40.2, return flow 12, rivers 2.96, and transboundary 4.78) while discharge is 61.7 bcm. The areas outside canal commands, such as, Potohar Plateau in the north generates runoff of 4.4 bcm and DG Khan hill torrents in the south provides runoff of 3.35 Bcm (Figure 2) (ADB 2021).

Situated outside the monsoon regions, Balochistan has three major sources of water : a) IBIS: consists of perennial and nonperennial flows as per the Accord (4.78 bcm) mainly available to Naseerabad and Jaffarabad; b) internally generated flood water (*Spate flows*) comprised of

seasonal flood flows; and c) groundwater including springs, open surface wells, and *karez*⁴ (underground irrigation tunnels bored horizontally into rock slopes to deliver water from source to point of use) (Figure 3) (Government of Balochistan and ADB 2007). Groundwater only accounts for 9 percent of the province’s total water resources which is an intensely utilized source but highly dependent on recharge. High groundwater recharge is 49.5 percent during wet years and a low 37 percent during dry years.

Figure 2. Water Resources of Punjab

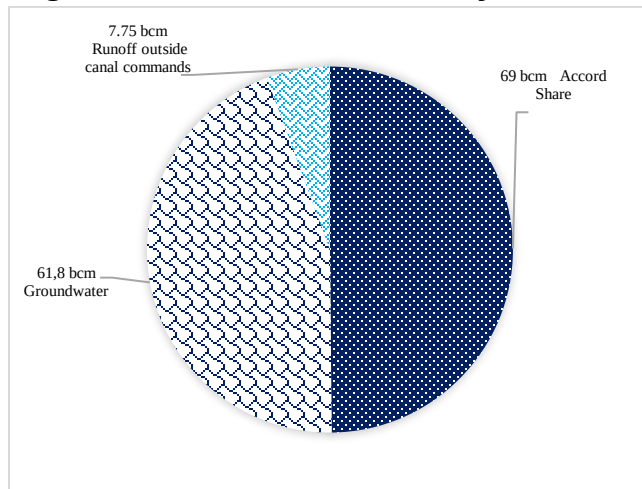
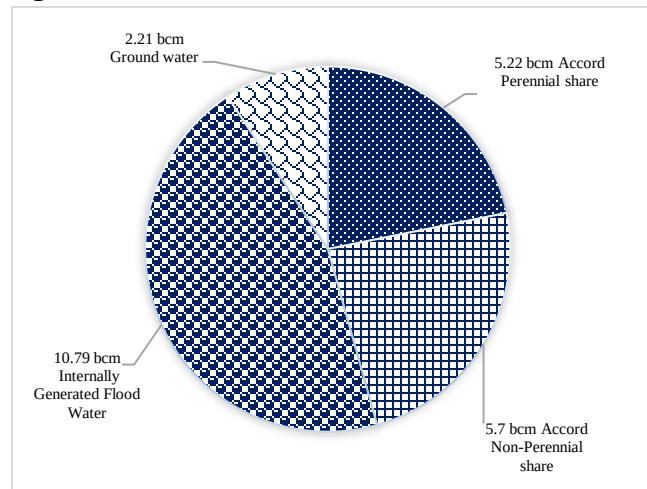


Figure 3. Water Resources of Balochistan



Source: (2) Asian Development Bank (2021) Issues and Options: Reallocating Canal Water in Punjab Province, Pakistan. (3) Government of Balochistan and ADB. (2007). “Water resources availability and use.” ADB-TA 4560, Supporting Public Resource Management in Balochistan

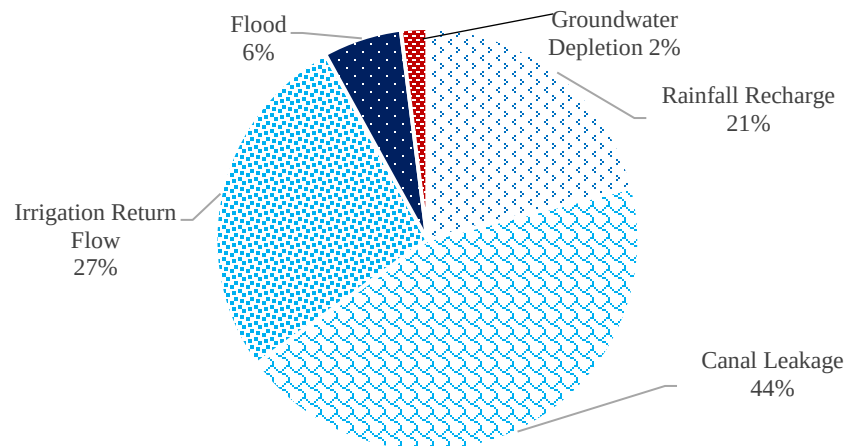
Significance of Groundwater and Emerging Challenges in Pakistan

Groundwater has emerged as a significant source of water in Pakistan. It meets 60 percent of irrigation demands, 90 percent of domestic water in rural areas, 70 percent of domestic water nationally, and over 50 percent of agricultural water mitigating the impacts of increasingly variable and uncertain canal water supply and rainfall. The proportion of groundwater in irrigation water supplies has risen significantly from a meagre 8 percent in 1960 to more than 60 percent in 2006 (Briscoe et al. 2005). The area irrigated by groundwater has increased by a remarkable 390 percent (from 2.9 to 14.3 mha) from 1960 to 2015 (Qureshi, 2020) because of increasing variability in canal water due to climate change, installation of private tubewells, and solarization of irrigation

⁴ *Karez* irrigation technology was developed in arid and semi-arid areas from India and western China through the Middle East into North Africa. The technology is believed to have originated in the 1st millennium BC in Persia from where the knowledge travelled east and westward along the Silk Route, throughout the Muslim world, arriving in Xinjiang in China during the Han dynasty (206 BC – 24 AD) and in Balochistan somewhat earlier. *Karez*es were reportedly built in Balochistan before arrival of the Mughals (Kahlown, Khalil, and Munir 1988). The *Karez* irrigation system is found in many countries, including those in Asia, Africa, and the Middle East, as well as the United States, referred to by a host of names, including Afalaj (Oman, Arabian Peninsula), Auyoun (Egypt), Foggara (North Africa), Galleria (Spain), Kanerjing (China), Karez (Pakistan, Afghanistan, and India), Khotara (Morocco), Mambo (Japan), and Qanat (Iran) (Ashraf and Hasan, 2016). *Karez* allow water to be transported over long distances throughout the year. Evaporation losses are minimal, and its underground coverage protects against sediment deposition from windstorms. The system is resistant to natural disasters such as earthquakes and floods.

pumps particularly in Punjab and Balochistan. Around 71 percent of the groundwater recharge comes from seepage from the rivers, canal networks, and return flows from water users, as indicated on Figure 4 (Laghari et al., 2012; Stewart et al., 2018).

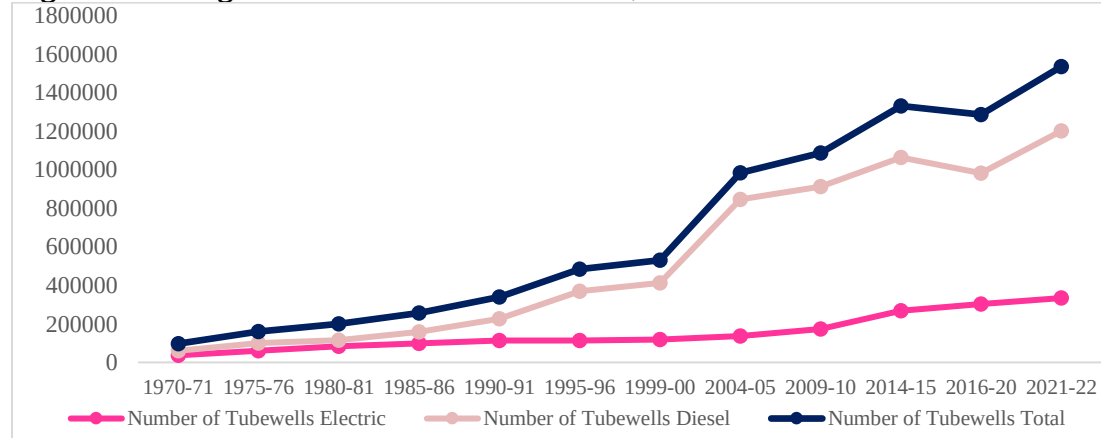
Figure 4. Sources of Groundwater in Pakistan



Source: Lytton, Lucy; Ali, Akthar; Garthwaite, Bill; Punthakey, Jehangir F.; Saeed, Basharat. (2021). Groundwater in Pakistan's Indus Basin: Present and Future Prospects, World Bank.

Groundwater resources were put under significant stress during the prolonged drought in Punjab and Sindh from 1999-2002 and in Balochistan (1998 to 2002 and 2009 to 2017). Estimates indicate that around 60,000 additional tubewells were installed in Sindh and Punjab during this period to counter the shortages from the canal supplies (Masood, et al., 2021). Total number of tubewells has increased by 1481 percent from 1970-71 to 2021-22, while electric tubewells increased by 805 percent and diesel tubewells by 1894 percent during the same period. 80 percent of the total tubewells are in Punjab (Figure 5). In Balochistan, the reliance on groundwater for agriculture increased by 120 percent between 1996 and 2017 (Balochistan Bureau of Statistics 2017) while it remained relatively less for livestock (0.094 bcm) and people (0.091 bcm) or 8.4 percent of the groundwater resource. The rate of groundwater utilization in three major basins (Pishin-Lora, Nari, and Zhob Rivers) is high, which could lead to severe depletion because of rapid growth of electric and solar tubewells with their low marginal cost of pumping (Ahmad, 2018).

Figure 5. Changes in the number of tubewells, Pakistan



Source: Agricultural Statistics of Pakistan 2021-22

Unsustainable groundwater extraction in the absence of appropriate and sustainable management mechanism poses a serious threat to country's water security (Laghari et al. 2012; Watto and Mugera 2016; Briscoe et al. 2005; Young et al., 2019). This results in lowering water tables, compelling people to install turbines for extracting groundwater for their needs. As they go deep, people start mining the aquifer, especially in Balochistan in the absence of any institutional arrangements to govern the groundwater.

In addition to falling water tables in many parts of Pakistan, water quality has deteriorated substantially. In some areas this is attributable to agriculture: over-application of irrigation water and lack of drainage facilities causing waterlogging and salinization, as irrigation adds around 16 million tons of salt to the Indus basin every year. Water logging and salinization threatening soil health and reducing agricultural production in up to 43 percent of the irrigated area. Chemical contamination, generally caused by pesticides, has been reported in groundwater in all provinces. Tahir and Rashid (2008) reported the highest percentage of nitrate contamination in water samples collected from Punjab and Balochistan provinces, with higher nitrate levels in water collected from groundwater sources such as hand pumps and wells. Other chemical contaminations include arsenic, fluoride, chlorides, and iron, which are naturally occurring in the aquifers (Kumar, et al., 2023). It is estimated that 50–60 million people in the Indus Basin use groundwater that has high levels of arsenic (Guglielmi, 2017). Van Geen et al., (2019) found the highest concentration of arsenic in groundwater in districts of Kasur, Lahore, Multan, Sheikhupura, GI Khan, Mianwali, and Vehari of Punjab. Arsenic exposure leads to severe health repercussions by causing skin, lung and urinary bladder cancers, as well as cardiovascular disease (Cardoso et al., 2020), and neurological disorders, gastrointestinal disturbances, liver and renal disease, reproductive health effects, dermal changes and other health disorders (Jomova et al., 2010). Fecal contamination of water resources is endemic due to poor water quality, sanitation, and hygiene (WASH) services. Because domestic water supplies in both urban and rural areas depend on groundwater, deteriorating groundwater quality is leading to a dramatic increase in waterborne diseases (Qamar

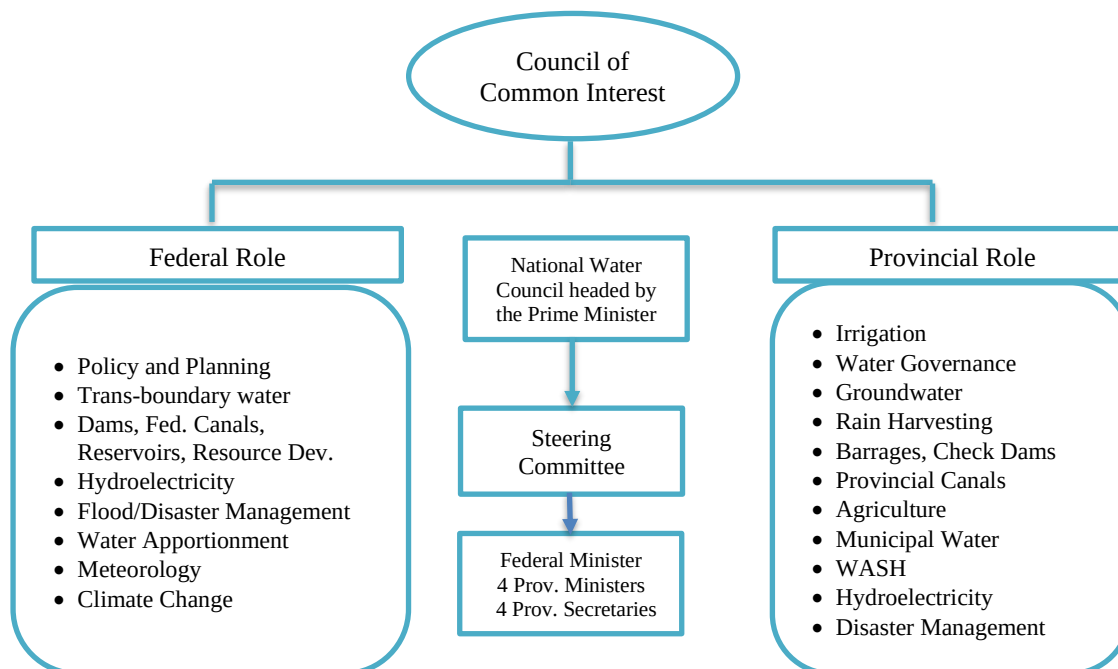
et al., 2022), including diarrhea, cholera, dysentery, typhoid, and polio. Over a decade ago, Tahir, Rasheed, and Imran (2010) estimated that diseases associated with water contamination in Pakistan lead to national income losses of PKR 25 billion to 28 billion annually, approximately 0.6 to 1.44 percent of the country's gross domestic product (GDP).

The depletion of groundwater quantity and quality therefore have serious repercussions for not only the sustainability of agriculture but also human health in Pakistan. Responding to these challenges necessitate effective management and governance of the groundwater, including reducing water extraction and developing a recharging system in the country.

Existing Water Governance

Governance and institutional framework for water management is complex. The 18th Constitutional Amendment in 2010 devolving water and agriculture to the provinces added to this complexity. Functional division of water sector between the federal and provincial governments is shown in Figure 6. Development and maintenance of IBIS is jointly handled by the federal government (dams, water reservoirs, hydropower, enforcement of water apportionment, Indus Water Treaty, and floods) and provincial governments (barrages, canals, water courses and water management for farming and other uses).

Figure 6. Functional distribution of water management, Pakistan

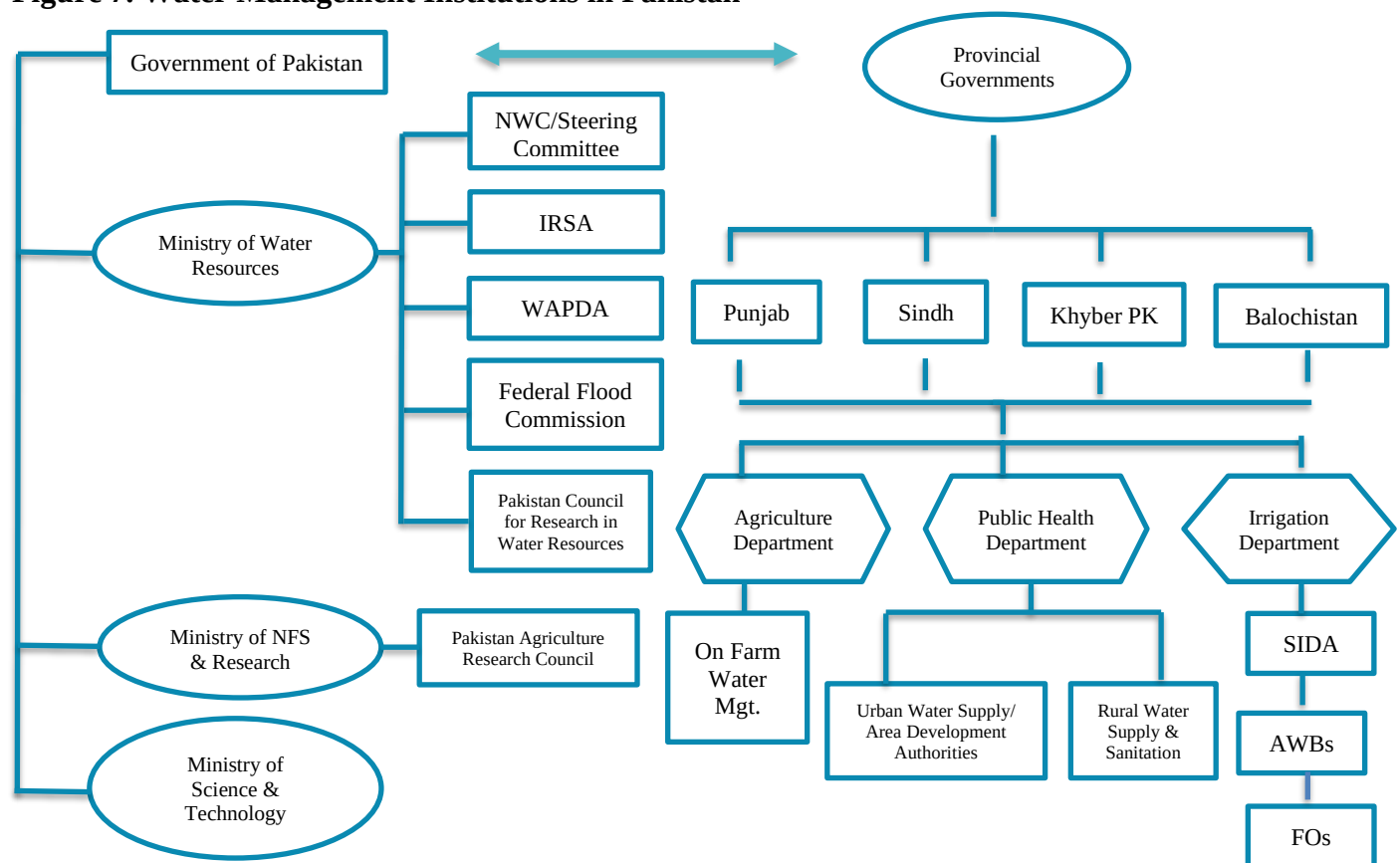


Source: Authors' Compilation

Pakistan has multiple federal and provincial legislations to govern water resources. However, the Canal and Drainage Act, 1873, is the most critical. It confers considerable administrative and judicial authority to the provincial Irrigation Department officials with little or no public accountability. At the same time, the law also recognizes the notion of public input into administration of the irrigation system meant to assist the government in policing and maintaining order in water use. All the provinces except Sindh have abolished the Provincial Irrigation and Drainage Authority (PIDA), substituting provincial Irrigation departments in 1997 and have reverted to traditional governance structures. The institutional structures at federal and provincial levels to manage and govern the water resources are in Figure 7.

Groundwater remained unpriced and unregulated in the country. Considering the emerging challenges and depleting groundwater, Punjab and Khyber Pakhtunkhwa have enacted water laws in 2019 and 2020 respectively to regulate groundwater. However, these laws still need to be operationalized and enforced effectively. Sindh is in the process of enacting a law for integrated water resource management while Balochistan is continuing with the 1978 law to regulate groundwater.

Figure 7. Water Management Institutions in Pakistan



Source: Authors' compilation

As discussed above, the reliance on groundwater for agriculture has increased substantially because of uncertainty about surface water flows and extreme weather events, which is resulting in lowering water tables and exacerbating water quality problems. The current formal governance structures are inadequate to address these challenges. The remainder of this paper addresses the scope for creating a more effective groundwater management, governance system, and water conservation and efficiency that involves local communities as well as government entities in participatory decision making.

CHARACTERISTICS OF THE STUDY SITES

Pishin-Hard Rock Area, Balochistan

Balochistan is the largest of Pakistan's four provinces in land area (347,190 km²). A provincial plateau characterized by a predominantly hilly surface. Balochistan's four unique geographic zones include: the upper high lands, lower high lands, plains, and deserts (Government of Balochistan, 2023).⁵ Each region has its unique climate, water supply, and agricultural practices. Farmers need access to water for irrigation, especially during the warmer and drier summer months (April to October). Irrigation systems are essential for agriculture due to very high evaporation rates.⁶ Out of 1,367 Mouzas with reported water depth of more than 500 feet in Pakistan, 964 are from Balochistan (Pakistan Bureau of Statistics, 2020).⁷ The average annual rainfall varies from less than 50 mm in the southwest to about 400 mm in the northeast of Balochistan.⁸

Pishin, a hard rock area, is located north of Balochistan's provincial capital, Quetta, and shares borders with Afghanistan, Killa Saifullah, Killa Abdullah, Quetta and Ziarat. The district has a land area of 6, 218 km² and lies in an arid region characterized by low rainfall and extremely high evaporation. It has a series of valleys with ground elevation ranging from 1,370 and 1,680 meters above Mean Sea Level, enclosed by Toba Kakar Range to the north. Pishin district has a population of 835,482 (2023 Census) 51.65 percent of which are male and 48.34 percent female. The share of the rural population is 80.62 percent. Rabi crops include wheat, barley, cumin, vegetables, and animal feed crops while during Kharif, fruits, melons, vegetables, potatoes, animal feed, onions and tobacco are grown. The principal crops are wheat, barley, potatoes, grapes, apples, apricots, and peaches.

The Pakhtoon code of Jirga, Pashtunwali, is applied in the district. The local Jirga mediate and resolve the local conflicts. In case of murder, people either go to the courts or families or tribes opt for outside court settlement after '*badal*' (revenge). There are strong religious and cultural ties among the local tribes where religion plays a dominant role.

Water resource management in Pishin considers competing demands on water: (a) drinking and domestic needs; (b) food production (agriculture, livestock); (c) economic infrastructure development and use; (d) conservation for periods of drought; (e) conservation for future generations; and (f) natural habitats. Of the 14 basins in the provinces, the Pishin-Loralai Basin is

⁵ Available at: <https://balochistan.gov.pk/explore-balochistan/about-balochistan/>

⁶ The World Bank. (2014). Small Scale Irrigation: Large Scale Benefits for Balochistan. Available at: <https://www.worldbank.org/en/news/feature/2014/06/16/pakistan-small-scale-irrigation-large-scale-benefits-for-balochistan>

⁷ Pakistan Bureau of Statistics. (2020). Balochistan Mouza Census. Ministry of Planning, Development & Special Initiatives. Agricultural Census Wing. https://www.pbs.gov.pk/sites/default/files/agriculture/publications/mouza_census_2020/mouza_census_2020_balochistan_report.pdf

⁸ The World Bank. (2014). Small Scale Irrigation: Large Scale Benefits for Balochistan. Available at: <https://www.worldbank.org/en/news/feature/2014/06/16/pakistan-small-scale-irrigation-large-scale-benefits-for-balochistan>

the most stressed due to unsustainable groundwater exploitation. The principal stream is the Pishin Lora, flowing from Barshore in the northeast into the Shorarud valley near Burj Aziz Khan. Its principal effluents in Pishin are the Muchka from the northwest, the Shorarud and the Kakar Lora. The Pishin Lora flows up to Bund Khushdil Khan and some of the water finds its way towards the north. From there it flows into Afghanistan. Another stream, the Surkhab Lora, flows from Sher Ghundi and it joins the Pishin Lora near Shadizai. A third stream is the Kakar Lora, which is composed of many small rivers and streams coming from the Takatu hills. The Kakar Lora irrigates Manzaki and three villages in Haiderzai. Most parts of Pishin district drain into Pishin Loralai at different locations. The basin is a transboundary watercourse as it leaves Pishin district to enter Afghanistan and again enters Pakistan in Noshki district, to end up at the Zangi Nawar lake.⁹

Karezs are community owned and governed. In Balochi area (Central and South Balochistan), most *karezes* are multitribal. Not only different tribes but also different social groups are allowed to have share in the *karez*. The exceptions are the few *karezes* owned by an individual or a tribe. The number of shareholders in *karezes* differ from one region to another. In Southern Balochistan, the average number of shareholders in a *karez* is 29. In Central Balochistan, it is 144 and in Northern Balochistan, 72. In general, the larger the command area, the greater the number of shareholders but there are many exceptions (Khan and Nawaz, 1995). However, pumping groundwater through tubewells remains the same across different ethnic groups. As tubewells are owned by individuals, the right to tap the groundwater also belongs to the tubewell owner. If multiple individuals contribute to the installation of a tubewell, water is shared among all depending on their investment share. Selling of water rights is also practiced among these tribes and the water charges vary from place to place, according to the crops and irrigation requirements.

Water scarcity is an emerging issue. The Lora River is an important source of water, and its tributaries flow through the district which serve as pathways for water during storms and flash floods. Band Khushdil Khan is one of the largest dams in the Pishin district, which also has several smaller delay action dams.¹⁰ These dams rely on precipitation for replenishment. Agricultural activities depend on groundwater, extracted primarily through tubewells. There are 4,373 tubewells in Pishin (private: 4181; public 192). Out of the 4181 private tubewells, 3,147 tubewells are electric, 1,015 are diesel, and 19 are powered through solar energy.¹¹ Over-pumping due to an increased number of tubewells has resulted in depletion of freshwater resources and lowering of water tables at the rate of 3 meters per year (Ashraf 2018).

The labor force participation rate in Pishin is 35.7 percent (60.7 percent for males and 7.1 percent for females). Although labor force participation is very low among women, of those women who

⁹ Pishin District Government (2011). Pishin - Integrated District Development Vision. IUCN Pakistan, Quetta, Pakistan

¹⁰ Any barriers, fill or structure that does or may impound water aiming at recharge of the groundwater surrounding and/or downstream of the dam through the dam and reservoir foundation, and/or recharge devices, e.g. infiltration pond, injection wells or natural river bed, alluvial fan, as well.

¹¹ Agriculture Statistics of Balochistan, 2020

are employed, 36.8 percent are in agriculture related activities compared to 18.9 percent of men (Table 1). The literacy rate is 66.9 percent, 85.6 percent for males and 45.6 for females.

Table 1. Sector Wise distribution of employed labour in Pishin

Sector	Total	Male	Female
Working age population	477,000	254,000	223,000
Labour Force	170,400	154,500	15,900
Employed	168,700	152,900	15,900
Agriculture (%)	20.6	18.9	36.8
Industry (%)	16.8	17.2	13.3
Services (%)	62.6	64.0	49.9

Source: Labour Force Survey 2020-21

Rahim Yar Khan-Alluvial Area, Punjab

Rahim Yar Khan (RYK) is the southern district of the province of Punjab, Pakistan and one of the largest crop-producing districts of Punjab. Additionally, a sound industrial base is developing in the district. The main factories include cooking oil, detergents, textile, poultry feed mills, marble, ginning, flour mills, sugar mills, auto industry, and fertilizer manufacturing. Sadiqabad is the 9th largest city of Pakistan in terms of population, with a population of 4.8 million. The district covers 11,880 square kilometers which is divided by three main physical features: i.e., riverside area adjacent to the Indus River, canal-irrigated area, and desert area called Cholistan. The average rainfall is about 100 millimeters.¹² It produces wheat, cotton, rice, and sugarcane, fruits, and vegetables.

The district has been selected for this study because of its key characteristics of being an alluvial area facing severe water crisis and its groundwater situation. The approved surface water supply of 15,000 cusecs to Head Banjand and the Shashmahi streams annually has decreased to 5,500 cusecs (Sindhu, 2018). Due to this shortage, 48 small and large streams have been closed (Sindhu, 2018). Water scarcity has negatively impacted many crops such as cotton, sugarcane, rice and fodder crops. Due to limited access to surface water in RYK, farmers are highly dependent on groundwater for irrigation (Sindhu 2018) through 37,882 tubewells including 2,2694 electric tubewells while the remaining are diesel based.¹³ Mistry et al. (2019) report that the amount of groundwater stored in RYK district is decreasing at the rate of 0.51 mm per month, resulting in a total loss of 1.38 km³ in 13 years. Aamer and Sabir (2014) found out that the increased abstraction of groundwater reserves has led to a decline in the depth of water table and increasing saline water.

¹²Government of the Punjab. District Rahim Yar Khan. Available at: <https://rykhan.punjab.gov.pk/climate#:~:text=The%20climate%20of%20the%20Rahim,Precipitation%20here%20averages%20101%20mm.>

¹³ Punjab Development Statistics. 2022. Bureau of Statistics. Planning and Development Board. Government of the Punjab. Available at: <https://bos.punjab.gov.pk/system/files/PDS%202022.pdf>

They also concluded that most of the groundwater samples collected around RYK were not suitable for irrigation purposes and were hazardous. Almost 70 percent of the agriculture land is affected by saline groundwater which is damaging to the crops.

The labor force participation rate in RYK is 53 percent (70.1 percent for males and 35.7 percent for females). Among the recognized labor force, the percentage of women working in agriculture related activities is more than doubled compared to men (Table 2) and there are more women than men engaged in agriculture. The literacy rate is 50 percent, 60.2 percent for males and 39.7 for females.

Table 2. Sector Wise distribution of employed labour

Sector	Total	Male	Female
Working age population	3,639,000	1,831,000	1,807,000
Labour Force	1,929,100	1,283,200	645,900
Employed	1,868,400	1,235,600	632,800
Agriculture (%)	54.0	38.3	84.6
Industry (%)	19.7	26.5	6.4
Services (%)	26.3	35.1	9.0

Source: Labour Force Survey 2020-21

METHODOLOGY

The methodology used for this qualitative study included focus group discussions (FGDs) and key informant interviews (KIIs). The pre-tests and FGDs were conducted through collaborators selected in a competitive process while the KIIs were conducted by the IFPRI-Pakistan office. The study fully complied with IFPRI's protocols and obtained Ethics Review from IFPRI Institutional Review Board.

Multi-stage sampling technique was employed to select participants for focus group discussions in each district. First, the districts of RYK in Punjab and Pishin in Balochistan were purposefully sampled based on the current groundwater situation and usage in the region. Second, all the four tehsils (sub-districts) were selected in RYK while four tehsils were randomly selected in Pishin. Third, villages were randomly selected in each tehsil (see list of tehsils and villages in Annexure 1). Fourth, participants were recruited through snowball sampling methods in each village. The collaborators¹⁴ in each district circulated information among the community for FGDs. The collaborators supported in identifying participants for FGDs.

The qualifying criteria for the FGDs were that the participant must be a groundwater user for carrying out domestic and/or agricultural activity. A total of 78 participants (38 male groundwater users and 40 female groundwater users) in RYK district, and 90 participants (40 male groundwater users and 50 female groundwater users) in Pishin district were recruited for conducting FGDs. Eight FGDs were conducted in RYK and 10 in Pishin, equally divided between men's groups and women's groups. Each FGD was conducted at a central location in the selected village. All the participants were asked for formal consent and were informed of their rights before proceeding with the discussions. All the participants were provided with a transportation stipend to compensate them for their time and travel cost. A structured questionnaire (Annex-2) was used to steer focus group discussions covering information along three basic themes: (i) groundwater use, quality and quantity, (ii) support mechanisms and legislation on groundwater management, and (iii) impact of floods on the community. The discussions were conducted in the local languages. The discussions were recorded and were transcribed by the collaborators in English, which were later coded for conducting a thematic analysis. The characteristics of the participants in Pishin district and RYK district are at Annexure 3 and 4 respectively). The lead author attended one of the FGDs of Pishin District in Quetta.

For conducting KII, a total of 17 male experts from groundwater management and governance were purposively selected to represent a range of institutions at the federal, provincial and district level (see list of informants in Annexure 5). They included 2 policy level informants from the federal government, 2 policy level from the provincial governments of Punjab and Balochistan, 2 from the On-Farm Water Management Department of Punjab and Balochistan, 4 operational/field

¹⁴ From Khwaja Fareed University of Engineering and Information Technology (Rahim Yar Khan) and Balochistan University of Information Technology, Engineering and Management Sciences (Quetta) supported in identifying participants for FGDs.

level officers in Pishin and RYK, 5 from research organizations engaged in quantitative and qualitative research on water, and 2 from international organization. The interviews were conducted both in-person and virtually. The interviews were guided using a structured questionnaire comprising sections on three specific areas (Annexure 6): (i) administration of groundwater in Pakistan, (ii) groundwater uses, monitoring and capacity building, and (iii) changes for the future. All consented orally for interview. The interviews were conducted in both English and Urdu and were later transcribed in English by the authors for conducting analysis. Transcripts of interviews were manually coded by authors and themes were identified for the purpose of the analysis. In cases where interviews were not recorded, detailed notes were taken throughout the interview to support the analysis.

COMMUNITY LIVELIHOODS AND WATER MANAGEMENT

This section presents an overview of the communities' situations in terms of irrigation and water access challenges, quality, and the impact of the 2022 floods on the case study sites, from the communities' perspective.

Main activities of the communities

In Pishin, the villagers generally live in a joint family system and male elders often make most of the decisions because it is believed that they have more experience and knowledge *“even if the father is bed-ridden, he commands. The other men in the household only follow his orders.”* Table 3 provides the general division of labor by gender in the two study districts.

The households rely on agriculture, mostly wheat, fruits, vegetables and livestock in Pishin. The male participants informed that *“there is no industry in Pishin, so we mainly rely on agriculture. We cultivate vegetables and wheat, and most of the farmers have a cow in their houses.”* Wheat produce is partially retained as reserve for the family to ensure food security until next harvest while the surplus is sold in the market. Most farmers still employ traditional method of flood irrigation for cultivation and therefore their income is low-- *“We use old methods for cultivation, which is why I think we do not get sufficient income from our farming business and 80 percent of the farmers are in debt. Flood irrigation method leads to huge water losses. We still cultivate grapes and apples by adopting old methods used by Afghans. They used flood irrigation as they have rivers in their areas.”* Some of the farmers have adopted a drip irrigation system, tunnel farming and have moved to growing crops that are not water intensive. *“With drip irrigation, if not for the complete season, at least for half the season, only one tanker of water is enough”.* But farmers want financial assistance to deal with the costs of these technologies to increase water use efficiency: *“we cultivate tomatoes, okra and cucumber. We fill small ponds and water the whole crop through drip irrigation. We need more resources for this... the government should help.”* Another male participant explained that *“I have learned the tunnel farming technique...it saves both water and fertilizer. These machines are expensive, we can buy them only if a subsidy is provided.”*

Commerce related activities rank second for income generation. Some participants underlined that *“we need more sources of income other than farming. To make ends meet, our sons work as waiters in hotels. I would say that only 20 percent of the farmers live in a somewhat better financial condition.”* A small percentage of the population is employed in public organizations. Commercial activities generally include transportation, trade, and running micro-enterprises. Many individuals have relocated and established tea stalls in cities like Karachi, Lahore, and Islamabad. One male participant informed that *“the city of Karachi is our business hub...if you find a tea hotel, let me tell you, someone from Pishin must be running it. We serve the best tea there”.* Some are employed in local industry comprising flour mills, tobacco, reinforced cement concrete and ice factories.

There is now increasing trend to send male children to educational institutions either in Pishin or Quetta or Sindh and Punjab. Nevertheless, the participants also pointed out the absence of an enabling environment and support system for pursuing productive endeavors. Elaborating on this one said that *“there are no technical training centers in Pishin. We send our sons to Punjab and Sindh to get training in technical skills”*.

In RYK, income in the community is mainly derived from agriculture and livestock farming, followed by industry. The participants explained that most of the people in the area are employed in agriculture and perform activities such as tillage operations, mechanical seed placement, application of fertilizers, crop irrigation, spraying and harvesting. In addition, many are involved in cattle farming, dairy farming, and poultry. Men are also employed in the government organizations and private sector industry, particularly fertilizer company, sugar factory, gas sector, commission agents in grain market, and private sector. Young men pursue higher education either in the country or abroad depending upon the financial ability of their families. One participant noted that *“young men are also employed in technical jobs such as welding. Some young boys are unable to continue their education because of low family income and rising inflation. People are trying to set up part-time businesses. One participant shared that “you cannot meet your expenses with only one job these days. I have four sons, two are working in Karachi and two support me in agriculture activities. Others have started breeding hens and have established dairy farms to earn extra money.”*

Women in Pishin are primarily responsible for taking care of the household chores including cooking meals for family members, care of domesticated animals such as cows, goats, and poultry, water storage in the tank located inside the house, and kitchen gardening. A female participant pointed out that *“Only men earn in Pishin... women are not allowed to engage in income generating activities.”* A few women are engaged in kitchen gardening and have knowledge of basic irrigation practices. However, they reported that because of the water shortage, they cannot do kitchen gardening anymore. The role of women in the decision-making process at the household as well as at the community level is marginal in social and economic activities in Pishin. One male participant explained that *“women are not allowed to work in the fields, nor they have leased or owned land. We do not give these responsibilities to women.”* A male participant informed that *“women work in the fields along with men in Killa Saifullah and Zhob”*, neighboring districts.

Young girls are now getting education and assist the older women with chores at home. As explained by a male participant, *“most union councils do not have schools. So, they go to the nearest schools and colleges in Pishin. In Barshore area, most of the young girls are getting education.”* A female participant noted that *“educated women are employed as a government teacher or give private tuition.”* A participant underlined that *“In rich families, people have the income to take care of girl’s education. In poorer families, we do not have the money to pay for educational expenses, so our girls take care of the livestock. However, the awareness of the*

importance of education is increasing". Most of the young women, however, get married at a younger age and do not get the chance to pursue a higher education. Some of the young women are also engaged in handicrafts. As pointed out by a male participant, *"there are handicrafts centers for girls in Pishin, girls from Muslim Bagh come there and learn skills. Those girls who completed the session were given certificates, sewing machines, and irons"*.

In RYK, women are engaged in land cultivation, sowing, picking and harvesting, animal rearing, kitchen gardening, poultry, sewing and embroidery work along with other household chores. One male participant shared that *"there is no difference in the villages and cities these days. Young women are getting education, they also learn sewing and embroidery and take care of the household chores. Those who have lesser resources still try and manage to get their daughters educated till matriculation"*. The participants highlighted that now women are getting into private and government jobs, some women also work in banks. Some females work as house maids in the village and at large farms where they perform various activities such as hoeing, harvesting, loading and unloading of the crops for storage and marketing. Generally, they get grains for domestic consumption, feedstock for their animals, and maize during harvesting. Some women make ghee and yogurt at home and sell it out in the market. One female participant of noted that *"we also raise chickens and sell their eggs in the market, rear cattle and sell their milk"*; another noted that *"women also earn income through cotton picking, weaving, wheat harvesting, fodder cutting and animal feeding"*. Women have also recently started kitchen gardening to ensure food supply at home and to earn additional income. A female participant shared that *"a rural education institute has made a committee group in which we deposit our money for saving. After receiving our savings from the committee group, we have started kitchen gardening, which helps us in earning extra income"*. The female participants however reported that each member of the household is considered responsible for taking part in income generating activities including men, women, children and elders.

Table 3. Division of labour by gender in agriculture and livestock sector

	Exclusively Men	Exclusively Women	Shared Tasks
Pishin	All agriculture related activities Extracting and storing groundwater for agriculture Breeding and slaughtering animals Marketing agriculture produce and livestock Purchasing transportation Field Grazing	Household activities including cooking meals and cleaning Storing water for household use Kitchen gardening Milking and feeding Processing by-products Fodder management Caring of livestock Poultry rearing Hand suckling of young	Fodder Collection

	Commerce, commercial and transportation activities		
Rahim Yar Khan	All agriculture and livestock including tillage operations, mechanical seed placement, application of fertilizers, crop irrigation, spraying and harvesting Cattle, dairy, and poultry farming Commerce, commercial and transportation activities Jobs in the private sector	Household activities Kitchen gardening Cotton picking Weaving Animal feeding Domestic poultry Sewing and embroidery Jobs in government and private sector organizations	Land cultivation Wheat harvesting Fodder cutting

Source: Authors illustration based on FGDs

Impact of floods 2022

The floods in 2022 are a grave reminder of the challenges that climate change can bring. Participants in Pishin shared that the torrential rains during July-August 2022 severely affected the people of Pishin: *“we have never seen floods at this scale in our lives, the floods have affected our agricultural production and animal population, and amid the flooding, we had no choice but to migrate to the higher land to save our lives”*. They reported that the infrastructure was vastly damaged, educational institutions were closed, and people lost their livestock including goats, sheep and hens. People also lost their agricultural produce: *“we lost our whole produce, the only source of our income due to heavy rains. The protective walls that we had made around our produce were washed away. The whole family is facing hardship”*. The heavy rains also destroyed most of the grape orchards: *“the produce of my garden was destroyed; I could not even get ten cartons to sell and earn income. Those families who had a side business had some income coming in but for others everything is lost; we had a spillway from old times...the flood destroyed the wall of the spillway. We went on social media to request the authorities to re-build the spillway...but nothing has been done”*.

Farmers also noted that the level of the groundwater has risen a few feet after heavy rains and flooding in 2022 which led to water seepage into their tubewells and caused the machinery to malfunction; *“tubewells...and solar systems of many landowners have been destroyed.”* It was further noted that there are *“no regulations, coping strategies, or preventative measures in place to mitigate such flood. Normally, the level of precipitation is low in the region, so the residents were not prepared to deal with such a situation, the district administration was also underequipped; and the people had made houses and gardens in the water passages during prolonged drought in Balochistan for livelihood.”* People are attempting to repair their homes on their own in flood affected areas without any help from the government or non-governmental

organizations: *“No one was there to protect us...you know we had to leave our village at 3 a.m. in the morning; we need funds for restoration and repair work. We need plastic bags to store our produce. The meteorological department did not even warn us about the flood...so that we could have done something to protect ourselves”*.

Similarly, heavy rains in 2022 led to major losses in RYK. Crops were destroyed in several areas, and the health of livestock was seriously compromised. Since agriculture is the main employment sector in the area, this damage translated into loss of jobs and income for many. People had not expected such heavy rainfall and were not prepared at all to deal with the situation. They pointed out that in situations like these, the Meteorological Department should inform the community beforehand. There were no government or private authorities in the area which could support the affected individuals. People were trying to recover their losses on their own, taking loans and selling their animals. One positive outcome of the flood was that the level of the water table increased. The surface water availability has also improved: *“we tried to cope by planting crop varieties that can tolerate excess water.”* The participants were of the view that the government should support the people to help them in reconstructing their houses. They demanded subsidies on agricultural inputs such as fuel, electricity, new seed varieties, and the latest machinery that would withstand harsh weather conditions. They also expressed that *“development projects should be launched by the government that could generate jobs for the community. The government should take the initiative to educate women farmers on advanced agricultural techniques and livestock practices.”* Kitchen gardening is an important source of income and food security for the local households, and improved skills in this regard could help the women in ensuring a steady source of income and food supply at home. They were of the view that technical and vocational training institutes should be set up by the government.

Main sources of water

Groundwater is the only source of water used for domestic and agricultural activities in Pishin. It is mainly extracted through tubewells. Previously *karez*es and wells have been the main conduits for water extraction. Currently, there are only a few *karez*es that flow during the rainy season. The *karez*es have dried-up due to several factors including long spans of droughts during late 1990s and 2000s, heavy extraction of groundwater through proliferation of tubewells, and absence of recharge system in the province. The demand is highest during the summer months of May through September due to intense heat and higher water usage in the fields and domestic level. However, this demand for water declines during winter partially because of low agricultural activities and partially due to rainfall providing additional water.

In RYK, groundwater and canal water are the main sources of water in the district. Groundwater is needed all year round for agriculture, livestock and for other domestic activities. Participants highlighted that groundwater is mixed with surface water for crop irrigation. Water requirements

increase during the summer season from April to October. Summer crops such as sugar cane and maize also need water in high quantities. Participants agreed that overall, more water is used for irrigation purposes compared to domestic, industrial and commercial uses in RYK. It was further noted that *“when groundwater availability is low, farmers shift to cultivating short duration crops such as pulses, cereal crops and vegetables to ensure that water remains available for domestic chores. Sometimes, they opt for livestock farming only”*. Another participant added that *“in my opinion, water usage has decreased per acre due to adoption of techniques such as laser land levelling and bed and furrow techniques. People are now aware of the concept and importance of water conservation”*.

Men extract water mainly for agricultural activities. Women use groundwater for domestic purposes such as cooking, cleaning, and caring for animals in Pishin. In RYK, a greater proportion of groundwater is used in the agriculture sector for irrigation purposes. Water is also required in automobile washing, seed and pesticide companies and other small businesses.

Modes of groundwater extraction

Water extraction methods have evolved during the last 5-10 years as the communities' knowledge about technological advances increased. New technologies have made groundwater extraction easier.

Farmers are aware of different methods of extracting groundwater in Pishin. Most of them use electric tubewells, which are preferred over diesel tubewells. *“Since farmers get electricity for 6 hours only, to maximize water extraction, some of them have also installed more than one tubewell”*. The government has also provided various incentives to encourage installation of tubewells to extract groundwater for agriculture. A participant shared that *“we get a fixed bill of electricity at a flat rate of PKR 6,000 per month. The remaining balance is subsidized by the federal and provincial governments, but electricity is available for only 15 days a month”*. Almost all the respondents complained about the long hours of electricity load shedding. To deal with the electricity load-shedding, transition towards solar tubewells is increasing. A participant highlighted that *“at many places, large landholders have installed both solar and electricity tubewells. They run the solar pump from early morning till 3:00 p.m. in the afternoon and after that they run the electricity tubewells. Solar pumps are better than electric tubewells because we only have electricity for 6 hours. Also, when it comes to electricity, there are problems of voltage, which causes circuit breaking and issues with the fuse. Farmers have also gotten electric shocks and lost their lives while dealing with electricity problems. Diesel is expensive.... I would say that a solar powered tubewell saves you a lot of money, it is a one-time expense”*. The participants observe that *“submersible machines of 40-50 HP have gradually taken the place of traditional suction pumps as they are considered superior in extracting water from increasing depth which is further depleting the groundwater.”*

The respondents in Pishin also shared that only a few public or communal tubewells have been installed in their area by the government to extract water for domestic use. A participant explained that *“previously, we had to go in the dark to get water from the karez... now it’s easy... our tubewells are set in automatic mode...as soon as we get the electricity, the tubewells start running within 3-4 minutes”*. However, the water supply from government installed tube-wells is not sufficient as *“the tubewells installed by the government have dried up”*.

In RYK, the groundwater is extracted through a variety of modes such as hand pumps, jet pumps, horsepower (HP) motors, diesel, electric and solar pumps, tubewells and turbines. Most of the centrifugal pumps used for extracting groundwater are single stage shaft pumps. A participant explained that *“over the years, the old methods of extraction such as wells have been replaced by tubewells. There is a shift towards deep well turbines and submersible pumps in the areas causing a decline in water table. Tractor tubewells do not work anymore. The use of handpumps has also declined”*. For agricultural purposes, *“we use turbines, HP pumps or generator operated motors for domestic purposes”*. There has been a shift from diesel or electric pumps to solar powered pumps. Participants had mixed views regarding the usage of diesel pumps; some believed that diesel-powered pumps (shaft coupled) are a good option as they require less capital to operate and can be used consistently to extract water as per the requirement, while some believed otherwise. A male participant explained that *“in my opinion, the best option is solar tubewells because the operational cost is very low. The price of electricity is very high...we pay PKR 60,000-70,000 per month in electricity bills when we use an electric tubewell. With increasing electricity tariffs for agriculture purposes, there have been cases of theft by breaking meters or taking a direct line”*.

In the tehsils of Khanpur, Rahim Yar Khan and Liaquatpur, farmers rely on diesel tubewells because of load shedding. In tehsil Sadiqabad, most farmers are using HP pump and hand pump, as water extraction is easier and quick through these methods. Hand pump is easier to use because it does not require electricity to function and is not expensive. Only large farmers with their landholding of 25 acres and above have installed private tubewells.

When asked about the cost of installing tubewells for groundwater extraction, respondents in Pishin informed that since water tables have been declining at a rapid pace, they are left with no choice but to dig deeper wells. The findings revealed that the average cost of installing a tubewell ranges between PKR 1.2 million to 7 million depending upon the depth of the water table. In areas where the water table is around 300 to 350 feet, the cost of installing a tubewell is around PKR 3 million whereas in areas where the water table is 700 feet deep, the installation cost is around PKR 7 million. A participant added that *“the operational cost however does not vary...We get a fixed bill of electricity.... monthly bill is PKR 6,000. The bill is on a flat rate and is subsidized but electricity is available for only 15 days a month”*. The participants believed that *“solar tubewells are more effective but initial capital investment is high. However, a participant added that “solar tubewells are better, because it is one-time cost and there are no bills after that. We also have an advantage...there is always sunlight during the daytime.”* Another participant added that *“it is*

very difficult for the small farmers to get solar panels installed....it costs around PKR 4.5 million to install solar panels while the annual income of a small farmer is between PKR 0.3-0.5 million.

The tubewell installation costs reported in RYK were relatively lower, averaging installation cost of PKR 0.2 – 0.6 million, depending on the size of the tubewell and depth of the water table. The participants highlighted that both diesel and electric tubewells have high operational costs. Electric pumps have an installation cost of PKR 1 -1.5 million, but the operational cost is high as they pay PKR 60,000 -70,000 per month in electricity bills. The average installation cost for a diesel tubewell is approximately PKR 0.25 to 0.3 million with an operational cost of approximately PKR 500 per hour. All the participants were of the view that electricity operated tubewells and motors are better than diesel powered tubewells. The farmers feel that given the high electricity loadshedding, electric pumps are no longer a feasible option. They consider solar-powered pumps as the best option as they have little to no operational cost, but their high installation cost (PKR 2 -2.5 million) acts as a barrier for small farmers. A participant added that *“our expenses related to water extraction have gone up because the water level has declined.”*

Access to groundwater

Participants in Pishin had mixed views about the accessibility of groundwater. One set of participants reported that small farmers do not have equal access to groundwater, as only wealthy farmers can afford to install tubewells. Small farmers mostly purchase water from large farmers on need basis, particularly in the case of wheat. The participants shared that most of the *“people in the area have drinking water but do not have sufficient water for irrigation purposes.”* They informed that the houses having electricity or solar run tubewells have more water supply and face water shortage when either the water table falls substantially or the well dries up. Most of the tubewells that were installed 5 years ago have dried up. A participant noted that *“if a small farmer wants to install a tubewell, he makes a contract with the landlord where the landlord initially bears the cost and installs the tubewell. Under the contract, the small farmer does not make a full payment to the landlord but starts making payments in annual installments.”* Another participant described a different arrangement: *“If a farmer owns only one acre of land while others have 20 acres of land, then the one who owns smaller land will enter into agreement with the big landlord. He will get water from him at the cost per hour basis mutually agreed.”* Another participant pointed out that *“even if a farmer succeeds in arranging money for installing the tubewell, he is unable to bear the maintenance and repair costs”*. Another participant added that *“I think that there are no small farmers anymore... a farmer who does not have his tubewell, in my opinion, cannot be considered a farmer”*. A participant underlined that *“previously farmers who were not in a good financial condition would get free water once a week [from the large farmers]... but this is no longer the case”*. One participant further highlighted that *“a farmer who has installed a tubewell close to his residence, would have no problems in accessing water. Also, when a farmer has a solar system, he has access to sunlight for about 11-12 hours but the one who only has an*

electric tubewell, has access to electricity for only 6 hours. Such disparities lead to unequal access to water.” A female participant shared, “those who have tubewells, have more water available than others... sometimes they do not share water with others...those who do not have their own tubewells depend on government installed tubewells to get water for domestic use”. There were others who reported that in their view everyone has access to groundwater. A participant added that “everyone has equal access to water for domestic use. I have a tubewell in front of our house... all villagers use it. One of my relatives has a solar tubewell, many Afghan refugees take water from there for drinking for themselves as well as for their livestock. In some cases, though the Afghan migrants have to get water from far-off areas”.

RYK showed mixed results. When asked about the access to groundwater, it was reported that in some areas where water table is low, only large farmers can afford to install the tubewells, while in other regions with a relatively higher water table, small farmers have also installed tubewells. The participants shared that *“everyone has access to groundwater and anyone who requires it can extract it. The only obstacle to groundwater extraction is the cost of pump installation. Small farmers use the tubewells of others to extract water. Everyone has installed a hand pump at home and a tubewell is installed for agriculture...so they take water whenever they want. If there is no water, then they can take it from each other. Some people meet their water requirements by installing multiple small water pumps”*. Villagers who can afford installation costs have either installed hand pumps, donkey pumps or tubewells while those who cannot afford to bear the costs travel long distances to fetch water.

Impact of declining or depleting groundwater

During the last 5 to 10 years, while water usage has increased, water availability has decreased. As expressed by the participants that in Pishin, *“during summer, everyone runs tubewells on a daily basis. The water table lowers by 20-30 feet [annually]. We have not had monsoon rains this year (2021) so the water level has not increased by a single foot”*. Another participant added that *“previously, we used to get water at 100 feet, but now the water level has dropped to 500 feet and in some areas to 800 feet”*. In RYK, groundwater is decreasing at the rate of 0.51 mm per month (Mistry et al., 2019). Over abstraction of groundwater has led to decline in the depth of water tables and increase in saline water.

In Pishin, Karezat tehsil, as the name indicates, had a vast system of *karez*es, which supported orchards and other crops. To enhance water supply for irrigation and expand cultivation, this system was subsequently replaced (almost entirely) with tubewells, which caused the *karez*es to dry up as well as depleting the groundwater. Participants underlined that *“water level is going down. Karezes have dried up after the drought and there are no canals or dams in the area in Pishin.”*

Rainfall is the primary source of water replenishment. However, *“there are only a few rain spots in Pishin. We consider four months of winter as the resting period regarding agricultural land. During this period, we do water the land but not much. We close our tubewells to store water for the next 8 months when we need it the most.”* Rainwater generally gets wasted because of non-availability of community level or district wide water storage, pond, or small dams. This is a clear opportunity for potential collective action. Many delay action or check dams¹⁵ built by the Government in the region were destroyed or cracked during floods in 2022 which could have been avoided following international code as to determining the size and quality of safety measures and the risk (threats) factors and proper feasibility study determining the suitability of site selection.¹⁶ The existing man-made lake Bund Khush Dil Khan water reservoir has lost its full capacity due to sedimentation and now serves a small number of settlements. It can be a substantial source of water if it is desilted, and its storage capacity is enhanced to recharge not only the groundwater but also making the *karez*es functional to provide better access to water to the entire district Pishin.

The size of the landholdings of the participant farmers ranged between 5-7 acres (small) to 100 acres (large) in Balochistan. However, declining water availability enables the farmers to cultivate only part of their landholding. This is converting the large landowners into small farmers and small farmers either resorting to labor or migrating to cities. Secondly, many of them are shifting towards less water intensive crops, such as, from apples (water thirsty crop) to water thrifty crops including vegetables, olives, pomegranates, and apricots. One of the farmers pointed out that *“for growing apples, water should be available for 5 months. We were planting ten varieties of apple, but now we are planting only three.... I used to have 1100 apple trees, now I only have 80. We are now moving towards growing vegetables, olives, pomegranates, and apricots that require less water. Talking about grapes, before we were planting three to four varieties but now, we are planting only one.”*

While water usage in the agriculture sector takes precedence over domestic purposes, everyone has access to drinking water in the villages, either through public pump or groundwater extraction or getting water from owner of tubewell free of cost for household use purpose. One FGD respondent reported *“people who used to give water to villagers free of cost for two hours, now give them water for a lesser duration with declining groundwater availability.”*

Quantity and quality of groundwater and health diseases

As highlighted above, the water-table is lowering, and the quality of water is also deteriorating in some areas of Pishin. Due to less water availability, domestic water requirements are primarily met through purchasing water from water tankers. One participant noted that *“since the water*

¹⁵ A structure that may impound water aiming at recharge of the groundwater surrounding and/or downstream of the dam through the recharge devices, e.g. infiltration pond, injection wells, natural river-bed, or alluvial fan.

¹⁶ 103 dams had been severely affected in Balochistan, of which 40 dams completely washed away or cracked (Friday Times, December 28, 2022).

table has declined drastically, we have no option but to buy water tanks¹⁷. Moreover, there is no laboratory in our area for testing water quality.” Another participant explained that *“in the winter season if we call the tanker driver to bring water, we do not have to wait for long. In summer, however, he makes a lot of excuses... there is not enough water. There is a long queue of people, and he brings water after 2-3 days”*. A female participant noted, *“due to non-availability of electricity, water cannot be extracted through tubewells so we have to buy water tanker from outside.”*

The water quality downstream from Bund Khushdil Khan in Pishin is not good and the water is not potable. Pishin district has four to five filtration plants but all of them are not fully functional. So, to purify water, women boil water at home. A participant pointed out that *“the lower the level of water, the worse the quality gets”*. The participants based their assessments of groundwater quality on taste and color. Female participants reported that the groundwater at times has a bitter taste and seems contaminated. As stated by a male participant *“water has such a strong smell...bad smell... it is harmful for our garden and unsuitable for human consumption, domestic use and even the livestock. Our stomach becomes heavy when we drink water”*. The deteriorating water quality in the area is one of the reasons for increasing health issues in the community particularly gastroenterological diseases such as stomachaches, constipation and diarrhea, especially among children and the elderly. It has resulted in an increase of kidney-related problems in the community. However, *“the hospitals here are at maximum capacity.... peoples’ kidneys are getting damaged. People are suffering from kidney and bladder stone.”* The livestock’s health is also suffering from poor quality of water. *“We collect water in ponds... both humans and animals drink water from there...and everyone is getting sick. If one could keep a hundred goats before, he can only keep ten goats now”*.

Women in Killi Khudaidd Zai-Tehsil Saranan also reported poor water quality, it is *“hard, very salty, silty and clayey”*. The female respondents of Killi Gangalzai-Tehsil Huramzai reported that the water quality is *“good, but the quantity of water available in the area is less”*. The female respondents of Killi Haikalzai- Tehsil: Saranan pointed out that *“they purchase water for drinking purposes as the water quality in the area is poor”*. Women in Killi Malazai- Tehsil Pishin also complained that the *“water in the area is hard and salty.”* One participant noted that *“the water stored in ponds also develops a salty white surface.”* They were also not satisfied with the quantity of water in the area.

People have migrated to other cities such as Karachi and Quetta due to water shortage. A participant highlighted that *“many people have left the area...more are leaving. We cannot plant gardens due to lack of water, and the water is not fit for drinking. Earlier, people used to migrate to Pishin from mountainous areas, but now everyone is leaving Pishin as well”*. The participants believed that contamination and depletion of groundwater is caused by a *“confluence of*

¹⁷ Tankers are often owned by a water mafia, which charges extortionate rates or finds ways to cut supply from government and private sector actors, creating an artificial need for water (Mustafa, Akhter and Nasrallah, 2013).

environmental and human factors". On one hand, the number of tubewells has increased considerably in the absence of an effective monitoring and law enforcement system, while on the other hand, decrease in precipitation and snowfall over the past 20 years has severely affected the rate of water replenishment. As one of the respondents explained, *"before, the mountain tops used to be covered with snow for three to four months, and water would come down from there... this is not the case anymore. About 15 to 20 years ago, each family had only one tubewell, but this number has now increased to 5-6 tubewells per family"*. Most participants, drawing from their past experiences and the existing situation, believe that *"both water quantity and quality will worsen over the next few years"*. The farmers estimated that the water table drops by an average of 50 feet per year. The situation has worsened over the previous 5-10 years. One participant added that *"in good old days, we used to take out water using buckets, then with time... We moved to the hand pump... but now the level has become very low...it is due to climate change you know"*. In tehsil Huramzai, the participants shared that *water quality is good in winter*. A participant suggested that *"installing water filtration systems can improve the water quality for drinking purposes."* In tehsil Huramzai, there were filtration plants installed by NGOs, but have now been damaged because of lack of maintenance.

In RYK, most of the respondents were satisfied with the quantity of groundwater available in the area but not with the quality. The participants reported that the quality and quantity of groundwater is adequate for both agricultural and domestic purposes in Liaquatpur tehsil. *"People from other areas have also migrated to Liaquatpur because of the good quality of groundwater."* The quantity, however, declines in summer due to increased water usage. Groundwater quality is generally poor especially for domestic use in other three tehsils viz. Sadiqabad, Rahim Yar Khan and Khanpur. The participants highlighted that *"Water here smells bad and turns yellow after it is stored in cans or utensils. It also tastes bitter and has a higher concentration of salts"*. As one of the respondents explained, *"the water turns yellowish like sewage in 24 hours. The quality is so bad that it cannot be used even for taking a bath. When performing domestic chores such as washing clothes, it is difficult to wash away the soap from the clothes during rinsing"*. The quantity of water is also decreasing.

The health of the animals is also getting affected, and they refuse to drink the water. *"Animals are happy when they are given canal water to drink"*. The poor quality of groundwater results in lower crop yields. The participants explained that *"the saline groundwater keeps the crop alive, but it is damaging to the crops. The quality of groundwater is not good, but what option do we have but to use it. We get good quality water during winter. The groundwater near the canals is also of good quality"*.

Overall, the respondents were of the view that the quality of surface water is much better than the quality of groundwater. Surface water is available in many areas through perennial canals and in some areas through non-perennial canals. However, the farmers believe that the river flows are limited and not sufficient to meet their requirements. Progressive farmers store water and later use

it for high efficiency irrigation. It was reported that adoption of latest techniques such as laser land levelling, and bed and furrow has increased as people are looking for ways to enhance food production and improve food security using water-efficient techniques. The community resorts to using surface water to meet its water requirements when the groundwater falls short. They were of the view that *“treatment plants should be installed to clean surface water as well. While canal water is of good quality, it is not available in adequate quantity”*. To meet their water requirements, sometimes people bring water from Taranda Saway Khan.

The cropping pattern has also changed during the last ten years due to water shortage. Wheat and cotton have now replaced sugarcane and rice cultivation in the area. A participant added that *“rice and sugarcane are now cultivated on smaller areas due to less availability of water.”* Respondents shared that groundwater levels started declining during the last 20 years. Some believed that depletion started 10 years ago. All agreed that crop production has decreased significantly in the last ten years due to poor quality of groundwater. In areas where groundwater is brackish, the crop growth has been stunted and quality of soil has deteriorated. A participant added that *“if you feed one animal with water from a filtration plant and another with unfiltered water...you can clearly observe the difference between the health of animals. Among the community, hepatitis is widespread. The poor quality of groundwater is also resulting in gastrointestinal problems, weak eyesight, jaundice, liver problems, high blood pressure, and poor teeth, which are very common among the people living in these areas.”*

The participants were of the view that if steps are not taken for course correction, the quality and quantity of water will decline considerably in the coming years. Some attributed the *poor quality of groundwater to malfunctioning of sewage system in the area*. A participant shared that *“everyone in the area dumps their sewage water in the ground near their houses by digging a well”*. A proper sewage system should be restructured to ensure that wastage is not mixed with groundwater. One participant pointed out that *“People have started migrating towards Sindh due to poor quality of water”*.

Most of the respondents believe that groundwater depletion and poor quality are human induced. The excessive use of fertilizers, pesticides, and chemicals are primarily responsible for deteriorating water quality. Respondents were of the view that *“The quality of water has deteriorated significantly after industries/factories have been set up in the area”*. The advancement in water extraction technologies and the ease with which they are available have led to depletion of groundwater resources. Some believe that the increasing groundwater depletion is mainly because of massive and rapid installation of tubewells. Earlier, it was possible to extract water at 50 feet but now the water table has dropped so much that extraction is not possible even at 70 feet. The respondents shared that *“fertilizer companies in the area extract water at extremely high rates.”* Only a few believe that poor groundwater quality is also due to the change in natural conditions. They stated that in the last ten years, *“groundwater has been depleting at an increasing rate, mostly due to less rain and increased extraction.”* However, participants observed that the

water table has improved after heavy rains and hill torrents in August-September 2022. The participants suggested that *“farmers should be provided with gadgets that can check Electrical Conductivity (EC) to monitor the quality of groundwater and should be educated in precision agriculture. Moreover, a shift must be made towards using organic fertilizers, like compost, animal dung and fruit and vegetable waste for better nutrient absorption in the cereal crops.”*

Presently, there is no mechanism to check groundwater quality and track occurrence and sources of groundwater contaminants. People are contaminating both the surface and groundwater by discharging their garbage, dead animals, chemicals and other hazardous material in the land. At the time of the study, only one salinity control and reclamation project (SCARP) by the World Bank was underway in RYK. Measures are not taken to improve the quality of water.

Groundwater storage

The findings highlighted that in Pishin there is no strategy in place for groundwater storage in the area. The farmers primarily rely on saving water from wastage by using drip irrigation methods and planting crops that are less water intensive, instead of apples and grapes. One way through which farmers store groundwater for agriculture in the area is to extract water through the tubewell and fill it in a pond. It normally takes 4-6 hours to fill the pond adjacent to the tubewell. Once the pond is filled with water, it is used to irrigate the farms. A male participant explained, *“Water stored in the ponds is used for farming...10 percent of the ponds that we use are lined and are in good condition... while 90 percent are raw, and water is seeped through them”*. Groundwater storage in a pond is, however, contingent upon the availability of electricity; *“we stay awake until the late hours to fill our ponds with water and do other farming activities...when electricity is available. It is cold at night and not easy to do agriculture activities at night”*. For domestic use, water tanks are constructed inside the house. Most houses have underground tanks for storage purposes while only a few have roof top storage tanks. A female participant stated that, *“In one house, young men have dug a well for groundwater recharge”*. A participant expressed, *“We pay our taxes. It is now the job of the government to build dams. We need a better system of pipelines, so that water is not wasted. The raw ponds and canals absorb the water”*.

In RYK, the participants shared that due to insufficient and unreliable surface water supplies, ponds are used for water storage. They endeavored to minimize water usage through laser levelling and bed and furrow techniques. The respondents believe that dams or small ponds should be built to store water for up to 20 days. Women were of the view that water availability can be increased by storing canal and rainwater, but at the time, they were unaware as to how this can be achieved. They suggested that atmospheric harvesting seems like a suitable option to collect water for drinking purposes, but technology is not available and is quite expensive.

Community governance of groundwater

Water rights in Balochistan vary among ethnic groups including Baloch, Pashtun, and Brahvis, as per customary tribal laws. While ethnic groups face no restrictions on pumping groundwater for

domestic purposes and for taking care of livestock, water rights differ for irrigation purposes. Pashtuns recognize the rights of all along surface stream or river, Baloch and Brahvis do not recognize the water users' rights in the central and coastal areas. Local communities representing various tribes act as water managers and make their own decisions based on agreed sharing of common resources (Majeed and Qureshi, 2000).

Balochistan has strong traditions of customary groundwater governance focusing on *Karez*, which are owned and managed by the community. The Pashtuns believe that ownership of water rights depends on ownership of the mother well and the mechanisms to transport water must pass through the owner's land (Majeed and Qureshi, 2000). For Balochis and Brahvis, *Karez* water is owned by several shareholders based on their land contribution for the construction of *Karez*. In the Baloch dominated areas, *Karez* water is recognized as a common property and all who provide land for the construction of *Karez* can use water according to their investment share without any payment. However, these governance traditions do not carry over to management of tubewells (Ashraf and Hasan, 2019). As a result, the *Karez*-irrigated farming is threatened by a number of factors: (a) lowering of water tables and mining of groundwater resulting from indiscriminate development of deep tubewells, (b) reduction in flow because of siltation of channels as a result of deferred maintenance, (c) soil erosion affecting the mother well and the vertical shafts, (d) lack of skilled manpower for maintenance, and (e) lack of support from the government regarding repair and maintenance of the systems (Ashraf and Nawaz, 2016).

In Punjab, farmers' entitlement of surface water is linked to size of their landholding and managed through a system of *warabandi* (rotation) under the supervision of Provincial Irrigation Departments (Majeed and Qureshi, 2000). Nevertheless, there are consistent indications that *warabandi* based water distribution is quite often influenced by the local elites and is inequitable affecting the tailenders (Jacoby, et al., 2018).

Gender roles in water management

In Pishin, a participant informed that *"it is the responsibility of the woman to turn on the donkey pump, keep an eye on the water tank, and then turn the motor off. Women also collect water for animals"*. A female participant explained that *"I remember I used to go with my mother to long distances to collect water, but now we have water taps in our homes... we just press a button to turn on the donkey pump in our homes and fill the water tank"*. In tehsil Huramzai, a participant pointed out that *"Afghan migrants in our area travel significant distances to collect water for household use. Generally, it is not preferred that women go outside the houses and travel long distances, but when there is water shortage, they have no other choice."* Women highlighted that they can only go out after taking permission from the men of the household. The female respondents were of the view that females use more water compared to men due to various household requirements such as washing, cleaning, and cooking. Water usage is also high when there are children at home. Male participants were of the view that women waste a lot of water while performing household tasks. They explained that *"if a woman wants to wash a cup or a*

plate, she will just keep the tap open, and would waste a whole bucket of water. Men know that it is difficult to get water, so he is careful.” Most farmers extract water on a daily basis in summer months for running their irrigation systems. In winter, water is extracted two to three times a week. The landowners and farmers decide how much water can be extracted and used for agriculture.

Usually, men make decisions on water extraction at the household level as well as agriculture purposes. Women in Pishin shared that they have no role in groundwater management decision-making. They have little or no knowledge of water management as their role is only limited to households. There is a committee comprising only male members that makes necessary decisions on water related issues. A male participant pointed out that *“Women, given our cultural context, could only get involved in the decision-making process if some female officers visit the area.”* The female participants indicated that they would be more than willing to communicate with the government departments on water issues and participate in stakeholder dialogues. A woman shared that, *“Women at houses can run both hand pumps and solar tubewells. Those who are unaware wanting to learn water extraction techniques.”*

In RYK, both men and women collect water for daily use. A participant informed us that *“we extract groundwater daily. We keep our tubewells on automatic mode... When our tank is filled, the tubewells turn off automatically. We also fill ponds for storing water for later use”*. Participants indicated that women use more water than men: *“Groundwater is extracted multiple times a day for domestic use.”* For agricultural activity, water is mostly extracted during the month of January when the canal operation is closed for the perennial irrigated areas. A participant added that *“water is extracted for irrigation after 8-15 days depending upon the weather”*. For kitchen gardening, water is extracted 2-3 times a week and for cattle farming, water is extracted daily. In RYK, participants, both men and women, were of the view that women should be part of groundwater management authorities and should be involved in the decision-making process.

CHALLENGES IN GROUNDWATER MANAGEMENT AND GOVERNANCE

In this section we present how views of key informants complement and contrast with those of community participants in FGDs about various challenges related to groundwater governance on different levels.

Groundwater management

Both the groundwater user communities in Pishin and RYK as well as the key informants underlined the serious challenges to groundwater management. They expressed deep concerns over the lowering water tables because of over extraction and declining quantity and quality of groundwater and highlighted weak enforcement of existing laws.

Like the water users in Balochistan, key informants from Balochistan informed that “*groundwater overdraft¹⁸ in the province has reached distressing level and is threatening sustainable agriculture and livelihoods*”. A key informant explained this as “*due to weak enforcement of existing law and regulations, poor recharge mechanisms, and recurring droughts, groundwater overdraft is now impacting the social and economic opportunities for the population. Farmers do not have any incentive to conserve water. They are encouraged in the form of subsidies provided by the government to pump more water. It seems that the subsidy on electric tubewells for agriculture is adversely affecting the water economy of Balochistan. There is lack of awareness amongst the public as well as the government regarding critical situation of water in the province, and the need for its conservation and effective management of groundwater.*” While both community and government respondents identify the urgency of problems with groundwater, the government staff feel that community members are not aware of the issues.

Similarly, both the water user communities and key informants from RYK believed that the groundwater is reaching critical stage due to high usages because of increasing industrialization including a fertilizer company in RYK. The key informants also reported that most of the groundwater samples collected around RYK were not suitable for irrigation and human consumption purposes and were hazardous. Additionally, increasing quantity of brackish water in the areas is threatening agriculture cultivation and productivity.

Institutional arrangements

Community perspective

FGD participants in Pishin shared that there are no official community organizations or water user associations in the area with the mandate to support groundwater regulation. However, farmers

¹⁸ Groundwater overdraft occurs when groundwater use exceeds the amount of recharge into an aquifer, which leads to a decline in groundwater level

have their own association known as the Zamindar Action Committee. These committees usually organize protests on load shedding (electricity is available for 6 hours only) and other concerns affecting the farmers. In a water dispute, the jirga system is utilized by involving village elders for resolving the conflict: *“farmers come to the jirga if they have any water disputes. If someone is not letting him take water from a common tubewell, he complains to the jirga. There are so many cases in courts regarding water disputes between the farmers, but the system is extremely slow. The jirga system is better than the courts as it is swift as jirga takes decisions in a timely manner.”* Community participants informed that the Irrigation Department is *partially functioning and is not well equipped to provide support in emergency situations such as drought or flood*. Participants were of the view that relevant departments should be established in each village and the representatives should educate the villagers on groundwater management. Additionally, they should also keep checks on the condition of the tubewells and carry out maintenance tasks if required.

Several FGD participants voiced their discontent with district water and electricity authorities: *“we demanded from the authority to provide us with an uninterrupted supply of water for 8-10 hours; we cannot close down our tubewells... we have to feed our families.”* The participants informed *“proper water management system was in place when karezes were functioning in the district. The Irrigation Department at that time distributed water through tributaries of the dam, but this system has also broken down after a drastic decline in water availability.”* They further shared that *“earlier there was also a system in place that regulated tubewell installation, you had to get a no objection certificate (NOC) from the government. The procedure required that the land must be in the name of the applicant, and proof that neighbors will not be harmed. It was essential to place an advertisement in the paper as well to make this public knowledge that a tubewell would be installed. Now there is no such system in place.”* Another participant added that *“the government does not care anymore... this happened after the drought. Now, whenever a farmer decides to install a tubewell, the next day he starts the installation”*. In some cases, farmers have installed multiple tubewells on their farms, within proximity to each other. A female participants reported that a farmer has installed 14-15 tubewells for his orchards in Killi Gangalzai Village of Tehsil Huramzai and does not share water with any other house. Such extraction of groundwater would affect the whole community: *“water is essential for survival; how will we live without it...The tanker mafia here will rob us if nothing is done...We will only be dependent on water from the tanker driver”*.

Most of the FGD participants in Pishin believed that political parties could play an important role in bringing groundwater issues to the centerstage but presently groundwater does not seem to be a critical issue on their priority list. In the absence of appropriate legislation and regulatory framework, the groundwater situation would continue to deteriorate in terms of both quantity and quality: *“this land will become barren in the coming years if effective planning is not done. There is no water left anymore...there is only soil.”* An effective framework should be developed for regulating groundwater extraction: *“laws should be implemented to control the unregulated*

extraction of water. Getting the NOC to install the tubewell and making announcements through ads should be made mandatory with strong enforcement mechanism”.

There is neither a formal system nor any community-based organization to regulate and govern the groundwater in RYK. FGD participants highlighted that water user associations do not exist in the area. A private organization called Rural Education and Economy Development Society (REEDS) is working and guiding groundwater users about the right use of water in Rahim Yar Khan tehsil. The field facilitators teach the farmers effective management of water through demonstration plots. Only a few participants were aware of the organization and its role.

The groundwater quantity in some tehsils of RYK is declining. Most of the large farmers have installed solar tubewells which has led to uncontrolled water extraction. A participant put forth the idea that *“a local man who knows the area and problems faced by the community should be put in charge to ensure fair distribution of water.”* Participants agreed that forming an authority that regulates groundwater usage would be highly beneficial, as they believe that it would result in better monitoring, management, and distribution of groundwater. They were of the view that the government and community should work together to manage groundwater. *“Government should develop check and balance mechanisms to regulate water usage especially by industries. Big companies extract more groundwater by installing heavy turbines.”* Regular public and farmer awareness seminars and workshops should be arranged where both men and women would take part. FGD participants were of the view that government should take charge of groundwater monitoring, but they believe that allocation and distribution of water should remain at the discretion of farmers. They were apprehensive about a government authority taking charge: *“no, we do not want such an authority in our area, they would hinder us from extracting as much water as we want”*. Secondly, the government is not doing enough to build the capacity of farmers for groundwater management. They believed that farmers should be educated in effective water management and alternative farming practices. Presently, most of the farmers rely on traditional irrigation methods, which results in significant water losses.

Groundwater quality is also worsening. FGD respondents report that no government body or community organization is there to monitor this and *“we are facing health issues from the contaminated water...as no one is monitoring it. We do not even have filtration plants. We are left with no option but to try and gauge the quality ourselves through traditional methods such as increasing the length of the pipe and checking the color of the water”*.

Key informants’ perspective

All the key informants were generally of the view that groundwater is not being managed effectively in the country while some of them categorically said that groundwater is not being managed at all. One informant expressed, *“The fundamental problem is that government*

institutions do not have the capability to deal with the Herculean task of groundwater management. Most departments are engaged in developing ad hoc approaches for attracting funding; departments are not willing to bring about the required change and are only engaged in jurisdictional fights. The concerns of the end user who is an ordinary citizen are largely being ignored.” Groundwater extraction was regulated about 30-40 years ago, but the regulatory system has weakened with time, instead of getting streamlined. *“Gross mismanagement and unsustainable practices are at the heart of the current water crisis”.*

Overexploitation of groundwater, lowering water tables and depletion of groundwater in some areas is raising alarm. The government departments have begun to recognize the consequences of ominous mismanagement of the groundwater resources and are taking initiative to address the situation, especially in Punjab. Nonetheless, most of these projects are makeshift, overlapping and are not sustained: *“there are rules and legislation in place, but the primary challenge is the enforcement of laws. So far, the legislation is only on paper.”* For example, in Balochistan, a Groundwater Rights Administration Ordinance has been in place since 1978 (amended in 2001), which sets forth the various conditions for extracting water through licensed tubewell development in the province, but these are hardly enforced. *“Rules are in place that set the standards for permissible distance between the two tubewells depending upon the type of the soil, which have largely gone ignored”.* In Balochistan, tubewells have been installed within a short distance of 100 feet. One interviewee stated that *“To address this critical situation of over extraction, implementation of the radius law is urgently required”.* As stated by another interviewee, *“An individual has rights over the land it owns but only the state has the rights over water. Anyone who wants to install a domestic or irrigation pump should go through a proper application process with the district water authority”.*

One informant highlighted that *“the unplanned and uncontrolled extraction of groundwater has resulted in the lowering of the water table in Pishin, Baluchistan to 500ft. In Pishin, fossil water is being extracted which is essential for the health of the ground. There is no mechanism for water recharge in Pishin and it will take 100 years if action is taken today. If water extraction continues at the same rate, the city will sink in endorsing the ‘land subsidence’ phenomenon that has been pointed out in various studies.”* In ten years, the district may completely run out of water. They stressed that the groundwater situation in the Balochistan province is extremely fragile. Rapid urbanization in Pakistan has led to increasing water and sanitation requirements in the cities. One interviewee pointed out that the current pace at which groundwater is being extracted in urban areas is not sustainable. He emphasized that *“the development authorities should ensure that groundwater availability assessments should be done before construction of new houses, and water efficiency measures must be incorporated into the building plans”.*

These interviews also revealed that there were no coordination mechanisms between different government departments related to groundwater. An informant from Pishin stated that *“The district administration does not coordinate with line departments. All departments are working in silos*

leading to duplication of efforts which is not yielding any meaningful results in Pishin. Another interviewee explained that *“The failure of the departments to communicate and coordinate with each other has led to weak policy enforcement and this institutional deficiency seemed to be chronic”*. An interviewee suggested that *“a platform should be established where all the stakeholders can work under one umbrella and to ensure institutional accountability, the roles and responsibilities of all the departments involved should be clearly defined. The Ministry of Water Resources can be given the lead role to conduct periodic progress review of all the departments involved. Penalties should be imposed on those who fail to meet the set targets.”* In addition, *“the Council of Common Interests can serve as the platform for knowledge exchange. PCRWR can develop a reporting mechanism that shares the information regarding water resources and various parameters on a periodic basis”*. The informants further highlighted that the *“structure of the institutions governing water and development at the federal, provincial, and local levels are severely complicated and extremely disconnected without any accountability for action and data collection procedures.”*

Information deficit and monitoring tubewells

Both community respondents and government key informants agree that better information on groundwater quantity and quality is needed, although they differ some in emphasis on what data should be collected, and considerably on how data should be made available (and to whom).

Community perspective

FGD participants, both male and female, were unaware of the existing policies on groundwater management in Pishin. They desired access to data on water table and quality, which they believe would help them in identifying changes over time and prepare accordingly: *“we must be informed as to how much water we will get in a year or at least six months. Both men and women should have equal access to such data”*. Women shared that they do not have access to any information or data on groundwater. They do not have access to televisions and mobile phones. A female participant in Pishin pointed out, *“Even educated women in the area do not own or have access to cell phones and television, which limits their access to information and data. We have to rely on household men for getting information.”*. Both male and female respondents were also uninformed about groundwater recharge system. Majority of the male respondents were of the view that only men should learn about technologies related to groundwater management as women do not really use them. A participant explained, *“Women do not go outside the house...only men take part in income generating activities...women do not need to learn about new techniques and technologies”*. Few of them were of the opinion that *“women should learn about new technologies because it is equally important for them, as they are engaged in water management within the household and can manage the farm irrigation water in absence of men”*. A female participant however pointed out that women *“know how to use electricity and solar run tubewells, hand pumps and donkey pumps and even run them in the absence of men.”*

Similarly, data and information are not available to groundwater users in terms of quantity and quality in RYK. They believe that, as one respondent reported, “if the data on groundwater is made available to the users, it would help them in decision making, adjusting the crop patterns and be aware of the contamination level of water”. Some of the respondents underlined that people should be made aware of the dire situation resulting from unregulated extraction. Techniques and technology for water saving should also be introduced and implemented. Most importantly, as one respondent noted that “small farmers should be targeted first for information sharing as they are larger in number and have little to no access to useful information”. No participants had knowledge of the National Water Policy 2018 and Punjab Water Act 2019. They desired that there is a need to adopt new technologies to manage groundwater. Majority were of the view that both men and women should learn about these technologies as they both are groundwater users.

Key informant's perspective

The key informants generally expressed the need for more information and enforcement of regulations. All the interviewees seemed to agree with the perspective reported by one that *“for groundwater management to be effective, a strong checking and monitoring system should be developed that track installation of tubewells and water quantity extraction. The licensing laws for installing a tubewell should be effectively enforced and unauthorized installation of tubewells should be heavily penalized. One respondent put forward that “before giving a license for the installation of a new tubewells, the recharge capacity of the area should be evaluated to ensure that water extraction would be done in line with water recharge capacity of a particular area. In addition, the provincial environmental departments must ensure that no activities that could pollute groundwater would be allowed.”* One key informant reported that *“number of tubewells in Punjab has reached to 1.2 million out of which only 10-12 thousand tubewells are installed by the government. To get concrete data, the concerned department in Punjab has started geotagging of the tubewells, and so far, has tagged 500,000 tubewells. In addition to the tagging of tubewells, data is also being gathered on different characteristics of the tubewells. The idea is to consolidate the information and share it with all the stakeholders”*.

One of the informants stated that *“currently, it is difficult to make informed decisions because of non-availability of data relating to potential areas in terms of possible extraction and recharge. All data collection projects are in the pilot phase. Various organizations such as Pakistan Council of Research in Water Resources (PCRWR), Water and Power Development Authority and provincial Irrigation Departments are working to collect data for their jurisdictional domains. “Datasets are scattered between different departments and are not consolidated at one platform to enable us to see the bigger picture.”* Another informant shared that *“Lahore and Sheikhpura divisions have data on water quantity and quality, but no official data sharing mechanisms have been developed to access that data. He stressed that “academia can play an important role in research if they are given access to such data”*. It was suggested that *“a ‘data portal’ should be developed with all the data to date on groundwater resources and a focal organization should be tasked with the responsibility for data management. A subscription fee from the user may be charged for accessing the data.”*

Some of the key informants also addressed groundwater quality. As one explained, “*groundwater is being extracted through tubewells without accounting for its quality. No quality checking mechanism has been put in place to assess if the extracted water is fit for agricultural purposes. Fecal and other waste matter is getting injected into the groundwater. In Punjab, because of this mismanagement, every third person is a hepatitis C patient.*” Discussions with the key informants revealed that different initiatives are underway by various federal and provincial governments are underway to map the groundwater and monitor its quantity and quality¹⁹ as well as geo-tagging the tubewells,²⁰ investigations as to quantity and quality of groundwater, piloting groundwater recharge system, and developing fully instrumental pilot sites for groundwater monitoring.

Lack of public participation in decision making

The dominant theme of FGDs was lack of public participation in decision-making about water. In Pishin, participants reported absence of dialogue between the government stakeholders and groundwater users regarding management of groundwater: “*no one comes here to take the local perspective into account before making any decisions. All the decisions are made in Quetta offices. There should be a seminar or workshops on the issues we face. This is high time that we increase awareness.*” Some of the participants informed that this is the first time in their lifetime when someone is discussing with them water and agriculture issues. A female participant stated, “*No one has ever visited our homes to discuss water related issues with us. We feel that government representatives should visit us and discuss with us.*” They expressed their willingness to be part of participatory decision making to improve groundwater management. Similarly, FGD participants in RYK said that representatives from provincial water departments have never held any dialogues with the community affected by groundwater management to take their viewpoint when designing policies.

Gap between policy and implementation

The first ever National Water Policy (NWP) in the country was approved in 2018 to set the policy objectives and priorities going forward including monitoring and recharging the groundwater.²¹ One of the key steps that has been highlighted in the policy document was to establish provincial groundwater authorities for regulation of groundwater. The key informants shared that, to the best of their knowledge, the ‘groundwater authorities’ as mentioned in the National Water Policy 2018 were non-existent at the federal and provincial level. One informant highlighted “*Huge financial resources are required to hire the manpower to make these authorities functional, which unfortunately are not at the country’s disposal currently*”. National Water Policy 2018 requires of

¹⁹ Groundwater Analysis in 3 pilot distributaries in Faisalabad, Bahawalnagar, and D.G.Khan

²⁰ Geo-Referenced Database for tubewells in Punjab

²¹ Previously, national groundwater management rules were drafted under Provincial Irrigation and Drainage Authority (PIDA) act in 1999–2000 and included in the Canal Act of 2006.

the provinces to move towards Integrated Water Resource Management (IWRM).²² The key informants underlined that provincial Irrigation departments do not have an adequate understanding of the IWRM concept. One informant highlighted that *“IWRM is just a buzzword, with little to no practical application. To successfully adopt the IWRM approach, assessment is needed regarding current water allocation of a particular area from various sources, surface, groundwater and rainfall.”* The question remains as to how these policies will be translated into targeted action by the concerned authorities.

In 2019, the Punjab Water Act was enacted for comprehensive management of all water resources in Punjab. An informant pointed out that *“Punjab Water Services Regulatory Authority’ as envisioned under Punjab Water Act 2019 is not functional because of the stay of proceedings in the court regarding the recruitment in the said authority. In the absence of these authorities, there is no groundwater management; Irrigation Department is only monitoring groundwater level and quality. In Punjab, it will be the responsibility of Punjab Water Resources Commission and Punjab Water Services Regulatory Authority to manage groundwater once these bodies are functional.”* The Khyber Pakhtunkhwa Water Act was enacted in 2020 for comprehensive management of all water resources in KP. At the time of the interviews, no such act was present in Balochistan for the regulation of groundwater resources.

The lack of capacity building initiatives in the water sector departments was highlighted by many key informants. *“Most of the staff in government organizations have worked their whole lives in the same departments and have not been exposed to modern methods for resolving and managing issues related to water management and regulation.”*

Other challenges

Water Pricing

The key informants suggested pricing of groundwater and its enforcement as one of the options to manage increasing extraction of groundwater. However, the communities and groundwater users did not suggest this option. Some of the key informants were of the view that a *“water pricing mechanism should be adopted to make the user cognizant of the value of water. Pricing of surface and groundwater is the only way to move forward to tackle the issue of water scarcity and water waste head on. When it comes to water usage, the agriculture sector stands out as the most wasteful sector, and this is because of the minimal abiana (water charge) per acre paid by the farmer for the surface water while [they] pay nothing for the groundwater which does not generate adequate revenue to deal with costs associated with the operation and maintenance of water infrastructure.”* On top of this, the worsening climate situation would further exacerbate the water scarcity situation

²² In 2006, the Balochistan IWRM policy was approved by the provincial cabinet (Khair, S. M., Mushtaq, S., and Reardon-Smith, K., 2014). “

in the country. *“This is high time to adopt the water metering mechanism across the country. Water pricing should first start with industry and households and then move to agriculture.”*

Stance on solarization of tubewells

Some of the key informants were of the view that, as one indicated, *“solarization of the tubewells would lead to uncontrolled extraction of groundwater;”* and it is important to *“conduct a feasibility study before installation of solar tubewells.... solarization should only allowed as an option in areas where groundwater conditions permit for such interventions; water zones should be marked and standardized size of the solar tubewells should be decided according to water availability.... Relevant government departments should monitor all the solar tubewells.”* One of the informants also suggested that *“farmers who have installed solar tubewells may be incentivized to utilize the tubewells for multiple purposes. Patterns of such approaches can be taken from other countries that have adopted these practices. For example, when solar tubewells are not being used for irrigation, the connection could be given for non-agricultural use. Options such as feed-in tariff must be explored.”* It was also highlighted by one of the informants that *“farmers in Punjab are first encouraged to install drip and sprinkler irrigation, if they are to opt for solar tubewells”*.

Nature-based solutions

Some of the informants suggested that the *“way to move forward is to adopt holistic nature-based solutions.”* One of the informants highlighted that the *“Ministry of Water Resources is undertaking multiple interventions at the selected sites of Rawalpindi and Islamabad. These include installing rainwater harvesting systems, building small tanks in front of the houses for collecting rooftop rainwater, and installing water filtration plants. For the sustainability of the project, user organizations are being established, which are run by the people of the community to ensure the continuation of activities”*. He further added that the Ministry of Water Resources is also mapping the water resources in Balochistan. The informants highlighted that it is essential to gather baseline information for coming up with groundwater management and conservation strategies. It was also emphasized that *“if the government intends to correct the course, then it should prioritize fund allocation to water conservation initiatives for the next 2-3 years instead of spending it on usual brick and mortar projects. If funds are not adequate for constructing big dams, then the government should start building smaller dams. The absence of such dams in Balochistan at the time of floods led to huge water losses.”*

RECOMMENDATIONS

The findings of this report highlight that groundwater governance in Pakistan is weak, with limited to non-existent interactions between key stakeholder groups and little to no management of the groundwater resource. Pakistan has long been grappling with challenges in formulating appropriate policies and establishing effective governance systems for its groundwater resources. Both the communities as well as the key informants agreed with the need to urgently address the declining groundwater quantity and quality as well as the lowering of water tables.

While the communities underlined the need for a mechanism for an open dialogue on water management amongst all stakeholders including the concerned departments of the government and a participative decision-making, the key informants emphasized the need for the establishment and operationalization of an institutional framework provided in the Punjab Water Act as well as the Balochistan law for effective governance of groundwater. They did not encourage participative and inclusive decision-making but underscored the need for an interdepartmental and inter-governmental coordination platform and communication strategy to create public awareness about water conservation.

Since groundwater systems are affected by both nature and anthropogenic activities, a collaborative approach involving all stakeholders-- government, private sector and communities-- is required to develop an all-encompassing groundwater governance and management framework for sustainable use of groundwater resources. The key to effective management of water lies in regular interaction with the users along with investments in modern water and agricultural technology and forming an enabling environment through the development of policies, rules and laws suited to the needs of Pakistan and decision support systems. Recommendations can be grouped under the headings of information, institutions, technology, and incentives, but to be effective, these need to be seen as an interconnected whole.

Information

Both community and government stakeholders identified the need for better information about groundwater. The following recommendations draw largely on the key informants' perspectives.

- *Monitor the groundwater system:* The government must put in place an effective mechanism in place for periodic assessment of groundwater availability, its quantity and quality. A first step toward this would be mapping groundwater in each agro-ecological zone, including identification of critical groundwater zones, geo-tagging of all existing tubewells with modes of groundwater extraction, usages, and quantity of groundwater extracted for different purposes.
- *Study solarized wells:* Concerns over the likely impact of solar-powered wells call for a specialized study of the impact of solarized pumps on groundwater availability and

extraction at the local level, including not only the amounts extracted but how this water is shared.

- *Establish a data portal:* Developing a ‘data portal’ on groundwater resources at the community, tehsil, and district level that can be accessed by the community or government organizations in that district is a first step towards making information available but needs to be accompanied by clearly designated responsibility for disseminating that data to all groundwater users in a manner that will enable them to take informed decisions.
- *Raise awareness:* To make all the stakeholders cognizant of the critical situation of ground and surface water, outreach campaigns should be conducted to make people aware of the water scarcity situation and criticality of groundwater, teaching them how valuable the resource is, making them cognizant of the fact that water is not an infinite resource and the serious consequences of groundwater overuse for everyone. As farmers are the major users of groundwater, outreach campaigns should be specifically targeted at them educating them on high efficiency irrigation systems.
- *Address the emerging health and WASH challenges:* The quality of groundwater has been deteriorating over time in both study areas, making it unsuitable for human or livestock consumption or domestic use. Monitoring water quality is therefore as important as water quantity. Information on groundwater quality needs to be shared with communities as well as government actors. Water quality data also need to be linked to monitoring of health problems such as gastroenterological diseases, diarrhea, kidney-related issues, bladder stones, weak eyesight, jaundice, liver related issues, high blood pressure, and hepatitis C. Combining information on water quality and disease can provide stronger motivation for action on groundwater governance.

Institutions

- *Implement policies and statutory enforcement:* The government should prepare an Action Plan with timelines as well as establish necessary frameworks for implementation of the National Water Policy 2018. If the policy requires review and updating in view of changing weather patterns and climate change, it may be updated. Concurrently, the government establishes required regulatory structure to enforce the existing laws to regulate groundwater including the licensing regime for installation of new tubewells.
- *Move away from the siloed approach:* Coordination and collaboration between federal, provincial and local bodies is essential to improve enforcement of laws to reduce abstraction and pollution of groundwater.
- *Improve participation:* Ultimately, government agencies alone cannot govern groundwater without local water users’ informed participation in decision-making. Bringing the communities at the local level together can help in increasing ownership of the interventions by community members, but the FGDs indicated that communities

are not consulted. The Farmers Association or *Khal Panchayat* may be appropriately empowered to involve the end-user in the decision-making process.

- *Engage women in groundwater management:* Since women are also users of groundwater for their households' chores, livestock, kitchen gardening, filling household tanks, and at certain places for irrigation also, it was strongly suggested both in Pishin and RYK that they must have access to information about water resources and be involved in skills training to use modern technologies, water conservation techniques, monitoring quantity and quality of groundwater, and be engaged in decision making process at local levels.
- *Establish a dispute resolution mechanism:* The law should provide for a dispute resolution mechanism at the local level rather than pursuing cases in the courts of law which take much longer time. In Balochistan this can build on the *Jirga* system, which takes decisions in a timely manner and are accepted by the community. In other provinces, local dispute resolution mechanisms may need to be developed.
- *Enhance capacity:* Capacity building of groundwater personnel as well as the farmers and local communities is crucial to enhance their skills, knowledge, and capabilities in managing and maintaining groundwater resources effectively. This can be done through training programs, workshops and seminars, field visits and practical experience, teaching data management and analysis, institutional collaboration, education on sustainable groundwater management and climate change adaptation, familiarization with legal and regulatory framework, and evaluating and assessing training impact.

Technology

- *Review and consider groundwater recharge mechanisms:* Approaches to increase groundwater recharge at both the local and national level should be explored and adopted. An approach repeatedly suggested by FGD and KII participants in the study was the adoption of rainwater harvesting and flashflood water storage to recharge aquifers. For this, small to medium check dams with proper hydrological and soil feasibility may be constructed. Construction of delay action dams or recharge dams at appropriate locations are needed to provide an inbuilt mechanism to recharge the Balozai Dam in Balochistan. In addition, water ponds can be developed. Appropriate measures may also be taken to treat the wastewater, if is not contaminated and hazardous to human health, as a supplementary source for irrigation. The Government of Balochistan may develop a project to recharge and restore *karez* system wherever possible.
- *Promote modern irrigation practices:* FGD participants highlighted that there is a need for government's support in promoting modern irrigation practices, such as, drip irrigation, sprinkle irrigation, construction of community ponds for rain harvesting and

- water storage, expansion of delay action dams network, etc. for water conservation and water efficiency.
- *Address the economic and social implications of worsening groundwater quality:* The poor quality of groundwater is resulting in lower crop yield and adversely impacting the gardens in the study areas. People are migrating to other cities because of the worsening quality and depletion of groundwater as highlighted in Pishin as well as Sadiqabad, Rahim Yar Khan, and Khanpur. This may result in economic as well as social crisis requiring necessary mitigating measures. It was strongly suggested to install water treatment plants to clean groundwater as well as providing proper sewage systems. Farmers may be provided with gadgets that can check Electrical Conductivity (EC) to monitor the quality of groundwater and should be educated in precision agriculture.

Incentives

The key informants were concerned that the current price and subsidy systems do not provide appropriate incentives for groundwater conservation. The following recommendations draw primarily on the key informant interviews, but do not necessarily reflect community perspectives or feasibility of implementation.

- *Review the current subsidy system:* Government stakeholders felt that electricity subsidies encouraged overexploitation of groundwater, particularly in Balochistan, and recommend recovering full cost of electricity from the consumer, gradually. At the same time, community members felt the need for greater subsidies to cover the capital costs of water-conserving technologies. A review of the entire subsidy system, with input from both officials and communities, could help identify how subsidies can shape incentives in an appropriate manner.
- *Consider changes in water pricing:* The key informants highlighted that current insignificant water charge has been indicated as one of the major causes for flood irrigation using surface water, water waste, and overexploitation of groundwater. It is important to revisit the water charges for irrigation, industrial and commercial activities, drinking, and groundwater. Raising water charges can generate revenues to pay for the operation and maintenance of water infrastructure, and potentially create incentives to reduce water use, though this has proved very problematic, in practice (Molle and Berkhoff, 2007) .
- *Analyze the solarization of irrigation pumps:* Key informants were concerned that solarization of irrigation pumps would lead to uncontrolled extraction of groundwater while moving to renewable energy. However, the groundwater user communities identified a number of factors that affect adoption and use of solarized tubewells. To address this requires a solid empirical understanding of water use under different types of pumps, and using that to craft a policy framework to regulate and monitor solarization of irrigation pumps/tubewells according to water availability. Combining

solar pumping with the use of drip irrigation for agriculture purpose or possibilities to sell electricity back to the grid were also suggested as strategies to incentivize careful use of groundwater under solar powered tubewells.

CONCLUSION

Groundwater is an essential freshwater resource to meet the water requirements of the country. Over the years, dependence on groundwater has increased remarkably because of climate change and unreliable surface water flows leading to groundwater extraction. The occurrence of extreme environmental events such as floods and droughts have exacerbated the already existent water availability and inequality.

The country's water resources are under immense strain due to fast growing population (annual growth rate is 2.55 percent), rapid urbanization, shift towards water-thirsty crops, competing water demands across various sectors, climate change and deterioration of ecosystem services. Prolonged droughts and erratic weather patterns, coupled with the absence of groundwater recharge systems, variations in surface water availability, and the widespread installation of tubewells fueled by lower electricity tariffs or flat rate in agriculture, collectively contribute to the overexploitation of groundwater resources. Moreover, insufficient water storage infrastructure has led to the wastage of rain and flash flood water. Water tables are lowering at a rate of 30-40 feet per year at certain places in Balochistan (Islamic Relief, 2018) while the water table in Quetta and Pishin-Lora basins has declined to 900-1200 feet (Khair, et al. 2015). RYK is facing a similar phenomenon, albeit at a slower pace. Concurrently, worsening groundwater quality is resulting in various health challenges including gastrointestinal problems, kidney and liver issues, bladder stones and hepatitis C. This is also affecting livestock and agriculture productivity. Depleting groundwater and dried up *karez* system in Pishin are not only reducing land cultivation but also compelling people to diversify to other economic activities and migrating to cities.

Groundwater governance and management and required institutional structures are weak or non-existent. Most groundwater users are aware of water stress in Pakistan, but lack the water conservation techniques, access to modern technology, and timely data availability to take informed decisions. Currently, the decision-making at the government level is non-participative and alternate dispute resolution system in rural areas has weakened over time. However, *Jirga* system in Balochistan is still operational to resolve local water disputes rather than users going to the courts. While Balochistan had a sophisticated and community-based groundwater governance to manage the *karez* system which were built with collective investment, it has not carried over to governance of wells, which are developed through individual investment. Indeed, the lack of governance of groundwater extraction through wells has undermined the *karez* systems. It is important to revisit community-based groundwater governance and how these institutions can be adapted to meet current challenges.

The discussions with key informants also revealed gaps between policy and implementation, laws and their enforcement, weak capacity in relevant institutions, absence of effective coordination platforms and appropriate water pricing. The National Water Policy 2018 highlights the need to course correct when it comes to groundwater overexploitation and puts a way forward as a starting

point, but it requires not only institutional structure and framework but also allocation of needed resources. Despite broad consensus on the importance of groundwater, the understanding of the resource is at best murky (Lytton et al., 2021). Scant data on groundwater makes it difficult to efficiently manage and regulate groundwater. To establish an effective governance framework, a thorough awareness of the available water resources in terms of their quantity and quality is required by all the stakeholders involved at multiple tiers. Deep understanding of integrated water resources management at federal and provincial levels must be supported by corresponding capacity. Rectifying the weaknesses in the legal, institutional and regulatory policies that deals with groundwater management and governance requires taking all the relevant stakeholders on board. The recommendations highlighted above propose to address most of these issues that emerged from discussions during the FGDs as well as KIIs.

Groundwater contamination can impact human health, environmental quality and socioeconomic development. Rising groundwater contamination due to chemical and biological contaminants is posing a serious challenge to human and livestock health as highlighted by the participants of FGDs in the two study areas discussed above. Drinking groundwater with microbial contaminants is causing urological and kidney issues as well as serious diarrheal diseases, such as gastroenterological, typhoid and cholera. The presence of fluoride, nitrate, metals and persistent organic pollutants is especially critical for infants and children, who are more susceptible to the effects of these contaminants. Human health is also affected by the contaminated groundwater through effects of food production system as it accumulates toxic elements in cereals and vegetables. At the same time, contaminated groundwater is causing health issues for the livestock as well as resulting in soil erosion and cultivable land degradation.

To conclude, lowering water tables, depleting aquifers, excessive groundwater pumping for irrigation and declining water quality is emerging as a case of triple jeopardy. It is accelerating the process of water scarcity, negatively impacting human and livestock health and threatening agricultural production systems. These crises should motivate urgent actions by communities and the government to work together to invest in research to determine the extent of groundwater contamination, technology, techniques and training to address these challenges. It also requires a range of remedial and effective policies for groundwater governance.

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ANNEXURES

Annexure 1.

Table A-1. Tehsils and Union Councils in Pishin District

Tehsil	Union Councils
Barshore	Bagh, Barshore, Behram Khan, Bela, Ghaizh, Injani, Kach Hassanzai, Kaza Viala, Kut, Mandozai, Walma, Ziarat.
Karezat	Balozai, Bostan, Dilsora, Khanozai, Khushab, Lumran, Mughutian, Rod Mulazai, Yaru
Huramazai	Alizai, Gangalzai, Hajian Shakarzai, Manzari, Huramazai
Pishin	Ajram Shadizai, Batezai, Bazar Kohna, Dab Khanzai, Karbala, Malezai, Malikyar, Manzaki, Muchan, Pishin Bazar, Saranan, Shahdizai

Table A-2. Tehsils Selected for Male FGDs in Pishin

FGD	District	Tehsil	Villages	Language	Location
1.	Pishin	Pishin	Nauabad, Batazai, Imadan, Gulanzai	Urdu	Pishin
2.	Pishin	Huramazai	Kili Syedan, Shakhezai, Kamalzai, Midabzai	Urdu/Pushto	Quetta
3.	Pishin	Pishin	Malakyar, Sheikanzai, Kamazai, Malazai, Alagaizai and Nauabad	Urdu	Quetta
4.	Pishin	Barshore	Barshore, Malazai, Toorshah, Lamadaan, Adalzai, Batanaoi	Urdu	Barshore
5.	Pishin	Huramazai	Huramazai, Hamdan Killi, Kili Syedan, Killi Gul Mohammad, Miskankehel	Urdu	Huramazai

Table A-3. Tehsils Selected for Female FGDs in Pishin

FGD	District	Tehsil	Number of participants	Language	Location
1.	Pishin	Huramazai	10	Pashto	Killi Khudaaid Zai (Village)
2.	Pishin	Huramazai	10	Pashto	Killi Gangulzai (Village)
3.	Pishin	Saranan	10	Pashto	Killi Hackel Zai (Village)
4.	Pishin	Pishin	10	Pashto	Killi Malazai (Village)
5.	Pishin	Pishin	10	Pashto	Killi Abdullah Jan Yaroo (Village)

Note: Saranan is a smaller population area as compared to Pishin and Huramazai.

Table A-4. Tehsils selected for male and female FGDs in Rahim Yar Khan

FGD	District	Tehsil	Villages	Language	Location
1	Rahim Yar khan	Rahim Yar khan	Mud Hassan, Basti Meer Muhammad Basti Allah Dad	Urdu/ Punjabi / Saraiki	Mud Hassan
2	Rahim Yar khan	Sadiqabad	Sanjar Pur, Chak # 32NP East, Basti Maitla Chak # 32NP West.	Urdu/ Punjabi / Saraiki	Sanjarpur
3	Rahim Yar khan	Liaquatpur	Hayyat Lar Chak # 124 NP Rasheed Abad	Urdu/ Punjabi / Saraiki	Hayyat Laar
4	Rahim Yar khan	Khanpur	Basti ShieKhan Chak # 28P Chak # 29 P	Urdu/ Punjabi / Saraiki	Basti Sheikhan

Annexure 2. Questionnaire for FGDs

Research Topic: Understanding Groundwater Governance NEXUS Gains

Please make sure that the participants of all the tehsils in each district are represented in the FGDs.

Instructions to researchers: At least one researcher and one recorder/note-taker are needed to conduct a focus group.

Name of the researcher _____

Name of the recorder/note taker _____

Name of the observer _____

Introduction: Thank you for participating in this discussion. We are going to have a conversation today about how groundwater is used in this area, what it is used for, and how its quality and quantity has changed over the years. Your opinions are important to us and will help us learn ways we can improve groundwater management and governance in [RYK/Pishin].

1. Demographic Characteristics of the Participants

1.1. Location

Region /____/ Department /____/ Commune /____/ Village /____/ Tehsil/____/ Date /____/ Hour /____/ GPS Coordinates (if possible)

1.2. Characteristics of the focus group participants

(note—convert names to numbers during translation, try to keep FGD size at 8-10 participants)

Sr. #	Sex 1=Man 2=Woman	Age	Level of Education 1=not literate 2=less than primary 3=Primary 4=less than secondary 5=Secondary 6=Higher secondary 7=B.A/ M.A.	Occupation and position in the village	Using groundwater for					
					Irrigation	Drinking	Other domestic	Livestock watering	Small business	Other
1										
2										
3										
4										
5										
6										
7										
8										

9										
10										

2. Main Activities of the Communities

1. In your community, what activities are most important for income and food security?
2. Among family members, who is primarily responsible for this activity? (men, women, young, old?)
3. In what seasons do people need groundwater for this activity?
4. What are the most important activities for women?
5. What activities are most important to men?
6. What activities are most important to male youth?
7. What activities are most important to female youth?
8. Are people now doing new things to increase their income and ensure food security that they did not do before?

3. Groundwater Usages

Theme 1: General use of water (current practices)

I'd like to start the conversation about your current practices and usage related to groundwater.

- What are the key sources of water in your village?
 - What is their quality? Does the quantity and quality vary by season?
- Please describe how groundwater functions here in this village.
- For what purposes do people in this area use groundwater? (e.g., farming, kitchen garden, domestic use, etc.)
- Is there competition between uses, like irrigation and drinking water?
 - Do men and women use groundwater differently? If so, how?
 - Are there other sources of water that are also used? What are these sources?
 - For what purpose the groundwater is used the most in this area?
 - Has this changed over the last 5 years? 10 years?
 - In which season is the groundwater available sufficient?
- What is the main mode used to extract groundwater? (e.g., hand pump, HP Pump, solar pump, solar tubewell, diesel pump, electric tubewell, etc.).
 - Ask about awareness of each option – which do they think is best and which option do they prefer and why? (Especially note reasons given by women)
- Have methods to extract water changed?
- Are there more sources today than 5 years ago?
- How often do you extract groundwater for your needs? Daily, multiple times a day, weekly basis, etc.?
- When is it available? Can everyone in the village access it?
- Is groundwater better or worse than surface water?
- Who usually collects water in your household? (for economic activities and for domestic use?)

- How much time is spent on water collection? How does that affect other activities?
- Are you satisfied with the amount of water you receive through extraction?
- Do you feel all farmers and other water users/industries have equal access to extraction of groundwater? (Explore and probe – who has most access and why, do small farmers have access, women, etc. Who can access groundwater first?)
 - Who makes the decisions on how, when, and who can extract? Is there any decision-making or governance mechanism? Can everyone participate in decision-making? Whose voices/opinions are usually left out?
- If you are a farmer who uses groundwater, is your land owned, leased, or share-cropped?
 - If you own or lease what is the size of your farm holding?
- Do you do anything to store groundwater for future use?
 - If yes, how do you store and how long does that water last?

Theme 2: Groundwater quality and quantity (changes observed)

Now I'd like to talk about the groundwater quality and quantity and if you've experienced changes overtime.

- How would you rate or describe the groundwater quality in your area? Are you satisfied with the quality? Why or why not?
- If not:
 - What are some of the problems with groundwater quality in this area?
 - What do you think are the reasons (man-induced or natural) for increasing groundwater depletion and poor quality of groundwater?
 - Do you think anything can be done to fix this?
- Has poor water quality or quantity affected migration in/out of this area?
- Has health of humans and livestock been affected?
 - Who is getting sick from water-related illnesses – children, adults?
 - What are the coping strategies to deal with the changing water quality?
- In your opinion, have there been changes in groundwater levels in this area over the years?
 - When would you say groundwater levels started depleting (or rising), since how many years?
- Has groundwater depletion affected your livelihood or daily activities/household life?
 - Please share specific examples.
 - For farmers, how has water availability affected cropping patterns over the last 10 years?
- What do you think will be the status of groundwater quality and quantity in the upcoming years?
 - Have you thought of any different strategies to adopt to ensure you will have enough water?

Theme 3: Technology/Hardware for Groundwater Extraction

Now I'd like to shift our discussion to the actual technology/hardware used for groundwater extraction and the associated costs.

- Are there any public or communal tubewells?
- Who is able to install tubewells? What is the average installation and operational cost?
 - Is this affordable for small farmers? What about affordability for other water users?
 - Does the cost differ by use?
- Are the tubewells in your area powered using electricity or diesel?
 - Do you know the pros and cons of using electricity versus diesel?
- Do we need new technologies to manage groundwater?
- Should women learn about these new technologies and how to use pumps?
- Do you think there are better alternatives to groundwater? Are other sources available?

Theme 4: Support Mechanisms

Now I'd like to move on to discuss support mechanisms in relation to groundwater availability in this area.

- Are there any farmer or community organizations or water user associations currently in place that monitor and regulate groundwater use?
 - How active are they? Who is mainly involved
- Is there any 'government or private groundwater' water authority in your area?
 - Should there be? Do you think an authority like this could be useful?
 - What should it do?
 - Do you think women could participate in the decision-making process of these groups/authorities?
- What do you think is the role of politics/government in groundwater management (quality, quantity, monitoring extraction, etc.)
 - Is the government able to monitor groundwater quality/quantity?
 - If not the government, who is responsible for overseeing groundwater use, distribution, etc.?
- Do you know about any projects or practices for groundwater recharge?
 - Have there been any salinity or reclamation projects implemented in this area?
- Do representatives from provincial water departments hold dialogue with stakeholders and communities affected by groundwater management to take their viewpoint when designing policies?
 - Would you participate in discussions like this?
- What kind of support do you need in terms of accessing groundwater?
 - What ideas do you have of the kind of policies or interventions that should be put in place to improve groundwater quality, quantity, and fair monitoring?
 -

Theme 5: Rules, Legislation and Monitoring

I'd like to expand more on legislation and mechanisms for groundwater regulation

- What is the current system in place (norms, institutions, and rules, etc.) for groundwater management?
 - Is there a formal system or more informal system?
 - Are the rules or regulation applied?
- Is there any management system in place for both surface and groundwater?
- Is there any mechanism currently in place to regulate monitoring of water pumping in your area?
 - If yes, has measurement and monitoring of groundwater level been conducted in your area? How often?
 - Is the monitoring useful? How do you think monitoring of pumping should happen? Who should be in charge of allocation and how can we maintain fair distribution and access of water?
- The National Water Policy 2018 and Punjab Water Act 2019 highlight that an integrated water resource management (IWRM) approach should be adopted to deal with issues arising from unsustainable and unplanned abstraction of groundwater. Are you familiar with the NWP? Punjab Water Act? (For Pishin: do you know of any water policies in Balochistan?)
- Do we need more/new policies to manage groundwater?
- Do you have access to data/information on the levels and quality of groundwater in your area?
 - If data were available, would you want to see it? How would it help you?
 - What information would be useful for you to know?
 - Do you think men and women have equal access to information about water?
- Is there a mechanism in place to track occurrence and source of water contaminants?
 - What should be done to control contamination?
- What steps do you think can be taken to improve groundwater governance in your area?

Theme 6: Impact of Floods

I'd like to conclude our discussion by talking about the ongoing flood crisis in the recent months and how you have been impacted.

- How have the recent floods impacted your livelihoods? (agriculture, livestock, aquaculture, etc.)
 - How have they affected your household/family?
 - Probe about economic and social impacts.
- How has groundwater and surface water been affected by the flooding?
- Are there any rules during flood events?
- Were you prepared at all to handle the floods? If yes, how so?
 - What strategies or coping mechanisms have you adopted since the floods to rebuild?

- What kind of support is needed to get back on your feet?
 - What kind of support do women need v. men?
- What rules should be put in place?
- How frequently does this area flood? Have there been floods before? When?
 - In previous flood situations, how did you cope?
 - Did you adopt any new technologies or strategies to deal with losses?
- Are there rules when there is a drought in terms of who can access groundwater and how it can be used?

Thank you for taking the time to discuss this topic with me today. Is there any other information you'd like to share about groundwater or other water issues?

Annexure 3. Characteristics of the participants selected for FGDs in Pishin

Table A-5: Age group of the male respondents in Pishin

Age group	Number of Respondents	Percentage (%)
24-30	6	15.00
31-36	12	30.00
37-42	9	22.50
43-49	5	12.50
49-68	8	20.00
Total	40	100.00

Table A-6: Level of education of male respondents in Pishin

Level of Education	No. of Respondents	Percentage
Not Literate	7	17.5
Less than Primary	8	20
Primary	3	7.5
Less than secondary	3	7.5
Secondary	4	10
Higher Secondary	2	5
B.A/M.A.	13	32.5
Total	40	100

Table A-7: Occupation of male respondents in Pishin

Occupation	No of Respondents	Percentage (%)
Agriculturalists	32	80
Agribusiness	5	12.5
Agriculturalists and with other occupations*	3	7.5
Total	40	100
* work in the government, NGO or student		

Table A-8: Groundwater usage by male respondents Pishin

Purpose for which groundwater is used	No of Respondents	Percentage ²³
Agriculture	40	100
Drinking	40	100
Household use	40	100
Cattle	30	75
Small Business	3	7.5
Others	1	2.5

²³ The percentage total is greater than 100, as it was a multiple response question.

Table A-9: Age group of female respondents in Pishin

Age group	Number of Respondents	Percentage (%)
13-22	16	32
23-32	12	24
33-42	12	24
43-52	6	12
53-62	4	8
Total	50	100

Table A-10: Education level of female respondents in Pishin

Level of Education	No of Female Respondents	Percentage (%)
Not Literate	24	48
Less than Primary	1	2
Primary	2	4
Less than secondary	8	16
Secondary	7	14
Higher Secondary	7	14
B.A/M.A.	1	2
	50	100

Table 11: Activities of female respondents in Pishin

Activities	No of Respondents	Percentage (%) ²⁴
Households	50	100
Livestock	11	22
Irrigation	4	8
Embroidery/Stitching	3	6
Teaching/Studying	3	6

Table A-12: Purpose for which groundwater is used by female respondents in Pishin

Purpose for which groundwater is used	No of Respondents	Percentage ²⁵
Irrigation	4	8
Drinking /Domestic	50	100
Livestock watering	11	22
Small business	6	12
Other	-	-

²⁴ The percentage total is greater than 100, as the it was a multiple response question.

²⁵ The percentage total is greater than 100, as the it was a multiple response question.

Annexure 4. Characteristics of the participants selected for FGDs in RYK

Table 13: Age group of male respondents in RYK

Age Group (Year)	No. Of Respondents	Percentage (%)
21-30	11	29
31-40	10	26
41-50	6	16
51-60	7	18
60-70	4	11
Total	38	100

Table A-14: Level of education of male respondents in RYK

Level of Education	No. of Respondents	Percentage
Not Literate	8	21
Less than Primary	0	0
Primary	6	16
Less than secondary	11	29
Secondary	8	21
Higher Secondary	2	6
B.A/M.A.	3	8
Total	38	100

Table A-15: Occupation of the male respondents in RYK

Occupation	No. of Respondents	Percentage ²⁶
Agriculture	37	97
Livestock	37	97
Sharecropper	1	3
Own business	1	3

Table A-16: Groundwater usage by male participants in RYK

Purpose for which groundwater is used	No. of Respondents	Percentage ²⁷
Irrigation	38	100
Drinking	38	100
Other domestic	38	100
Livestock watering	37	97
Small business	2	6
Other	0	0

²⁶ The percentage total is greater than 100, as the respondents were engaged in multiple income generating activities.

²⁷ The percentage total is greater than 100, as the it was a multiple response question.

Table A-17: Age group of the female respondents in RYK

Age group (years)	Number of Respondents	Percentage
11-20	6	15
21-30	15	37.5
31-40	13	32.5
41-50	4	10
51-65	2	5
Total	40	100

Table 18: Level of education

of female respondents in RYK

Level of education	Number of Respondents	Percentage
Not Literate	26	65
Less than Primary	1	2.5
Primary	7	17.5
Less than secondary	2	5
Secondary	4	10
Higher secondary	0	0
B.A/M.A.	0	0
Total	40	100

Table A-19: Occupation of the female respondents in RYK

Occupation	No of Respondents	Percentage
Livestock	3	7.5
Agriculture farming	27	67.5
Agricultural labour	5	12.5
Other labourer work on daily wages	3	7.5
Other business (handicrafts)	2	5
Total	40	100

Table A-20: Usage of groundwater by female respondents in RYK

Purpose for which groundwater is used	No of Respondents	Percentage ²⁸
Irrigation	29	72.5
Drinking	21	52.5
Other domestic	33	82.5
Livestock watering	30	75
Kitchen gardening	19	47.5

²⁸ The percentage total is greater than 100, as it is a multiple response question.

Annexure 5: List of selected key informants for interviews

Study Tools	International Organization	National/Federal	Provincial	Local	Total
Key Informant Interviews (KIIs)	1.World Bank (2)	2.Pakistan Council of Research in Water Resources (PCRWR) (1) 3.Water Resources Section, Ministry of Planning, Development and Special Initiatives and Planning Commission (1) 4.Water and Power Development Authority, Ministry of Water Resources (1)	1.Irrigation Department, Government of Punjab (1) 2.Irrigation Department, Government of Balochistan (1) 3.On Farm Water Management, Government of Punjab (1) 4.On Farm Water Management, Government of Balochistan (1) 5.University of Engineering and Technology (1) 6.International Water Management Institute (IWMI) (1)	1. On Farm Water Management (2 KIIs - 1 in each district) 2. Irrigation Department (2 KIIs - 1 in each district) 3. Stakeholders working on groundwater resources (2 KIIs - 1 in each district)	17 KIIs
	Total 2	Total =3	Total = 6	Total = 6	

Annex 6: Questionnaire for KIIs

Research topic : Qualitative formative study on understanding of groundwater governance in preparation for quantitative survey, Pakistan (NEXUS Gains)

Thank you for taking the time out for this interview. This interview is being conducted as part of the Nexus Gains Activity on groundwater governance. The qualitative formative study will help in building understanding on groundwater governance in Pakistan.

Time duration: The interview will last for 60-90 minutes.

Informed consent statement will be shared separately with the key informant.

Department of the key informant: _____

1. How are your current or past employments or studies linked to groundwater management in Pakistan? Please describe your experience.
 - In which areas are you currently working on?
2. For national key informants: can you describe how alluvial and hard rock aquifer areas function in Pakistan?
 - For province/district/local key informants: Are alluvial or hard rock aquifer areas found in your province/district/local area? How are the aquifers managed in your area?
3. How do alluvial/hard rock aquifers operate during droughts and floods?
4. How is groundwater used by women and men in rural areas?
 - Do you think women have the same access to groundwater resources when compared to men?
5. How has groundwater extraction evolved over the last 20 years? Will groundwater be sufficient in the future? *(probe for changes in methods of extraction, changes in quantity of extraction, etc; in Pakistan linkage to recent severe flood event.)*
 - What other things do you think we do know and what do we not know about groundwater in Pakistan?
6. In your opinion, how is groundwater currently being managed in the country/province/district/local—depending on the location of the key informant). *[Probe for legal and administrative situation and any institutions that might be in place].*
7. What norms, institutions, and rules are in place for groundwater management in your area (hard rock versus alluvial locations)? What legislative measures do you think should be put in place ?
 - How can a legal framework for groundwater management be developed ?
 - How can various laws for effective management of groundwater can be implemented with the involvement of groundwater users ?
 - The National Water Policy focuses on dealing with groundwater over-abstraction and also called for the creation of Groundwater Authority but so far no follow-through has been made on its implementation. What do think were the hurdles in creating the said authorities ?

- How do you think the creation of such authorities would help ?
 - The mandate of provincial irrigation and drainage authorities is to define groundwater extraction rights and empower water user associations. In your opinion, what progress, if any, has been made in this context ?
 - The National Water Policy calls for the adoption of integrated water resource management. What do you think can be done for successful adoption of IWRM approach ?
 - In your opinion what are the holistic approaches to optimize surface and groundwater use efficiencies ?
 - In your opinion, are there any strategies in place to explore the possibility of supplementing groundwater supplies with surface water for longterm sustainability ?
 - Do you have any idea what initiatives are currently in place, if any, to mitigate the impact of unregulated and unplanned groundwater abstraction ?
8. Is there any coordination mechanism between different departments/stakeholders to formulate a coordinated strategy and action plan to manage groundwater resources ?
 - If yes, can you please shed some light on the strategy ?
 - If no, what do you think can be done to develop a knowledge sharing mechanism that can aid in the formulation of coordinated strategy ?
 9. In your opinion, what are the institutional challenges in the context of groundwater management ? (Probe : what are the major bottlenecks to sustainable groundwater management : unavailability of needed data and information, lack of political will, and absence of relevant institutional arrangements).
 10. What efforts, if any, are being made to conduct monitoring of groundwater extraction ?
 - Is there any mechanism in place for demarcation of critical groundwater zones, licenses for tubewell installation in critical zones, and regular monitoring of pumping for all tubewells ?
 11. What do you think can be done to clearly define the roles and responsibilities of different organisations as well as appropriate institutional arrangements for monitoring and evaluation of groundwater and implementation of national policies on groundwater management ?
 12. Has any steps been taken or programs designed for capacity building of the staff on groundwater management ?
 - How can the capacity of organisations be developed to solve entitlement, pricing and regulatory issues ?
 13. Is there a regulatory framework in place to strengthen partnerships with the private sector on groundwater management ?
 - How can the private sector and civil society be engaged for the adoption of integrated water resources management ?
 14. What do you think can be done to protect the rights of smallholder farmers over groundwater ?

15. In your opinion, has groundwater governance received the attention that is needed to deal with the current crisis of falling water table and unequal access ?
16. What is your opinion on the massive development of private tubewells and informal groundwater markets ?
17. How do you think can accurate and timely information on the discharge and recharge patterns can be shared with groundwater users ?
18. What can be done to improve governance of groundwater resources in Pakistan and make groundwater governance sustainable in the long run? In both hard rock and alluvial locations?
 - In your opinion, what are the multiple tiers where interventions can occur ?
19. In your opinion, what can be done to improve knowledge of groundwater resources ?
20. How can the scattered groundwater datasets in the provincial and federal departments be streamlined and digitized ? (Probe : systematic long-term monitoring and archiving of groundwater data are largely absent. How do you think reliable database can be created to guide policy making?)
21. In your opinion, how can equity be ensured for different users of groundwater ?
22. In your opinion, how can institutional accountability be created ?
23. How can effective outreach work (communicate groundwater information) be conducted to create incentives that would encourage a change in behavior and targeted management interventions ?
 - How can public participation be enhanced in charting out solutions for groundwater management ?
24. What steps, if any, are being taken to understand the dynamics of groundwater use in agriculture and its impact on socioeconomic conditions of the farmers and environment ?
25. In your opinion, what is the long-term cost and other consequences of groundwater irrigation in Pakistan ?
26. How can evidence-based pathway to sustainable groundwater management can be delineated ?
27. What do you suggest we study about groundwater to improve resilience and governance?

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