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Article

Integrating Local Knowledge and Institutional Analysis to Address Soil Salinity in Agro-Based Rural Communities

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ABSTRACT

Soil salinity poses a global threat to agricultural productivity, affecting over one billion hectares, including 2.5 million hectares in Pakistan. This study examines how farmers in Jalalpur Pirwala adapt to salinity through locally driven strategies. Using the Critical Institutional Analysis and Development (CIAD) framework and participatory methods based on the Stakeholder Engagement for Research and Learning (SERL) approach. Data was collected by focus group discussions (FGDs) with 33 farmers engaged in the project. The analysis revealed challenges such as inadequate education and health services, poor soil and water quality, and limited access to agricultural extension services. Despite these challenges, the community demonstrated resilience by adopting advanced farming practices and early sowing through co-inquiry, leading to improved crop yields and livelihoods. The study underscores the importance of integrating local knowledge and socio-ecological dynamics into sustainable salinity adaptation strategies. It contributes to broader discussions on climate change adaptation and sustainable agriculture and offers key insights for stakeholders and policymakers.

Keywords: Soil Salinity; CIAD; Community Development; Farmers' Adaptation; Pakistan

1. Introduction

The increasing threat of soil salinity not only affects agricultural productivity and soil health but also affects farming communities by decreasing their livelihood, leading to an environmental-cum-socioeconomical concern to the world. Recently, Hopmans et al. (2021) reported that over one billion hectares of soil are affected by salinity, which is persistently increasing by over two million hectares per annum (Singh, 2018). This issue now extends to over 100 countries (Hammam & Mohamed, 2020), with the affected areas found in Pakistan, India, China, the United States, Sudan, and Turkey (Lal, 2004; Seifi et al., 2020).

In Pakistan, the effect of salinity is very drastic; about 6.3 million hectares of land are affected by saline soil (Z. Sathar & Khan, 2019). According to Pakistan's Nuclear Institute for Agriculture and Biology (NIAB) estimates, the salinization of soils in Pakistan is increasing by 40,000 hectares each year (Evans, 2023). Agricultural land deprivation due to salinity has posed a significant challenge for farmers who rely on their land for livelihoods (Hossain et al., 2020). The loss or decrease in agricultural productivity due to salinity results in reduced farmers' income, which tends to increase their vulnerability to poverty and food insecurity. The effects of salinity extend beyond the control of individual farmers. It affects the entire community and influences the social rest and economic stability among people in communities (Thaker et al., 2021). These facts highlight that there is a need for community action, not just for environmental protection but also for the well-being of farming communities and societal stability.

Most of the areas in Punjab and Sindh provinces depend on the Indus Basin Irrigation System (IBIS) to meet their agricultural and domestic water consumption needs. The Indus River contributes to over 90% of Pakistan's agricultural output and accounts for about 25% of the country's GDP (Zahra et al., 2023). Climate change and poor water management practices at the canal and farm levels result in water scarcity throughout the

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IBIS (Kamal, 2023). This scarcity, combined with the overuse of saline water for irrigation, results in the higher accumulation of salts in the soil in Pakistan. The Indus River basin is highly vulnerable to salinization, and the primary reliance of agriculture on this irrigation system has worsened the soil situation at the field level (Qureshi & Perry, 2021) . Due to the lack of access or scarcity of surface water, farmers are forced to pump saline groundwater to irrigate their fields, which results in more salt in the soil (Qureshi et al., 2008).

Pakistan and its farming communities are living through an economic burden posed by soil salinity, affecting agricultural productivity and rendering vast areas of land unproductive (Majeed & Muhammad, 2019). Inadequate irrigation practices, poor drainage systems, use of saline underground water, and changing climatic patterns are some major concerns that have worsened the problem of soil salinity in Pakistan. These factors do not account only for the accumulation of salts in soils, further degrading the soil quality and reducing the productivity of soils, posing challenges for future food security (Nachshon & Levy, 2023). One of the major contributing factors to soil salinization is the excessive extraction of low-quality groundwater for irrigation. More than 90% of the total groundwater abstracted is used to irrigate in Punjab province, with 73% of Pakistan's irrigated land supplied by groundwater (Qureshi, 2020). Overutilization of groundwater in semi-arid zones for irrigation purposes has decreased the water quality, which has further increased salinization in the area (Murtaza & Zuhra, 2024).

Over the last few decades, Pakistan has implemented many mega projects, schemes, policies, and debates to address the escalating issue of salinity in the country. A review conducted by Ali (2023) highlighted that many of these large projects had a hard time managing the issue of salinity and often didn't last. Ali emphasized the need to shift away from large-scale engineering projects, advocating instead for numerous small, farm-level interventions to address salinity more effectively. Since complete mitigation of salinity at this scale remains unfeasible, the only viable approach is to manage and reduce its impacts through physical, biological, and chemical methods (PCRWR, 2023).

This farm-level approach should involve farmers in inquiry, designing, and creation of solutions with clear benefits in collaboration with academia, researchers, and other stakeholders of the agriculture sector in the targeted communities. This would result in an approach of co-inquiry, co-designing, and co-creation of knowledge to address the issue of salinity in the area at the community level engagement, most cost-effectively and efficiently. Since farmers know their land best, they can help create good solutions for dealing with salinity. This method uses farmers' traditional knowledge and practical experience, making them feel more responsible and involved in the process (Frank et al., 2022; Pawera et al., 2024; Utter et al., 2021). Furthermore, combining traditional practices with modern world practices and technology can bring an effective management strategy to manage salinity at the farm level. For example, the cultivation of crops with mulch can reduce evapotranspiration, reduce weed cultivation in the field, and cultivation of salt-tolerant crops, and vertical cultivation of vegetables and fruits can enhance the productivity of land and provide good economic returns to the farmers (Cuevas et al., 2019; Korres et al., 2022).

A project titled "Adapting to Salinity in the Southern Indus Basin (ASSIB)" was implemented at a series of case study sites across South Punjab and Sindh in Pakistan. The investigations were implemented at the farm level with the focus on managing salinity and improving farmers' livelihoods through co-inquiry and collaboration. The project uses biological methods, such as planting salt-tolerant species and applying organic materials like compost and green manure, to improve soil and reduce salinity, while conjunctive use of irrigation water enhances water efficiency and reduces salt buildup. The project aims to provide knowledge about salinity to those involved in development, improve farmers' understanding of salinity adaptation options, and build their capacity, including women and youth, to plan their futures for adapting to salinity for better livelihood and food security. It also seeks to engage academia, researchers, government departments, policymakers, and other allied institutions to work together to create and implement strategies that address the root causes of soil salinity and promote sustainable farming practices, focusing on better water management, soil fertility, and the use of salt-tolerant crops.

This study investigates how farming communities in Jalalpur Pirwala are adapting to salinity through locally driven and context-specific strategies. Grounded in the Critical Institutional Analysis and Development (CIAD) framework and guided by participatory principles from the Stakeholder Engagement for Research and Learning (SERL) approach, the research emphasizes the role of local institutions, social dynamics, and biophysical conditions in shaping adaptive capacity. Data were gathered through Focus Group Discussions (FGDs), enabling a nuanced understanding of how farmers perceive salinity, mobilize resources, and implement adaptation practices at the farm level. By critically assessing these strategies, the study aims to generate practical insights for designing inclusive, low-cost, and sustainable solutions for salinity management, with relevance for both policy formulation and on-ground agricultural interventions.

2. Study area context within the CIAD framework

2.1. Rules and resource

Rules and resources of the study are explained as follow.

2.1.1. Biophysical and material

Jalalpur Pirwala tehsil[1] is situated approximately 90km south of Multan. The town has a rich history dating back to the pre-Mughal era, when it was a part of the Delhi Empire. The town has a unique cultural heritage, which is reflected in its traditions and architecture. Historically, the biophysical environment of Jalalpur Pirwala has undergone significant changes. Originally characterized by its fertile plains and abundant water resources from the Sutlej River, the area has seen alterations due to both natural and anthropogenic factors. These issues have been exacerbated by over-extraction of groundwater and intensive agricultural practices, leading to a decline in soil health and agricultural productivity (Z. Hussain, 2024). The introduction of canal irrigation systems during the British colonial period drastically transformed agricultural practices (Ali, 2016). These changes improved agricultural productivity but also led to issues such as waterlogging to some extent and salinity. In recent decades, climate change has impacted the region's weather patterns, affecting crop yields and water availability. Studies indicate an increase in temperature and variability in rainfall, posing challenges to traditional farming methods (Asif, 2013).

According to Hussain et al. (2020) changes in the vegetation and forest area across the Multan district were observed from 1988 to 2017. The area under crops of rice and cotton was reduced by 7.1 percent and 4.3 percent, respectively, from 1988 to 2017. The study also explained that the area under the rice crop was converted to other crops and built-up areas. Some changes have been noticed in the case of wheat ground coverage. During the last 30 years, the building area was also found to have increased to 7.2%. Water area has also decreased by 0.6% and 0.4% during the rabi and kharif seasons, respectively, from 1988 to 2017.

Ali et al. (2022) explored that groundwater levels decreased in Jalalpur from 2015 to 2019 due to low rainfall and river discharge, except for the years 2010 and 2015 when floods took place. Ahmed et al., (2015) concluded that out of 260 pumped groundwater samples from Jalalpur Pirwala, 71 (27.3%) were found fit for irrigation purposes based on the level of salt content, 10% were marginally fit, while 120 (46%) were extremely unfit due to the application of brackish water directly in the soils.

2.1.2. Political economy

The political structure during the pre-colonial era was largely feudal, with local landlords (zamindars) holding significant power. During the British colonial period, Jalalpur Pirwala was part of the broader administrative framework of British India. The introduction of the canal irrigation system under British rule transformed the agrarian economy and increased agricultural output. The colonial policies also introduced new land ownership patterns, which have had lasting impacts on the region's socioeconomic structure (Gilmartin, 1994). Following Pakistan's independence in 1947, the political scene in Jalalpur Pirwala evolved with the establishment of new governance structures. The introduction of local government reforms and political decentralization in the 2000s further changed the political dynamics, promoting local participation and development initiatives (Cheema et al., 2005).

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[1] In Pakistan, a tehsil (also known as taluka in Sindh Province) is an administrative sub-division of a district. It's a territorial unit below the district level, further divided into smaller units called union councils. Essentially, it's a second-tier administrative division in Pakistan's local government system.

According to the census of 2017, its total population is 588,068 (304,794 male and 283,274 female), and the population growth rate of 2.2%. The tehsil has 17 union councils covering an area of 978 square km (NDMA, 2020). It has an agricultural background, and its main sources of income are agriculture and trade. Foreign remittances add to the income of many families. The tehsil is now connected to the China-Pakistan Economic Corridor (CPEC) via the Lahore-Karachi Motorway. The tehsil is divided into 114 mouzas; 109 are rural, 4 are urban, and 1 is unpopulated. The education status shows that there are 260 schools (189 primary, 38 middle, 22 high, and 3 higher secondary schools, with another 8 established in mosques). The average distance to a health facility is 11 km, 12 km to a veterinary facility, and 86 km to an education facility. Government veterinary facilities are available in 66 mouzas, with private veterinary facilities available in 24. Electricity is available in 108 mouzas (GOP, 2020).

2.1.3. Social Attributes

Naqvi and Ibrar (2015) studied the degree of consideration of women's decisions in family matters in Multan District. 58.33% of women surveyed said that their opinions on family matters are not at all considered, 22.5% indicated their opinions are sometimes considered, and 19.16% indicated their opinions were given due weightage. The study found that most respondents were illiterate because their brothers were against girls receiving education and opposed that right. Most respondents indicated that traditions and culture are the main hurdles in restricting women's role in decision-making, while some saw the cause as being a lack of education and empowerment for women.

2.1.4. Discourse

As per the census of 1988 of Pakistan, 67% of the population in the district of Multan is Saraiki-speaking. There are 07 ethnolinguistic groups in the district of Multan, which are Saraiki, Haryanvi, Punjabi, Urdu-speaking Muhajir, Sindi, Pashtun, and Baloch with populations of 66.58%, 14.59%, 11.14%, 5.68%, 1.04%, 0.62% and 0.07 % respectively. History reveals that the first effort to reclaim salinity and waterlogging started with the initiation of the Colombo Action Plan (1953-54). Under this, two important institutions were established, namely WAPDA in 1958 and Irrigation Drainage and Flood Control Research Council in 1964, which was renamed as Pakistan Council of Research in Water Resources (PCRWR) in 1985 (Bhutta & Smedema, 2007).

About 6 SCARP (Salinity Control and Reclamation Projects) were implemented from 1964 to 2000 by the government. During the same time, various infrastructure projects were also implemented with the help of the World Bank, which include two large dams (Mangla in 1967 and Terbela in 1976) and a network of five barrages and eight link canals (Briscoe et al., 2005). During the 1980s, a major project, Left Bank Outfall Drain (LBOD), was launched and concluded in 1995 under the project, surface drains of 195 km, 2000 tubewells, and 5999 structures were built (Qureshi et al., 2008). Another program of the National Drainage Program started in 1997 and concluded in 2004 with the objectives of policy reforms and institutional evolution for sustainable management of surface and groundwater, along with maintenance of irrigation networks. In short, the projects achieved success on a small scale (Ashraf et al., 2022).

2.1.5. Rules and Norms

Traditionally, the social structure of Jalalpur Pirwala was hierarchical, based on caste and kinship. The joint family system was prevalent, with strong community ties and patriarchal norms. The establishment of educational institutions during the colonial period and post-independence has gradually altered social norms. Increased access to education has facilitated social mobility and changes in traditional gender roles (Sathar and Lloyd, 1994).

In recent years, there has been a gradual shift towards more egalitarian social norms, influenced by increased educational opportunities, urbanization, and migration. These changes have started to challenge traditional power dynamics and gender roles, promoting a more inclusive society (Gul & Farooq, 2019). Globalization and modernization have influenced social norms, leading to shifts in marriage practices, family structures, and gender roles. However, traditional values and customs still play a significant role in the social fabric of the region (Ali et al., 2021; NESPAK, 2012).

2.2. Social Situation

Tehsil Jalalpur Pirwala, located within District Multan, Punjab, Pakistan, is geographically positioned in the southern part of Punjab. Its boundaries are defined by neighbouring tehsils and natural landmarks, which delineate its extent. To the north, Jalalpur Pirwala is bordered by other parts of District Multan. The eastern boundary of Jalalpur Pirwala adjoins District Lodhran. To the south, Jalalpur Pirwala shares its boundary with District Bahawalpur, and the western boundary is adjacent to Shujabad.

The River Chenab flows to the northeast of Jalalpur Pirwala, providing a significant water source for irrigation and contributing to the fertile soil in the region. The area is crisscrossed by a network of canals derived from the Sutlej and Chenab rivers. These canals are crucial for sustaining agriculture in Jalalpur Pirwala. The combination of these geographical boundaries and features shapes the agricultural and socio-economic landscape of Tehsil Jalalpur Pirwala, making it a vital part of District Multan's rural economy.

The total number of Mouzas (units of land) of the tehsil Jalalpur is 114, and out of that, 109 mouzas are rural, 04 are urban, and 01 is unpopulated (GOP, 2020). About 10% area of the tehsil is barren due to soil salinity and waterlogging (Soil Survey of Punjab, 2016). Water resources in Jalalpur Pirwala are crucial for agriculture and domestic use, primarily sourced from rivers, canals, and groundwater. Sources of irrigation water are canals for 80 mouzas, rivers for 18 mouzas, tubewells for 93 mouzas, and flooding for 07 mouzas. The average water table depth is 66 feet, which ranges from 50 feet to 250 feet (GOP, 2020).

The main challenges of the tehsil include land management and water management. Land management includes soil salinity and waterlogging. Poor drainage and excessive irrigation are the primary causes (Sajid et al., 2022). Periodic water shortages due to climatic variability impact agriculture, necessitating efficient water management practices (Asian Development Bank, 2021). Over-extraction for irrigation leads to declining water tables, threatening long-term water security (Punjab Irrigation Department, 2022).

3. Methods of the Study

The study employed the Critical Institutional Analysis and Development (CIAD) Framework, as articulated by Whaley (2018), to investigate the community decision-making processes within the farming community of Meerkot, located in the tehsil of Jalalpur Pirwala in the Multan district. This framework is particularly advantageous for structuring research agendas, as it emphasizes the most relevant aspects of the situations under scrutiny. The focus of this research is on the Meerkot community's efforts to address challenges related to agricultural productivity and sustainable livelihoods, which are exacerbated by their reliance on saline soils. Such environmental conditions complicate farming practices and necessitate innovative strategies for resource management.

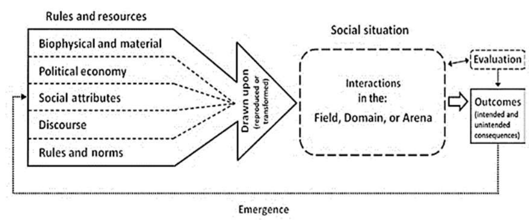

Figure 1. The CIAD Framework; Source: Whaley (2018)

To collect pertinent data, a Focus Group Discussion (FGD) was conducted with community members, facilitating comprehensive discussions about their collective experiences and coping mechanisms. The insights garnered from this FGD were systematically organized and analysed through the lens of the CIAD framework. This methodological approach enabled a nuanced examination of how land resources, while managed on an individual basis, are utilized collaboratively, underscoring the community's cooperative decision-making processes.

For focused group discussions, a total of 33 participants were selected to ensure representation across the different ages, genders, and farm sizes, particularly considering the farmers who are actively engaged in project-related activities. To accommodate farmers' availability and facilitate meaningful discussion, participants were organized into five smaller groups comprising 7, 8, 6, 7, and 5 participants, respectively. Although conducted in parallel sessions on the same day, these group discussions collectively constituted a single FGD event, guided by a shared protocol and facilitation team.

Few similar studies have utilized the CIAD framework to explore community governance and resource management. For instance, Cleaver (2000) examined water management in the Nkayi district, Zimbabwe, highlighting the emergence of local institutions and their role in shaping governance dynamics. Cleaver's work aligns with the CIAD framework's emphasis on understanding the complexities of institutional arrangements and the interplay between structure and agency in resource management contexts. Furthermore, research by Armitage (2005) has also contributed to the discourse on community-based resource management, emphasizing the significance of local governance systems and their adaptive capacities in the face of environmental challenges. These studies collectively reinforce the relevance of the CIAD framework in analysing the intricate relationships within community decision-making processes and the governance of common resources.

4. Results and Discussion

4.1. Rules and resource

4.1.1. Biophysical and material

The people of Meerkot (a village in Kotli Adil union council) face significant challenges related to education and health facilities. About 60% of the population is illiterate, and among the 40% who are literate, most have completed their education up to the primary school level. The reason behind this low level of education is mainly the unavailability of educational facilities close to the village, whereas the nearest high school and private schools are located about 3-5 km away. Similarly, the health facilities in the area are inadequate; there is only one clinic in the village, where the doctor is available only during the day rather than 24/7 services. Even the clinic operates without providing necessary medicines to the patients, and the nearest hospital is 15-18 km away from Meerkot in Jalalpur Pirwala city.

The area of Meerkot village extends over about 6,062 acres of land, of which only 77% of the land is used for agriculture, 20% for residential purposes, and the remaining 3% of land is classified as non-arable land. The groundwater table depth ranges from 60 to 75 feet in the area, and people dig bores up to 80 to 110 feet to pump groundwater normally. Table 1 describes the soil sample testing reports of the area, which reveals the occurrence of high salinity and sodicity levels in the area. The existence of salinity and sodicity in the soils of the area indicates poor soil quality and health that is adversely affecting the agricultural productivity in the region.

The poor water quality further worsens the problem of salinity in the area, as the water testing result presented in Table 2 shows that the water is not fit for irrigation purposes. Application of such poor-quality water in fields has even adversely affected the soil quality, as previously described in Table 1. The farming community agreed that this poor water increases the soil salinity in the area. On the other hand, the availability of canal water for only six months in a year has resulted in a major concern of water scarcity that does not meet the water requirements of crops in the area. Therefore, the farmers are constrained to use groundwater of such poor quality for irrigation. Table 2 describes the water testing result, which highlights that the water is not fit for irrigation.

Table 1. Soil Samples Testing Results

Sample #	Depth (Inches)	EC (dS/m)	SAR	pH	Soil Salinity Class
01	0" -6"	23.68	57.03	6.7	Saline Sodic
02	6" - 12"	10.18	28.26	7.83	Saline Sodic
03	0 - 6	37.36	37.90	7.82	Saline sodic
04	6 - 12	32.66	32.29	8.50	Saline sodic
05	12″	2.64	7.33	8.33	Non saline
06	0-6	40.2	11.62	7.51	Highly saline
07	0" -18"	2.81	5.9	8.1	Non saline
08	0" - 6"	4.10	5.2	8.2	Saline
09	6" -12"	5.75	5.6	8.3	Saline

Source: Compiled by the Author with information gathered from the Soil & Water sampling and testing team of the Project

Table 2: Water Testing Results for Irrigation Purposes

S. No.	Electrical Conductivity (µS cm-1)	Ca + Mg (meq/L)	Sodium (meq/L)	Bicarbonate (meq/L)		Residual Sodium Carbonate RSC	Sodium Adsorption Ratio SAR	Water Quality Category
01	4454	22	22.54	0.5	7.58	Nil	6.80	Unfit
02	3700	18	19	0.5	7.58	Nil	6.33	Unfit

Source: Compiled by the Author with information gathered from the Soil & Water sampling and testing team of the Project

It has been learned from FGD that wheat is the major crop for the rabi season, and cotton is for the Kharif season, whereas fodder crops like berseem and Jantar are also being grown by the farming community of the area to feed their livestock. Nevertheless, irregular rainfall and temperature patterns have affected crop yields in recent years, with incidents such as no grain formation in wheat at the maturity stage. Despite these challenges, early sowing practices and innovative farming techniques introduced by the ASSIB project have shown favourable results in improving crop yields.

A study on farmers' learning and successes by participating in a research project conducted by Kraaijvanger and Witteveen (2018) highlighted that delegating responsibilities to farmers in participatory experimentation increases farmers' natural, human, and social capital, while researchers gain insights into farmers' livelihood complexity. Similar results have been observed in the field after the involvement of the project team in the Jalalpur Pirwala community, resulting in better yield for farmers and higher returns on their produce, improving farmers' livelihood. Kraaijvanger (2018) also found that participatory experimentation, in which farmers lead the development of recommendations, can increase crop productivity and sustainability while empowering farmers and improving their social and human capital.

4.1.2. Biophysical and material

The extension services by the Government department are limited and inefficient in the Meerkot area. Government offices for agriculture extension, livestock, water management, and other allied agricultural services exist in Jalalpur Pirwala and Alipur cities, which are about 20 to 25 km away from the village. The participants of the FGD reported that before the ASSIB project intervention, the officials of these government departments merely visited the area; however, their visit frequency increased after the ASSIB project team's collaboration. The participants reported that only about 5% of the community hold government jobs, while most individuals work as labourers in nearby towns and cities. Due to the low literacy rate, the community has a very low level of awareness about government policies and subsidies offered to farming communities.

The ASSIB project team has played a pivotal role in introducing soil and water quality testing, innovative farming methods, and value-added techniques. The project has also facilitated visits from government department representatives, encouraging them to participate in project meetings and fostering a more collaborative environment. Multi-actor co-design processes can generate new and challenging interventions, highlighting the importance of effective communication and engagement initiatives across diverse communities. A similar response and communication among farmers and extension agents were observed by Macken-Walsh (2019). Furthermore, Lacombe et al. (2018) stated that the relationship between farmers and other local stakeholders (i.e., agricultural extension workers) plays a significant role in designing agroecological farming systems.

4.1.3. Biophysical and material

With the evolution of social systems around the world, the social system of village Meerkot has also evolved from a joint family system to a nuclear family system. The participants reported that about 95% of the families in the area are nuclear families. Along with the evolution of the family system, the dietary patterns of people have also evolved with time. Along with traditional food patterns, such as consuming Lassi and Makhan (butter) for breakfast, persist, and modern dietary patterns like purchasing cold drinks and fast food for guests are becoming more common among the people of the community.

To muddle through the persistence of high food inflation in the country, especially in rural areas where the sources of livelihood are limited, all family members, including children, worked in the fields to contribute to the household income. About every family in the area owns livestock at their convenience. As livestock ownership is widespread, each family typically owns 1-2 large animals (cows or buffaloes) and/or 2-4 small animals (goats or sheep), which are used to meet emergency expenditures as well. The participants added that now women are fully involved in household decision-making, reflecting a significant shift in gender roles. The community has embraced innovative agricultural practices introduced by the ASSIB project, leading to improved household incomes. The findings of this study are consistent with the results of Carnegie et al. (2020) who found that integrating women in technical learning through farmer-participatory crop benchmarking led to joint agricultural decision-making and agronomically sound farm practice changes.

4.1.4. Biophysical and material

The participants added that the community discussions in Meerkot mostly turn around agricultural challenges and salinity issues in the area. They further added that the communal sharing of knowledge has led to the adoption of various coping strategies to mitigate salinity and increase productivity. The people in the community are intensely aware of climate change and its impacts, stating that a significant change in patterns of rainfall and temperature over the last few decades. Such community-level discussions play a significant role in fostering a collaborative approach to solving problems faced by the people of the community. In this regard, the ASSIB project team has played a vital role in facilitating these discussions, introducing innovative agricultural practices to mitigate climate change, and highlighting the importance of soil and water quality testing, thereby improving overall agricultural productivity and livelihoods.

Llones et al. (2022) stated that higher participation in collective actions among farmers leads to improved production efficiency, but engagement in collaborative work has a marginal effect on efficiency. Similarly Fuchs et al. (2019) found that project participation, including land size, horticulture farming, and crop species richness, significantly improves farmer livelihoods through climate-smart agricultural practices. Hence, our findings are consistent with the findings of existing literature and have the same impacts as observed by the given studies.

4.1.5. Biophysical and material

The management of land in the village of Meerkot is a communal endeavor, which is led by the collective wisdom of the farming community of the area. Most of the farmers follow the social norms and abide by the rules set by the irrigation department for the distribution of irrigation water. The participants highlighted that the traditional practice of keeping land fallow for some time is no longer in practice in the area due to increasing salinity in the area and changing cropping patterns. To mitigate the salinity, traditionally, farmers of the area adopt many strategies like scraping of upper layer of soil, employing green manuring of Jantar/Sesbania, and application of gypsum in the field.

The ASSIB project team has introduced the farming community to new methods to live with salinity, including mulching of fields, sowing on ridges, and vertical vegetable cultivation, which have been adopted by some active and vigorous farmers of the community for better productivity and higher income. These innovative practices have become part of the community's evolving agricultural norms. Innovative agricultural practices include ridge-furrow mulching systems, sustainable water management, conservation agriculture, and vertical farming to optimize crop yield within sustainable environments (Shah and Wu, 2019). Moreover, Zhou et al. (2012) stated that ridge-furrow and plastic-mulching techniques can potentially increase crop yields in semiarid rainfed regions by enhancing soil microbial biomass and increasing soil light fraction carbon, and Beacham et al. (2019) stated that vertical farming approaches provide greater crop yield per square meter of land.

4.2. Rules and resource

The social dynamics of Meerkot village have changed significantly over the past few decades. About thirty years ago, community bonds were stronger, having mutual support in managing agricultural issues and social matters being more common than nowadays. The religious practices are maintained even now, although only a few individuals regularly perform their prayers. With the evolution of the family system, family functions have also shortened in duration, and modern food trends have influenced the traditional dietary habits of the people in the area. The installation of solar pumps in surrounding areas for groundwater extraction is increasing with time, reflecting a shift towards modern farming techniques. The ASSIB project team has had a profound impact on the community by introducing innovative methods to live with salinity and enhance livelihoods through better crop productivity and value addition in crops. Training of women of the community on vegetable value addition, such as making pickles, has been particularly well-received, highlighting the project's role in empowering women and enhancing household incomes. Adaptation strategies introduced by the project, including early crop sowing, mulching, and different sowing techniques, have significantly benefited the community, improving both agricultural productivity and livelihoods.

5. Conclusion and Recommendations

Field surveys and participatory discussions with farmers in Meerkot indicate a significant escalation in soil salinity, leading to the disruption of traditional agricultural systems and cropping patterns. Previously fertile lands, which once supported diverse crop cultivation, have experienced declining productivity due to progressive salinization. In the absence of formal institutional support, local farmers have predominantly relied on indigenous knowledge and community-based adaptation strategies. Documented practices include soil surface replacement, green manuring, and regulated fallowing to mitigate salinity effects and sustain soil fertility. These measures demonstrate the community's adaptive resilience in response to deteriorating agroecological conditions.

However, the study identifies a critical gap in farmers' access to advanced, science-based salinity management techniques. To address this, the adoption of ridge sowing, vertical cultivation, and organic mulching is recommended to enhance soil structure, water retention, and long-term productivity. Additionally, given the pivotal role of women in agriculture, targeted capacity-building initiatives should be prioritized. Empowering women through training in climate-resilient farming, sustainable livestock management, and value-added agro-processing could strengthen household income and improve community-wide adaptive capacity. Based on the findings, we put the following recommendations.

From a CIAD perspective, the persistence of saline soils and poor-quality groundwater represents not only a biophysical constraint but also an institutional challenge shaped by limited access to extension services and infrastructural support. Farmers' reliance on saline groundwater reflects constrained choice rather than maladaptive behaviour, highlighting how institutional gaps at higher governance levels translate into local-level vulnerability.

The introduction of early sowing and adaptive farming techniques through participatory experimentation altered this dynamic by expanding the community's action arena. These practices were not merely technical fixes but institutional innovations that redistributed knowledge, reduced dependency on external actors, and strengthened collective learning processes—key determinants of adaptive capacity within the CIAD framework.

The study recommends educating the farming community regarding alternative strategies for improving soil health and reducing salinity issues, as well as improving their livelihood through a participatory approach. Women play an important role in agricultural activities; therefore, capacity-building programs for women regarding improved methods of cultivation in salt-affected soils, livestock rearing, and value-addition techniques will ensure an increase in household income and livelihood.

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References

Ahmed, N., Ali, M. A., Rashid, M. K., Noreen, S., & Butt, B. (2015). Irrigation Quality of Underground Water in District Multan. *Pakistan Journal of Agriculture, Agricultural Engineering and Veterinary Sciences*, *31*(2), 211–220.

Ali, A. (2023). *Improving Salinity and Agricultural Water Management in the Indus Basin, Pakistan: Issues, Management and Opportunities: A Synthesis from a Desk-top Literature Review*.

Ali, A., Khan, F. D., Bashir, F., & Khan, M. M. H. (2022). Assessment of Variation in Groundwater Quality and Level for Irrigation Using Long-Term Data. *South Asian Research Journal of Biology and Applied Biosciences*, *4*(1), 1–10. https://doi.org/10.36346/sarjbab.2022.v04i01.001

Ali, I. (2016). *The Punjab Under Imperialism, 1885-1947*. Princeton University Press.

Ali, S. H., Bhatti, A. G., & Chaudhry, A. G. (2021). Cultural Perception Regarding Mental Illness: A Case Study of Domestic Carers in Jalalpur Pirwala, District Multan. *Global Social Sciences Review*, *VI*(III), 159–167. https://doi.org/10.31703/gssr.2021(vi-iii).17

Armitage, D. (2005). Adaptive capacity and community-based natural resource management. *Environmental Management*, *35*(6), 703–715. https://doi.org/10.1007/s00267-004-0076-z

Ashraf, M., Fatima, B., Hasan, F. ul, & Salam, H. A. (2022). *Adapting to Salinity in the Southern Indus Basin: Policy Review*. Pakistan Council for Research in Water Resources.

Asian Development Bank. (2021). *Islamic Republic of Pakistan: Institutional Transformation of the Punjab Irrigation Department to a Water Resources Department* (Issue December).

Asif, M. (2013). *Climatic Change, Irrigation Water Crisis and Food Security in Pakistan*. Uppsala University.

Beacham, A. M., Vickers, L. H., & Monaghan, J. M. (2019). Vertical farming: a summary of approaches to growing skywards. *Journal of Horticultural Science and Biotechnology*, *94*(3), 277–283. https://doi.org/10.1080/14620316.2019.1574214

Bhutta, M. N., & Smedema, L. K. (2007). One hundred years of waterlogging and salinity control in the Indus Valley, Pakistan: A historical review. *Irrigation and Drainage*, *Special Is*, S81–S90.

Briscoe, J., Qamar, U., Contijoch, M., Amir, P., & Blackmore, D. (2005). *Pakistan's Water Economy: Running Dry* (Issue October).

Carnegie, M., Cornish, P. S., Htwe, K. K., & Htwe, N. N. (2020). Gender, decision-making and farm practice change: An action learning intervention in Myanmar. *Journal of Rural Studies*, *78*(September 2018), 503–515. https://doi.org/10.1016/j.jrurstud.2020.01.002

Cheema, A., Khwaja, A. I., & Qadir, A. (2005). *Decentralization in Pakistan: Context, Content and Causes* (No. RWP05-034; Faculty Research Working Papers Series). https://doi.org/10.7551/mitpress/2297.003.0009

Cleaver, F. (2000). Moral ecological rationality, institutions and the management of common property resources. *Development and Change*, *31*(2), 361–383. https://doi.org/10.1111/1467-7660.00158

Cuevas, J., Daliakopoulos, I. N., Del Moral, F., Hueso, J. J., & Tsanis, I. K. (2019). A review of soil-improving cropping systems for soil salinization. *Agronomy*, *9*(6), 1–22. https://doi.org/10.3390/agronomy9060295

Evans, M. (2023, March 27). Pakistan Shares IAEA Soil Salinization Solutions through South-South Cooperation. *International Atomic Energy Agency*. https://www.iaea.org/newscenter/news/pakistan-shares-iaea-soil-salinization-solutions-through-south-south-cooperation

Frank, M., Amoroso, M. M., Propedo, M., & Kaufmann, B. (2022). Co-inquiry in agroecology research with farmers: transdisciplinary co-creation of contextualized and actionable knowledge. *Agroecology and Sustainable Food Systems*, *46*(4), 510–539. https://doi.org/10.1080/21683565.2021.2020948

Fuchs, L. E., Orero, L., Namoi, N., & Neufeldt, H. (2019). How to effectively enhance sustainable livelihoods in smallholder systems: A comparative study from Western Kenya. *Sustainability*, *11*(6). https://doi.org/10.3390/su11061564

Gilmartin, D. (1994). Scientific Empire and Imperial Science: Colonialism and Irrigation Technology in the Indus Basin. *The Journal of Asian Studies*, *53*(4), 1127–1149.

GOP, G. of P. (2020). *Mouza Census 2020*.

Gul, S., & Farooq, M. (2019). Socio-Cultural Constraints to Women's Political Empowerment in Southern Punjab: An Evidence from Multan. *Pakistan Journal of History and Culture*, *40*(2), 21–42.

Hammam, A. A., & Mohamed, E. S. (2020). Mapping soil salinity in the East Nile Delta using several methodological approaches of salinity assessment. *Egyptian Journal of Remote Sensing and Space Science*, *23*(2), 125–131. https://doi.org/10.1016/j.ejrs.2018.11.002

Hopmans, J. W., Qureshi, A. S., Kisekka, I., Munns, R., Grattan, S. R., Rengasamy, P., Ben-Gal, A., Assouline, S., Javaux, M., Minhas, P. S., Raats, P. A. C., Skaggs, T. H., Wang, G., De Jong van Lier, Q., Jiao, H., Lavado, R. S., Lazarovitch, N., Li, B., & Taleisnik, E. (2021). Critical knowledge gaps and research priorities in global soil salinity. In *Advances in Agronomy* (Vol. 169, pp. 1–191). Elsevier Inc. https://doi.org/10.1016/bs.agron.2021.03.001

Hossain, A., Krupnik, T. J., Timsina, J., Mahboob, M. G., Chaki, A. K., Farooq, M., Bhatt, R., Fahad, S., & Hasanuzzaman, M. (2020). Agricultural Land Degradation: Processes and Problems Undermining Future Food Security. In S. Fahad, M. Hasanuzzaman, M. Alam, H. Ullah, M. Saeed, I. A. Khan, & M. Adnan (Eds.), *Environment, Climate, Plant and Vegetation Growth* (pp. 17–61). Springer. https://doi.org/https://doi.org/10.1007/978-3-030-49732-3_2

Hussain, S., Mubeen, M., Akram, W., Ahmad, A., Habib-ur-Rahman, M., Ghaffar, A., Amin, A., Awais, M., Farid, H. U., Farooq, A., & Nasim, W. (2020). Study of land cover/land use changes using RS and GIS: a case study of Multan district, Pakistan. *Environmental Monitoring and Assessment*, *192*(1). https://doi.org/10.1007/s10661-019-7959-1

Hussain, Z. (2024). *Jalalpur Pirwala: A Historical City In Punjab*. Graana.Com. https://www.graana.com/blog/jalalpur-pirwala-a-historical-city-in-punjab/

Kamal, S. (2023). Pakistan's Water: Changing the Narrative, Changing the Outcomes. In M. Ahmad (Ed.), *Water Policy in Pakistan*. Springer. https://doi.org/https://doi.org/10.1007/978-3-031-36131-9_1

Korres, N. E., Loka, D. A., Gitsopoulos, T. K., Varanasi, V. K., Chachalis, D., Price, A., & Slaton, N. A. (2022). Salinity effects on rice, rice weeds, and strategies to secure crop productivity and effective weed control. A review. *Agronomy for Sustainable Development*, *42*, 58. https://doi.org/10.1007/s13593-022-00794-4

Kraaijvanger, R. (2018). *Farmers in the Lead: Assessing effectiveness of participatory experimentation in Tigray, Northern Ethiopia*. Wageningen University.

Kraaijvanger, R. G., & Witteveen, L. (2018). FARMER RESPONSIBILITY AND RESEARCHER LEARNING: TWO SIDES OF THE SAME COIN? REFLECTING ON FIVE YEARS OF INVOLVEMENT IN PARTICIPATORY EXPERIMENTATION IN TIGRAY, NORTHERN ETHIOPIA. *International Conference - European Seminar on Extension Education*, *1*. http://www.escijournals.net/IJAE

Lacombe, C., Couix, N., & Hazard, L. (2018). Designing agroecological farming systems with farmers: A review. *Agricultural Systems*, *165*(January), 208–220. https://doi.org/10.1016/j.agsy.2018.06.014

Lal, R. (2004). Soil carbon sequestration impacts on global climate change and food security. *Science*, *304*, 1623–1627. https://doi.org/10.1126/science.1097396

Llones, C. A., Mankeb, P., Wongtragoon, U., & Suwanmaneepong, S. (2022). Production efficiency and the role of collective actions among irrigated rice farms in Northern Thailand. *International Journal of Agricultural Sustainability*, *20*(6), 1047–1057. https://doi.org/10.1080/14735903.2022.2047464

Macken-Walsh, Á. (2019). Multi-actor co-design of extension interventions: paradoxes arising in three cases in the Republic of Ireland. *Journal of Agricultural Education and Extension*, *25*(3), 245–265. https://doi.org/10.1080/1389224X.2019.1604390

Majeed, A., & Muhammad, Z. (2019). Salinity: A Major Agricultural Problem—Causes, Impacts on Crop Productivity and Management Strategies. In M. Hasanuzzaman, K. R. Hakeem, K. Nahar, & H. F. Alharby (Eds.), *Plant Abiotic Stress Tolerance*. Springer. https://doi.org/https://doi.org/10.1007/978-3-030-06118-0_3

Murtaza, G., & Zuhra, N. (2024). *Threats and challenges to water resources in pakistan: a comprehensive analysis of salinty, climate change, and soil salinization* (No. 202; World Water Day 2024). https://pecongress.org.pk/wp-content/uploads/2025/04/Paper-No.-202.pdf

N. Thaker, P., Brahmbhatt, N., & Shah, K. (2021). A Review: Impact of Soil Salinity on Ecological, Agricultural and Socio-Economic Concerns. *International Journal of Advanced Research*, *9*(07), 979–986. https://doi.org/10.21474/ijar01/13200

Nachshon, U., & Levy, G. J. (2023). Soil salination processes and management. In M. J. Goss & M. Oliver (Eds.), *Encyclopedia of Soils in the Environment* (Second Edi, pp. 236–245). Academic Press.

Naqvi, R. H., & Ibrar, M. (2015). Views and Opinion of Rural Women of District Multan about their Involvement and Participation in Family Decisions: A Means for Women's Empowerment in Pakistani Society. *International Journal of Social Science and Humanity*, *5*(2), 204–208. https://doi.org/10.7763/ijssh.2015.v5.453

NDMA, N. D. M. A. (2020). *Multi Hazard Vulnerability & Risk Assessment (MHVRA)*.

NESPAK. (2012). *Integrated Master Plan for Multan (2008-2028)*.

Pawera, L., Manickam, R., Wangungu, C., Bonnarith, U., Schreinemachers, P., & Ramasamy, S. (2024). Guidance on farmer participation in the design, testing and scaling of agricultural innovations. *Agricultural Systems*, *218*(April), 104006. https://doi.org/10.1016/j.agsy.2024.104006

PCRWR. (2023). *Living with Salinity-An Effective Strategy*.

Punjab Irrigation Department. (2022). *Recharge of Aquifer for Groundwater Management in Punjab*.

Qureshi, A. S. (2020). Groundwater governance in pakistan: From colossal development to neglected management. *Water*, *12*, 3017. https://doi.org/10.3390/w12113017

Qureshi, A. S., McCornick, P. G., Qadir, M., & Aslam, Z. (2008). Managing salinity and waterlogging in the Indus Basin of Pakistan. *Agricultural Water Management*, *95*(1), 1–10. https://doi.org/10.1016/j.agwat.2007.09.014

Qureshi, A. S., & Perry, C. (2021). Managing water and salt for sustainable agriculture in the indus basin of Pakistan. *Sustainability*, *13*(9), 1–14. https://doi.org/10.3390/su13095303

Sajid, I., Tischbein, B., Borgemeister, C., & Flörke, M. (2022). Performance Evaluation and Water Availability of Canal Irrigation Scheme in Punjab Pakistan. *Water*, *14*(3), 1–22. https://doi.org/10.3390/w14030405

Sathar, Z. A., & Lloyd, C. B. (1994). Who Gets Primary Schooling in Pakistan: Inequaalities among and within Families. *The Pakistan Development Review*, *33*(2), 103–134.

Sathar, Z., & Khan, K. (2019). *Climate, population, and vulnerability in Pakistan: Exploring evidence of linkages for adaptation*. https://knowledgecommons.popcouncil.org/cgi/viewcontent.cgi?article=1754&context=departments_sbsr-pgy

Seifi, M., Ahmadi, A., Neyshabouri, M. R., Taghizadeh-Mehrjardi, R., & Bahrami, H. A. (2020). Remote and Vis-NIR spectra sensing potential for soil salinization estimation in the eastern coast of Urmia hyper saline lake, Iran. *Remote Sensing Applications: Society and Environment*, *20*, 100398. https://doi.org/10.1016/j.rsase.2020.100398

Shah, F., & Wu, W. (2019). Soil and Crop Management Strategies to Ensure Higher Crop Productivity within Sustainable Environments. *Sustainability*, *11*(5), 1485. https://doi.org/10.3390/su11051485

Singh, A. (2018). Alternative management options for irrigation-induced salinization and waterlogging under different climatic conditions. *Ecological Indicators*, *90*(February), 184–192. https://doi.org/10.1016/j.ecolind.2018.03.014

Utter, A., White, A., Méndez, V. E., & Morris, K. (2021). Co-creation of knowledge in agroecology. *Elementa*, *9*(1), 1–16. https://doi.org/10.1525/elementa.2021.00026

Whaley, L. (2018). The critical institutional analysis and development (CIAD) framework. *International Journal of the Commons*, *12*(2), 137–161. https://doi.org/10.18352/ijc.848

Zahra, S. M., Shahid, M. A., Misaal, M. A., Zaman, M., Imran, M., Azam, S., & Hussain, F. (2023). Sustainable Water Management in Indus Basin and Vulnerability Due to Climate Change. *Environmental Sciences Proceedings*, *25*(36). https://doi.org/10.3390/ecws-7-14203

Zhou, L. M., Jin, S. L., Liu, C. A., Xiong, Y. C., Si, J. T., Li, X. G., Gan, Y. T., & Li, F. M. (2012). Ridge-furrow and plastic-mulching tillage enhances maize-soil interactions: Opportunities and challenges in a semiarid agroecosystem. *Field Crops Research*, *126*, 181–188. https://doi.org/10.1016/j.fcr.2011.10.010