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Small Research Activity (SRA): Opportunities for Brackish and Saline Aquaculture in Pakistan

Final Project Report

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LIST OF ABBREVIATIONS

ACIAR	Australian Centre for International Agricultural Research
CAPI	Computerized Assisted Personal Interviews
DAP	Di Ammonium Phosphate
EC	Electrical Conductivity
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GEE	Google Earth Engine
GIS	Geographic Information System
GWL	Ground water level
ha	Hectares
IRB	Institutional Review Board
IWMI	International Water Management Institute
KFUEIT	Khwaja Fareed University of Engineering and Information Technology
mS	Millisiemens
NGO	Non-Governmental Organization
PCRWR	Pakistan Council of Research in Water Resources
PKR	Pakistani Rupee
RSC	Residual Sodium Carbonate
SA	Saline Aquaculture
SAR	Sodium Absorption Ratio
SIS	Small Indigenous Species
SRA	Small Research Activity
SWARC	Saline Water Aquaculture Research Centre
USD	United States Dollar
WASH	Water, Sanitation, and Hygiene

EXECUTIVE SUMMARY

Saline aquaculture is an alternative livelihood option for rural communities in Pakistan affected by salinity and waterlogging, particularly in the provinces of Punjab and Sindh. Due to the arid and semi-arid climate of the region, rain is scarce and irregular, and thousands of hectares (ha) have been abandoned because of soil salinity. However, the potential for saline aquaculture in the area remains largely underdeveloped, and little is known about the production system and constraints of smallholder saline aquaculture farmers in Pakistan.

This report presents the findings of a scoping study on saline aquaculture in the Sindh and Southern Punjab provinces of Pakistan. The study was conducted by the International Water Management Institute (IWMI) in 2022 with the aim of understanding the production system and constraints of smallholder saline aquaculture farmers in Pakistan. The study was conducted across four districts in Sindh and Punjab and focused on filling the gaps of data and information to support sustainable development of saline aquaculture in Pakistan. This study was conducted under the "Opportunities for Brackish and Saline Aquaculture in Pakistan" project funded by ACIAR and in partnership with WorldFish.

Saline aquaculture has the potential to improve economic growth and social development in Pakistan, but the country is lagging. Currently, Pakistan's aquaculture sector only contributes 0.4% of GDP (producing an estimated USD 650 million of fish annually). According to one estimate, there are about 3,300 fish farms with 60,230 hectares across Punjab and Sindh provinces, key areas where saline aquaculture is active (Laghari, 2018). FAO (2024) estimates suggest there are 13,000 fish farms across all provinces with an average size of 5-10 ha. No data is currently available on the number of fish farmers (or disaggregated between freshwater and saline fish farmers), but some estimates suggest there are around 50,000 people employed either directly or indirectly in the aquaculture sector (FAO, 2024), while others suggest a figure of 390,000 (Patil et al., 2018). Compared to regional neighbors like India and Bangladesh, Pakistan has much lower production, less variety of fish species, and fewer fish farmers (FAO, 2021).

In the present study, a total of 121 male farmers were surveyed across five districts in Sindh and South Punjab. Most of the fish ponds are owned by respondents, with more pond ownership in Sindh (88%) as compared to Punjab (39%), while more respondents in Punjab leased their ponds. The average pond size in the study area is approximately 4.1 acres (1.66 hectares), with an average depth of 7.25 ft. and water depth of 4.8 ft. This is similar to the pond sizes reported in neighboring countries such as Bangladesh and India (Castine et al., 2017; Sarkar et al., 2015).

The predominant fish species under cultivation are tilapia, particularly notable mainly in Rahim Yar Khan (Sindh Province), and carp and rohu, which hold significance across all study areas. Farmers engaged in tilapia culture in Rahim Yar Khan and some other areas reported a higher survival rate and better growth to reach marketable size for tilapia compared to other fish species. Notably, this trend was observed in areas with a salinity level of 24 mS/cm in Rahim Yar Khan.

In Rahim Yar Khan, where the salinity level is favorable to tilapia farming, the species is chosen for its cost-effectiveness, particularly attributed to the lower prices of small-sized fish. Despite tilapia's tendency to remain smaller and not attain a marketable size, some farmers in saline regions of Rahim Yar Khan utilize wild tilapia seed for cultivation. This approach addresses challenges such as the expense of fish seed and management complexities associated with self-breeding during the growth stage. These farmers subsequently sell their produce within their villages at more affordable prices, opting for a cost-effective alternative compared to cultivating other fish varieties.

On the other hand, carp and rohu are widely cultivated across all study districts. These species are valued for their boneless nature, rendering them easily consumable, particularly suitable for small children. Their rapid growth and consistent availability in marketable sizes align with consumer preferences for larger fish. Overall, the cultivation trends reflect both regional environmental conditions, such as salinity levels, and consumer preferences, influencing the choice of fish species for aquaculture.

In terms of growth and survival rates of fish species, in Punjab, Catla and Rohu were reported to have maximum growth rates, while Grass Carp and Silver Carp had the maximum growth rates in Sindh. Further, Rohu and Catla showed the highest survival rates in Punjab, while Rohu and Common Carp had the highest survival rates in Sindh.

More than half of the ponds were being used for other purposes besides fish farming. Specifically, almost 75% of ponds in Sindh district are multi-use compared to 32% of ponds in Punjab districts. Besides fish production, 32% of the ponds serve as a source of water for livestock, while 11% are used for agriculture and irrigation. While this may have some health and hygiene implications beyond the scope of the study, the survey also found that some respondents use their ponds for water, sanitation and hygiene (WASH) activities including bathing, washing, and cooking.

The majority of fish farmers across both districts do not monitor pond water quality. Pond ownership, level of experience and pond size are major factors predicting who is likely to monitor water quality. For instance, 11.4% of farmers who own their ponds said they monitor pond water quality compared to 5% of farmers who lease the ponds. Almost 12% of experienced farmers monitor the water quality compared to 8% of less experienced farmers. The major constraints reported were the lack of technical knowledge and equipment to measure water quality and salinity. Due to these limitations, most of the farmers adopted rudimentary techniques in monitoring the quality of water such as tasting and drinking pond water with their hands.

The farming system in Punjab tends to be more advanced, with some progressive farmers practicing year-round fish farming without changing the water. They monitor water quality continuously and add or drain water to maintain salinity levels. In contrast, in Sindh, this trend was not seen. In Punjab, small-scale farmers often add water to the ponds as needed, but they may lack the instruments for water quality testing or measuring the water volume added. This disparity in practices and resources reflects the varying levels of adoption of advanced techniques and technologies.

Further, only a third of the farmers (40 out of 121) reported implementing some type of special management practice. Among these farmers, species selection is the most common improved management practice adopted (70%), followed by liming (65%) during both the pond preparation and the grow out period. Liming enhances water quality, stabilizes pH levels, promotes nutrient availability for phytoplankton growth, and reduces the toxicity of certain metals, ultimately contributing to the overall well-being and growth of fish in pond management. Other practices, such as maintaining stock densities (12.5%), testing natural food adequacy in the pond (0.05%), post-harvest handling (0.05%), and using quality fish seeds (0.05%) are rarely practiced. Considering the potential benefits that adoption of these management practices can bring to the sustainable development, productivity and profitability of the aquaculture business, there is a need for promoting Better Management Practices (BMPs) among farmers.

Farmers were asked their opinion on various topics such as type of support needed in the saline aquaculture sector and the involvement of women and youth in the sector. They were presented with a series of statements and asked to rate their level of agreement or disagreement with each statement on a scale ranging from strongly agree to strongly disagree.

Most farmers (86% Punjab/60% Sindh) agreed or strongly agreed that post-harvest infrastructure needs to be improved to expand marketing of aquaculture products, highlighting gaps in the aquaculture value chain. In line with this, all farmers strongly agreed that the government can support fish farming by providing farmers with more incentives. For instance, providing farmers with training on better farming practices, offering subsidies for fish seed and water quality testing instruments, and incentivizing pond construction can be effective interventions. Furthermore, subsidizing fertilizers can enhance fish farming sustainability. In the event of losses, the government could consider compensating affected farmers. In Sindh, where many faced losses due to flooding, there was a prevalent sentiment that their losses were not adequately compensated or addressed by the government. Further, majority farmers agreed that younger generations are interested in fish farming activities, but they need more incentives and an enabling environment to do so.

Farmers were asked a series of opinion questions on the extent of women's involvement in fish farming activities. Majority farmers either disagree or strongly disagree that women have access to aquaculture farming equally as men (i.e. they can become farmers). They also report that women vendors cannot be found in local fish markets, highlighting another gender gap in the marketing value chain. Farmers deemed certain tasks related to fish farming unfit for women, such as entering the pond for netting and keeping guard of the ponds at night. These types of tasks were seen as "man's work" and not appropriate for women due to their risky nature.

The study identified several challenges requiring investment needs, including the high cost of feed and seeds, lack of fresh water, poor technical knowledge, obstacles regarding post-harvest handling, low involvement of women, and poor sanitary conditions. However, potential investment opportunities were identified, including development of species tolerant to temperature and salinity variation in the region. Stakeholders came together following data collection in a series of workshops across Sindh and Punjab for further discussion on the current state of the sector and recommendations to improve productivity and development.

The challenges of developing a prosperous saline aquaculture sector in Pakistan can be attributed to several key factors. Firstly, insufficient investment in research and development, infrastructure, and technology adoption has hindered the modernization and expansion of the aquaculture industry, coupled with inadequate technical expertise and a shortage of skilled manpower. This lack of investment has constrained the sector's ability to compete with neighboring countries that have made significant investments in aquaculture. Secondly, regulatory challenges have further deterred investors and constrained industry development. Moreover, challenges related to limited availability of suitable land and water resources, environmental degradation, and pollution have further restricted the expansion of aquaculture activities across the country. Lastly, challenges related to market access, trade barriers, and export competitiveness have limited the sector's growth potential.

The following recommendations address barriers identified during the study and serve as a strategic roadmap, outlining short, medium, and long-term interventions and areas of research:

Short-term (6 months to 2 years)

1) Capacity building and training programs

- Develop and implement capacity-building programs for small-scale Saline Aquaculture farmers on technical knowledge in saline aquaculture (with a special focus on women and youth). These programs would include a social and cultural norms component to address norms that hinder women's participation in the sector and provide specific training for women on activities they can be engaged with in the value chain (e.g., pond management, seed handling, feeding, post-harvest processing, marketing and sales, small business development).
- In collaboration with fisheries departments and universities, create a guidebook for saline aquaculture farmers in local language and graphics to provide comprehensive information and practical guidance on managing saline ponds and cultivating fish species based on international best practices. This would include topics such as pond construction and design, choosing suitable fish species, water management, stocking and seed management, feeding practices, disease prevention, and harvesting and post-harvesting, etc.
- Provision of water quality and pH testing equipment to saline aquaculture farmers.
- Exposure visits of small-scale Saline Aquaculture farmers to state-of-the-art private aquaculture farms in Punjab and Sindh.
- Build networks with civil society organizations who work in sectors such as agriculture, Water, Sanitation, and Hygiene (WASH), nutrition, and engage them on the interconnectedness of SA to these sectors. Civil society are strong stakeholders whose power can be leveraged for better community engagement.

2) Expand saline aquaculture database in Pakistan

- Expanding on this study, utilize GIS and remote sensing to identify salinity-affected areas and provide a full extent of saline aquaculture potential in both Sindh and Punjab, along with mapping of saline fish ponds across Punjab and Sindh.
- Develop a centralized database that provides stock assessment information for saline aquaculture species.
- Collect sex-disaggregated data to map out the gender division of labor in saline aquaculture value chains, including paid and unpaid labor, and opportunities to address these challenges.

3) Develop building blocks for a saline aquaculture policy framework in Pakistan

- Building on the capacity building and training programs and the expansion of a saline aquaculture database, continue to initiate research projects or small-scale pilot programs/demonstration sites to generate empirical evidence on the feasibility and effectiveness of potential policy interventions. This approach ensures that policymakers are equipped with solid evidence and insights, increasing the likelihood of informed decision-making.

Medium-Term (2-5 years)

1) Diversification and Innovation through Private Sector Engagement

- Prioritize capacity-building initiatives for aquaculture experts in both public and private sectors, with a specific focus on breeding new salt-tolerant fish varieties. This includes organizing exposure visits to countries like Malaysia and Thailand to gather insights from successful practices and stimulate private sector interest and participation in capital raising and investment
- Demonstrate the market potential and profitability of saline aquaculture ventures to attract private sector investment. This can be done by conducting market analyses and feasibility studies to identify market opportunities for salt-tolerant fish species and products.
- Foster Public-Private Partnerships (PPPs) between government fisheries departments and private sector entities to introduce saline-tolerant species and reduce reliance on freshwater species. These PPPs may take the form of joint infrastructure development (e.g., hatchling and breeding facilities, distribution channels, processing plants, and cold storage facilities) with the government providing land and regulatory support, while private sector partners contribute capital investment, technical expertise, and operational management.
- Support the development of a comprehensive financing strategy to stimulate private sector investment. This could include market-based incentives, such as subsidies or tax breaks to reduce initial project costs. Additionally, financing mechanisms such as venture capital funds and credit facilities tailored to the aquaculture sector can provide investors which access to capital. Lastly, introducing risk-sharing mechanisms like insurance products will encourage more private sector investment. Responsibility for financing initiatives would involve government agencies, finance institutions, private sector investors, and international donors, each contributing regulatory support, capital, and technical expertise.

2) Value Chain Enhancement

- Further engagement with the private sector for processing facilities and provision of training to farmers on post-harvest handling techniques to improve the quality of the product and expand demand for fish by consumers.

3) Policy Development and Strategic Planning

- Building on the evidence base from research projects, initiate consultation on the development of a national and provincial saline aquaculture policy framework and implementation plans.
- Engage with the public sector and civil society to develop inclusive policies and programs to address gender inequalities in the sector and increase the participation of women in saline aquaculture.

4) Research and Infrastructure Development

- Develop chemical analysis facilities for soil and water to provide accurate information for decision-making by the public and private sector.
- Investment to improve aquatic animal health and disease prevention, including investment in skilled personnel/human resources/researchers.
- Establish model demonstration fish farms featuring multi-functional natural infrastructure aimed at enhancing water and land efficiency while mitigating the risk of natural hazards (e.g., flood and drought). These ponds can serve as retention basins during heavy rainfall or floods, reducing downstream flooding and helping prevent soil erosion. Additionally, they can contribute to water

management efforts, providing a reliable water source for irrigation and other agricultural activities during periods of drought or water scarcity. Ponds will also offer alternative sources of income and food security, diversifying livelihoods and enhancing community resilience to natural disasters.

5) Sector Modernization and Information Systems

- Engagement with the public and private sector to encourage private investment in R&D to catalyze the modernization of the sector.
- Engagement with the public and private sector to establish market information systems and cold storage facilities to help farmers make informed decisions about when to harvest fish for better profitability.

Long-term (5-10 years)

1) Industry Development

- Engagement with public and private sectors for the development of a functional value chain for saline aquaculture at the national level.
- Engagement with public and private sectors for the enhancement of saline aquaculture exports, specifically from South Punjab and Sindh.

2) Disease Control and Biosecurity

- Adoption of physical disease control measures, including quarantine, vaccinations, recommended stocking density, filtration, and irradiation of inflow water using ultraviolet light.

3) Policy Implementation

- Engagement with public and private sectors for the implementation of a National Policy and Strategy for Saline Aquaculture (including provincial policies for Sindh and Punjab).

Addressing these challenges will require collaborative efforts from the government, private sector stakeholders, and international partners, focusing on promoting investment, enacting supportive policies, enhancing research and development, improving resource management, and strengthening market access and export competitiveness. By overcoming these constraints, Pakistan can unlock the full potential of its aquaculture sector and bridge the gap with its regional counterparts in the global aquaculture market.

This study provides important insights into the saline aquaculture landscape in Pakistan, including farmer needs, government and private sector capacity and interest, as well as limitations hindering the growth of the sector. It is hoped that the findings of this study will inform policy and decision makers and investors on interventions, paths, and trends for the sustainable development of saline aquaculture in Pakistan.

CHAPTER 1. STUDY OVERVIEW

1. Introduction

1.1. Salinity in the Indus Basin

Long-term variations in climate, seasonal changes in weather, and changes in land use can disturb or influence the flows of groundwater and surface water and their concentration of salt. The accumulation of salts present in soil or water is referred to as 'salinity.' Salinity in the Indus Basin stems from both natural factors and human activities, particularly irrigated agriculture. Natural causes include the region's flat topography, aridity, and alterations to river courses for irrigation expansion. Additionally, the Indus River contributes about 31.6 million tonnes of salts annually, with a significant portion (19.95 million tonnes) deposited in canal commands via the Indus Basin Irrigation System (Ashraf et al., 2022). Groundwater use, especially in Sindh and Punjab provinces, also contributes to rising salinity, as pumping groundwater worsens its quality and leads to salt accumulation in soil, causing land degradation and reducing agricultural productivity. Poor drainage is another cause for waterlogging and salinity, particularly in the lower Indus plains. While salinity has been a natural part of the Indus Basin landscape in Pakistan (primary salinization), in recent decades it has mostly become associated as the result of irrigated agriculture activities (secondary salinization). (Ashraf et al., 2022).

Salinity currently affects 4.5 million hectares of land across Pakistan and 54% of the southern Indus Basin, threatening agricultural production and livelihoods and resulting in high rates of poverty for communities living in affected areas (ACIAR, 2022). A large area of inland groundwater reserves in Pakistan are saline, and about 40,000 hectares of agricultural land are abandoned annually within the Indus Basin from secondary salinization (Shaikh, 2019). In Punjab, 23% of the area suffers from poor groundwater quality, while in Sindh, 78% of the groundwater is saline (Jarwar, 2014). The sum of individuals directly impacted by saline, sodic or waterlogged soils in Pakistan was estimated to be about 16 million in 1998, anticipated at the time to double by 2020 (Jarwar, 2014).

Pakistan's National Water Policy (2018) notes "the menace of waterlogging and salinity continues to persist despite huge investments" in infrastructure, which has mostly been successful only in shifting the problem in time and space. Even the National Climate Change Policy (2021) calls for monitoring salinity and developing salinity-tolerant crops. There is increasing recognition that Pakistan will need to find new ways to sustain agricultural productivity in saline systems.

1.2. Saline Aquaculture in Pakistan

The value of saline aquaculture (SA) in Pakistan cannot be ignored. It addresses challenges posed by salinity in certain regions, providing a sustainable way to utilize brackish water resources for food production. Saline aquaculture also provides an alternative income source for farmers, particularly in areas where traditional agriculture faces constraints due to high salinity. The cultivation of fish species tolerant to saline conditions ensures a diversified and resilient source of income for communities in saline-prone areas. It also helps to reduce pressure on wild fish stocks by providing a source of farmed fish for local and international markets. Finally, it can help to promote food security and nutrition by providing a source of protein-rich food. Inland saline aquaculture in Pakistan is practiced using a variety of methods, including traditional pond culture, cage culture, and raceway culture. The most commonly farmed fish species include tilapia, catfish, and carp, although other species are also farmed in some regions. In addition to fish, some farmers also cultivate shrimp and other crustaceans in saline water.

Nearly every province in Pakistan practices aquaculture, with the largest concentration of ponds and saline aquaculture potential in the provinces of Sindh and Punjab. Around 60.47 thousand hectares of fish ponds are present in Pakistan, distributed among Sindh (49.17 ha), Punjab (10.5 ha), Khyber Pakhtunkhwa (0.56 ha), and other provinces (Balochistan, Azad Jammu Kashmir, Northern Regions) (0.24 ha) (Aslam et al., 2020). FAO (2021) concluded that population growth and declining capture fisheries will drive a large increase in demand for aquaculture production and that Pakistan has strong aquaculture growth potential from both demand and supply-side perspectives (Cai et al., 2019). However, production is almost entirely from inland and marine fisheries, with brackish water contributing relatively less. One study reported that the average fish yield in saline aquaculture was about 32.5% less than the yield obtained from freshwater pond culture, which the authors attributed to the lack of an enabling institutional environment for saline aquaculture (Chughtai & Mahmood, 2012).

Saline aquaculture can serve as an alternative option for saline areas which are not suitable for crop cultivation and contribute to improved economic growth and social development, but Pakistan is lagging behind. Currently, the country's aquaculture sector only contributes 0.4% of GDP (producing an estimated USD 650 million of fish annually). According to one estimate, there are about 3,300 fish farms with 60,230 hectares across Punjab and Sindh provinces, key areas where saline aquaculture is active (Laghari, 2018). FAO (2024) estimates suggest there are 13,000 fish farms across all provinces with an average size of 5-10 ha. No data is currently available on the number of fish farmers (or disaggregated between freshwater and saline fish farmers), but some estimates suggest there are around 50,000 people employed either directly or indirectly in the aquaculture sector (FAO, 2024), while others suggest a figure of 390,000 (Patil et al., 2018) Compared to regional neighbors like India and Bangladesh, Pakistan has much lower production, less variety of fish species, and fewer fish farmers (FAO, 2021). See **Annex A** for a list of common fish species found in Pakistan and the type of water they are cultured in. While Bangladesh and India are among the world's top-five aquaculture-producing countries, Pakistan ranks 28th (Patil et al., 2018).

Where saline aquaculture is economically valuable, it can make a valuable contribution to household income from traditional agriculture activities, given that around 37% of employment is in the agriculture sector (PBS, 2021). The feasibility of income replacement depends on factors such as the scale of aquaculture operations, market demand, and regional economic conditions. Integration of saline aquaculture with traditional agriculture practices might provide a more balanced and resilient income source for communities, and diversification of income sources can enhance overall economic stability. This is particularly important given Pakistan's vulnerability to climate change impacts and the ever-changing landscape.

Pakistan currently lacks a comprehensive saline aquaculture strategy or policy, and current governance structures are fragmented. In 2007 the National Policy and Strategy for Fisheries and Aquaculture Development was established, but this policy has no strategy for tackling salinity and addressing saline aquaculture. The absence of a national strategy impedes coordinated efforts, as provinces and provincial departments are making siloed interventions without addressing underlying cross-sectoral issues. The significance of a national strategy is underscored by the example of the National Water Policy approved in 2018. This policy paved the way for the enactment of provincial water policies and acts, leading to the establishment of new institutions at the provincial level dedicated to water management and conservation. Similar strategic guidance for the aquaculture sector, linked to agriculture, water resources management and food security, is seen as an important step to help guide future investments or interventions by government and the development sector.

Overall fish consumption in Pakistan is one of the lowest in the world, less than 5 kg per year, compared to the world average per capita consumption of 20.5 kg (FAO, 2022). This limited consumption is attributed to several factors: a scarcity of processing units hindering preservation and distribution, the perception of fish as a luxury, as one kilogram of fish may not stretch as far as one kilogram of chicken despite favorable price comparisons, and a seasonal decline in consumption during the hotter months from May to September.

While saline aquaculture has the potential to provide significant benefits for rural communities in Pakistan, there are also several challenges associated with the practice. These include water quality issues, such as high salinity levels and contamination from pollutants, disease outbreaks, and the high cost of inputs such as feed and equipment. In addition, the lack of access to credit and other support services can make it difficult for small-scale farmers to start and expand their operations.

There is tremendous scope for saline aquaculture in Pakistan as an alternative form of livelihood for farmers dealing with increasing levels of salinity, and as a means to address food security, protein deficiency, and malnutrition in the country by providing a source of protein-rich food that is accessible and affordable to local communities. There is even more potential to engage women and youth, who have limited involvement in saline aquaculture activities due to gender and cultural norms, through gender-transformative approaches. Women could be particularly involved in tasks such as pond management, post-harvest processing, and marketing, providing them with opportunities to contribute to and benefit from the sector. Youth engagement could focus on introducing modern and technology-driven approaches, training programs, and promoting entrepreneurship in areas like aquaculture-related services and value-added product development. These activities have low barriers to entry, making it easier for women and youth to participate in the saline aquaculture industry. Addressing these specific roles would also align with cultural norms while enhancing inclusivity in the sector. With the passage of time and women's increased involvement, there is potential for taking on more diverse and leadership-oriented roles as social norms on women's role in the sector evolve.

To date, research on the current state and potential of the saline aquaculture sector in Pakistan has been limited in scope, focusing on assessing growth performance and the economic viability of certain fish species. There are major gaps in comprehensive studies focusing on the current state of the saline aquaculture sector, including stakeholder mapping and farmer perspectives.

2. Project Overview

2.1. Context

The Australian Centre for International Agricultural Research (ACIAR) commissioned the Adapting to Salinity in the Southern Indus Basin project (LWR/2017/027) as the formative stage of a 10-year program to explore approaches to "living with salinity," including options for transformative adaptation which include shifting to entirely new food and agriculture production systems.

In this context, IWMI Pakistan in partnership with the WorldFish implemented a Small Research Activity (SRA) on Opportunities for Brackish and Saline Aquaculture in Pakistan with funding from ACIAR. The project aims to develop a shared understanding of the potential of saline aquaculture with farming communities and relevant government and non-government agencies as a productive and profitable new farming activity for smallholders living in marginalized saline areas of the Southern Punjab and Sindh Provinces.

The results of the SRA will feed directly into the policy and scenario analysis of the Salinity in Pakistan project, as well as informing policy directions for enhancing the production of saline aquaculture in Pakistan.

2.2. Objectives and Research Questions

The main objective of the SRA is to understand current practices, motives, and issues of low-income saline aquaculture farmers in select districts of South Punjab & Sindh to assess opportunities and potential for saline aquaculture in Pakistan.

The project objectives and associated research questions are listed in **Table 1** below.

Table 1. Project Objectives and Research Questions

Objectives	Research Questions
1. **Develop a resource inventory** of saline and brackish aquaculture for various farming systems in Southern Punjab and Sindh Provinces of Pakistan, by collecting secondary data from different government agencies and using Remote Sensing techniques.	1.1. What are various types of farming systems and agro-ecological zones for saline and brackish aquaculture production in the study area? 1.2. What are the potential bright spot locations for saline and brackish aquaculture production? 1.3. What are the socio-economic factors to understand the current practices of marginalized small-scale farmers for saline aquaculture production?
2. **Map the stakeholders** (government and non-government) and farming families to get a better understanding of local fish production issues and their needs.	**2.1.** What are the current institutional arrangements (organisations, networks, rules, norms) for inland saline aquaculture? **2.2.** How to bring awareness at different stakeholder (local, provincial and national) levels about the economic and social impacts of enhanced saline aquaculture on farming communities?
3. **Knowledge sharing by the WorldFish** from other regions (Bangladesh and Myanmar) for discussion on the preliminary results and identification of relevant learning and potential solutions from other countries.	3.1. What are the common fish species and farming systems suitable for saline and brackish aquaculture in Pakistan? 3.2. What are the key constraints and how to overcome them? 3.3. What are the opportunities for marginalized small-scale farmers and women to benefit from new aquaculture technologies and systems?

Under **Objective 1**, IWMI Team conducted a comprehensive saline aquaculture survey of fish farmers along with GIS mapping to create salinity maps and other related mapping (groundwater table, landcover, etc.) for the selected areas (See Chapter 2 and 3 for more detail).

Under **Objective 2**, desk research allowed for preliminary identification of major stakeholders/institutions across Sindh and Punjab (and Federal level) involved with saline aquaculture. Following the field survey, a series of 7 validation workshops were held in each district, as well as at the provincial and national level, to share findings and receive feedback from relevant stakeholders. During the provincial workshops, a detailed stakeholder mapping exercise was conducted with participants where

different stakeholder groups were ranked across 3 domains (power/influence, capacity, and interest). Chapter 4 discusses findings of the stakeholder mapping exercise and implications in more detail.

Under **Objective 3**, research partner WorldFish shared relevant evidence-based best practices from neighboring countries like Bangladesh and Cambodia. WorldFish supported with data analysis of the survey, as well as developing nutritional guidelines for fish farming families. Further detail on WorldFish knowledge-sharing can be found in Chapter 2.

Figure 1 below outlines the entire project scope.

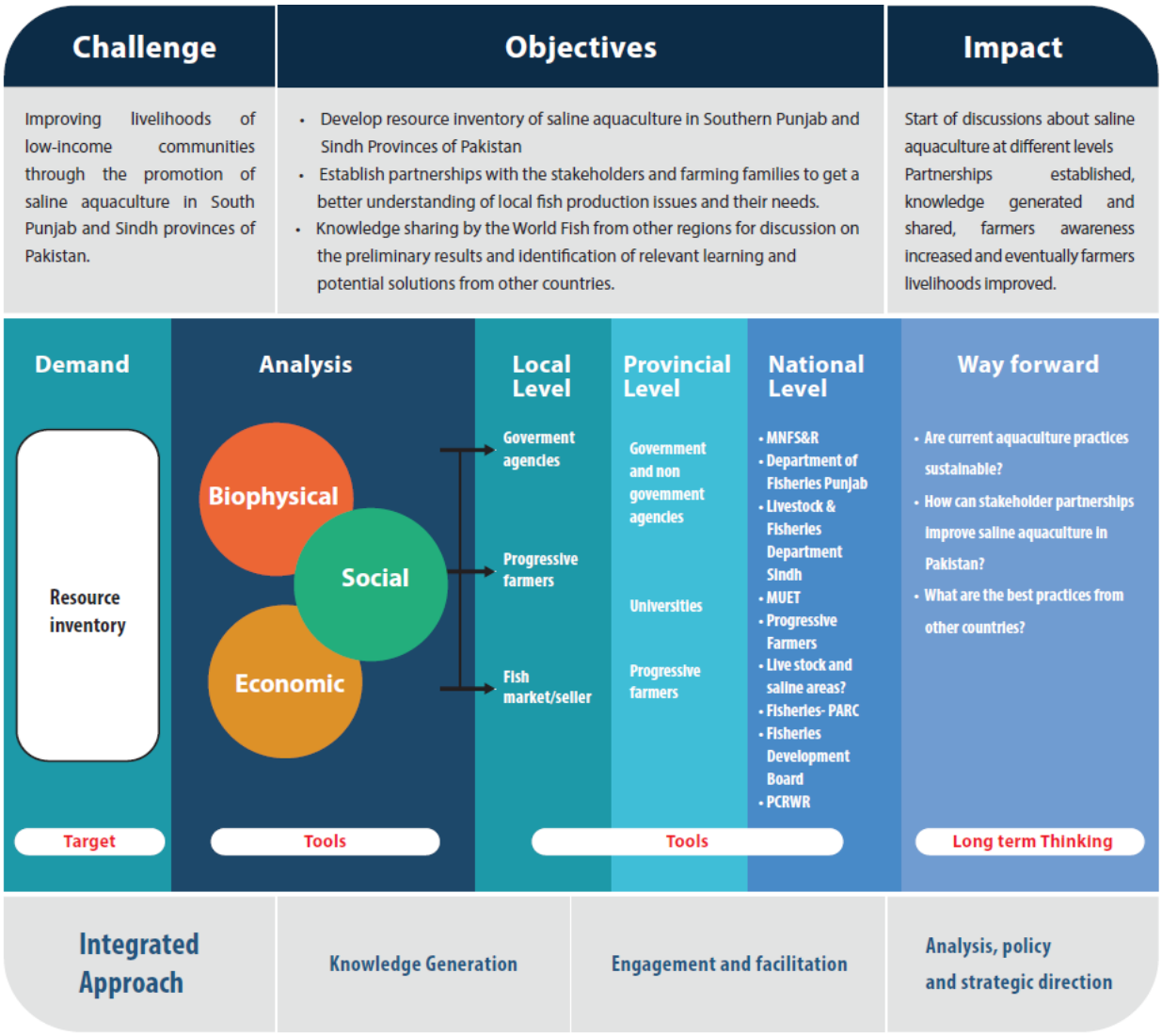


Figure 1. *Project Scope Overview*

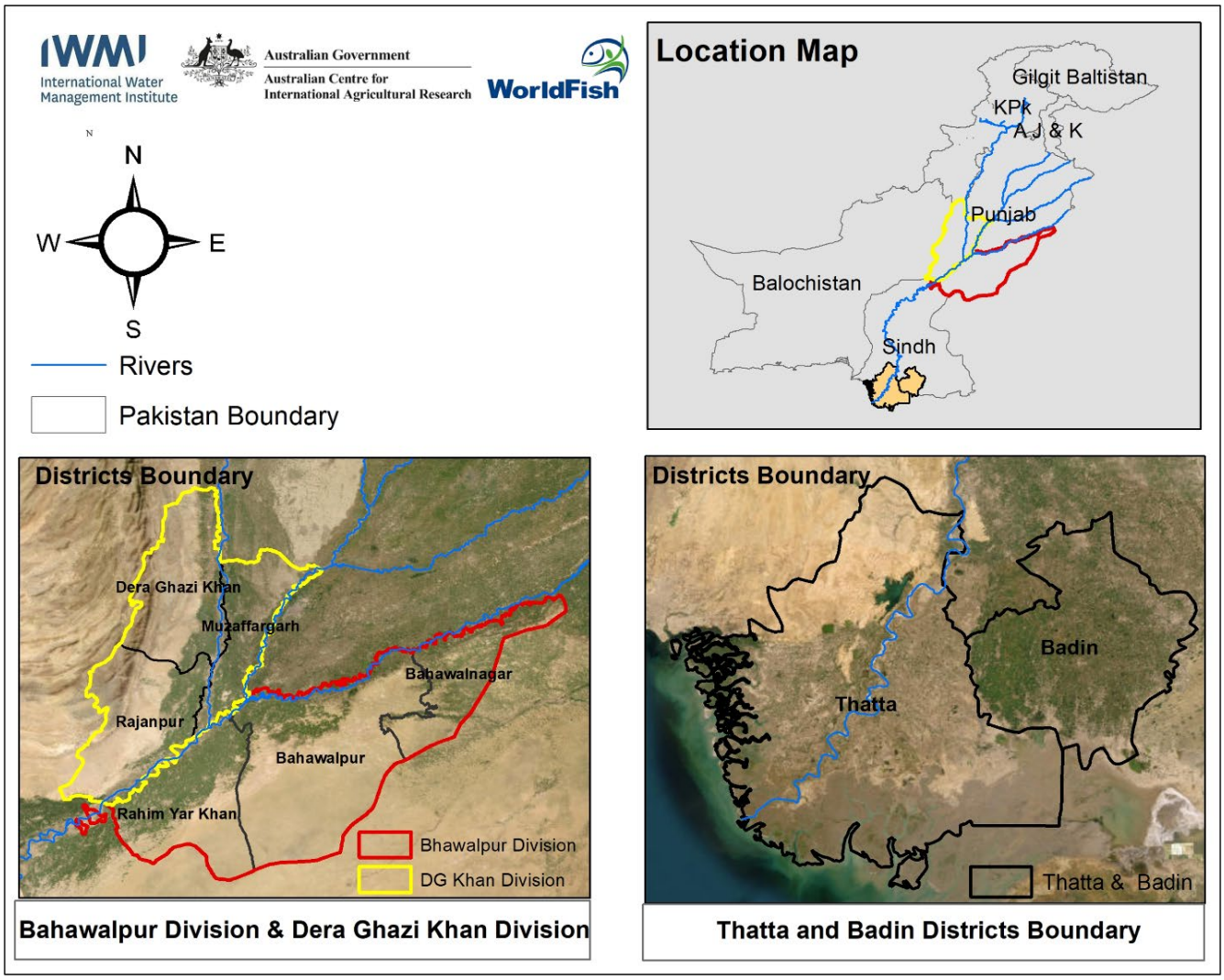
3. Methodology

3.1. Study Area

The study was conducted in Southern Punjab and Sindh Provinces where soil salinity is a growing concern affecting agricultural production. These two provinces were selected for the study after stakeholder

consultation as areas where saline aquaculture has the potential to improve income generation, food security and nutritional improvement. For district selection, consultation with stakeholders to identify marginalized saline areas where aquaculture could be improved resulted in shortlisting two administrative divisions of Punjab and two major districts from Sindh. The Bahawalpur division comprises the district boundaries of Rahim Yar Khan, Bahawalpur, and Bahawalnagar. The Dera Ghazi Khan division includes Muzaffargarh, Rajanpur, Dera Ghazi Khan, and Layyah. **Figure 2** below illustrates the study area.

Figure 2. *Study Area Map*



3.2. Sampling

The saline aquaculture farmer survey followed a purposive sampling methodology. A total of 121 farmers were surveyed across 5 districts. The goal was to interview at least 30 farmers per district. This target was met, with the exception of Rahim Yar Khan District, due to external factors which hindered the identification of farmers meeting the selection criteria.

Table 2. Total Sample Size per District

District	No. of Surveys
Bahawalpur (pilot)	5
Thatta	35
Badin	30
Muzaffargarh	30
Rahim Yar Khan	21
Total	**121**

The target population were low-income farmers, and pond size was used as a proxy to identify this group. The selection criteria composed of two main conditions: a) pond salinity must be >2 millisiemens (mS) per centimeter (mS/cm) and b) pond size must be between 1-5 acres (0.4-2 ha). Due to limitations in data collection in some districts, a small percentage of respondents surveyed had ponds greater than 5 acres (2 ha).

The team conducted bright spot mapping to create salinity maps for the selected areas. GIS and Remote Sensing were used to identify villages in collaboration with Pakistan Council of Research on Water Resources (PCRWR), local partners and universities to identify farmers available for interviews.

The 5 pilot surveys in Bahwalpur served to test the tool in terms of refining the local language translations and to test the tool on the Kobo App to ensure enumerators were familiar with the interface. There were no major changes made to the survey questions after the pilot testing. During analysis, the pilot data were consistent with the other survey responses and were included in the overall analysis and sample size.

3.3. Data Collection and Monitoring

Data collection was conducted over the course of two months across all 4 districts. Data were collected by the IWMI Team (male and female enumerators who were trained on the tool and who had background knowledge on saline aquaculture). Interviews took place in the local language (e.g., Urdu, Siraiki, Punjabi, Sindhi), with support from local partners with any language barriers. Data were collected via Computer-Assisted Personal Interviews (CAPI) using tablets and KoboToolbox, a survey/data collection application.

Data was collected in real time and uploaded immediately online, where the project field monitor conducted daily data monitoring, in tandem with daily debrief with enumerators to share their experiences and troubleshoot field challenges. Interview results that were faulty or low quality were excluded and replaced with new interviews with farmers who met the selection criteria. Inconsistencies in responses, logic skips, and time stamps of responses were also checked. This ensured reliability and quality assurance of data collected.

3.4. Ethical Considerations

The project followed all standard principles of research ethics. The survey tool was approved by the International Water Management Institute (IWMI) Internal Review Board (IRB). Additionally, participants' privacy was protected at all times with de-identified data, and all respondents participated on the basis of informed consent. Farmers were made aware that the survey was voluntary and that they could skip any question or end the survey at any time. Data were stored on a secure server with access only to the research team.

CHAPTER 2. SURVEY FINDINGS

This chapter provides an overview of the saline aquaculture fish farmer survey conducted in 4 districts of Sindh and South Punjab, as described in Chapter 1. The survey covered questions on the following: socio-demographic; general pond questions; aquaculture production, harvest, and income; fish seed use; fish disease and growth rate; knowledge, attitudes, and practices on improved aquaculture practices; general opinion questions on fish farming (role of women, youth involvement, etc.); nutrition and consumption of small indigenous species; and hygiene and sanitation. Results are based on responses from a total of 121 farmers (n=121), and specifically 65 in Sindh and 56 in Punjab.

The results should be viewed in light of the following study limitations:

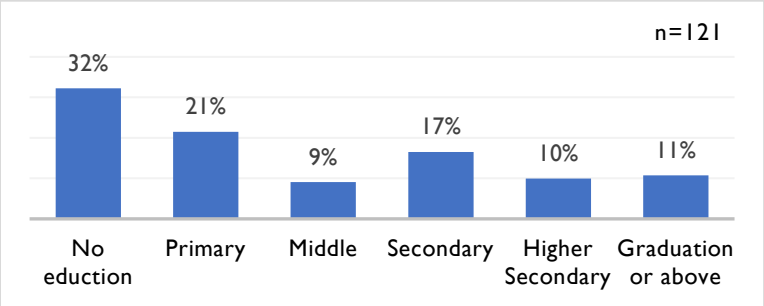
- Interviews were conducted based on availability of farmers on the day of field visits. It was not possible to schedule interviews in advance because salinity levels at each pond needed to be checked as a prerequisite to conduct the interview.
- Some farmers were suspicious of the team and thought they were tax collectors; educated farmers were more critical and asking questions related to the purpose of each survey question.
- Partial data collection took place during an extreme heat wave in Pakistan which affected identification of ponds, particularly in Badin district of Sindh province. During Badin field visits, approximately 70-80% of ponds visited were dried up and could not be included in the survey (i.e., for every 5 to 6 ponds visited per day, 4 to 5 were completely dry).
- After rainfall, some areas became inaccessible to visit due to mud and other physical barriers to the fish farms.

2.1. Socio-demographic characteristics

Saline aquaculture in the study area is entirely dominated by men. This is in contrast to the gender distribution observed in agriculture, where nearly 68% of women are employed in the agriculture sector (PBS, 2021). Although the survey did not investigate the reasons for male dominance in aquaculture, it is presumed that gender-defined roles and the labor-intensive nature of pond maintenance may be contributing factors. Further, women's labor and contributions are often undervalued, underreported, or even invisible in many industries, including agriculture and aquaculture. It is possible that women in the study areas are involved in saline aquaculture, but their contributions are not acknowledged or recorded.

Majority of fish farmers in the study area are married and have large families, with substantial experience in fish farming, but limited educational attainment (Figure 3). Nearly 90% of the respondents are married, and on average, their households consist of 10 individuals, including the farmer. Approximately 80% of the farmers are the primary earners in their households. In terms of experience, 12% farmers have 0-2 years of fish farming experience; 33% have 3-5 years; 27% have 6-10 years; and 28% have more than 10 years of experience.

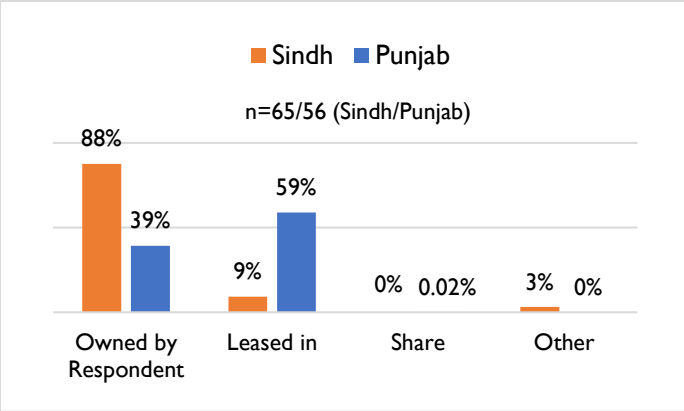
Figure 3. *Level of Education of Household Head*



2.2. Pond Characteristics, Usage, and Ownership Status

Most of the fish ponds are owned by respondents, with more pond ownership in Sindh (88%) as compared to Punjab (39%), while more respondents in Punjab leased their ponds (Figure 4). Majority of the ponds (98%) were permanent while only 2% were in seasonal use.

Figure 4. *Ownership Status of Pond*



At the time of the survey, almost all ponds owned or leased (93%) were in use for aquaculture while 7% of the ponds were aquaculture capable but currently not in use (e.g., pond had been emptied for leveling but would be active again in 1-2 months). In Sindh, water for ponds was predominantly sourced from irrigation canals (97%) while in Punjab water for ponds was mainly sourced from groundwater (89%).

The average pond size in the study area is approximately 4.1 acres (1.66 hectares), with an average depth of 7.25 ft. and water depth of 4.8 ft. This is similar to the pond sizes reported in neighboring countries such as Bangladesh and India (Castine et al., 2017; Sarkar et al., 2015). However, the size of individual ponds owned by farmers varies, with 37% of farmers owning small ponds measuring 1-2 acres (<1 ha), almost 50% owning medium-sized ponds of 3-5 acres (1-2 ha), and only 15% owning ponds larger than 5 acres (>2ha). This variation per individual farmer indicates there may be differences in the level of investment and resources available to farmers, but similarities in pond size with regional neighbors suggests the possibility of expanding aquaculture production to achieve similar levels of productivity as India and Bangladesh.

More than half of the ponds were being used for other purposes besides fish farming. Specifically, almost 75% of ponds in Sindh district are multi-use compared to 32% of ponds in Punjab districts. Besides fish

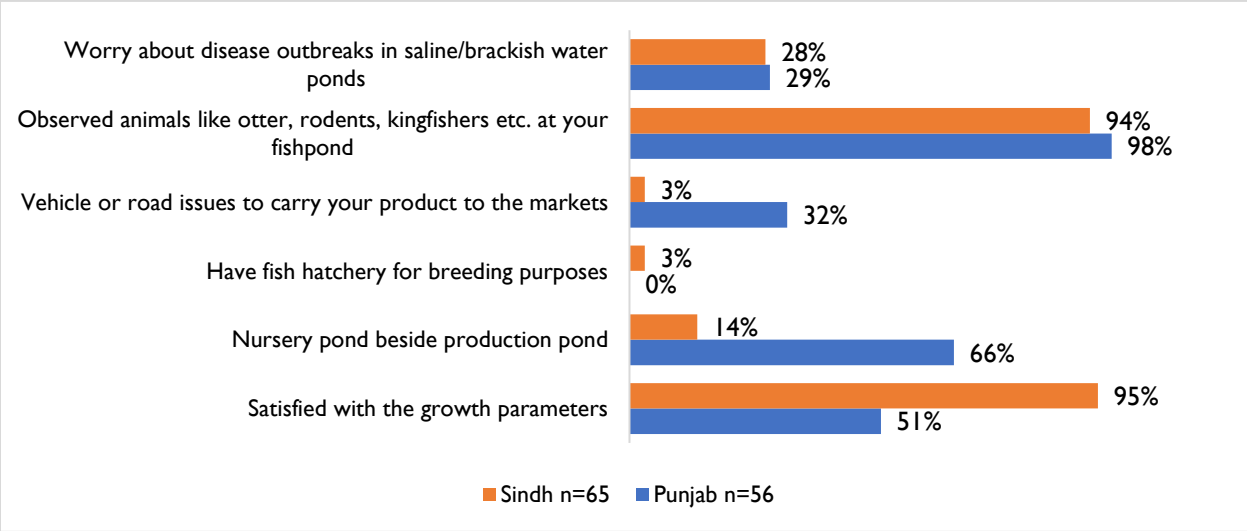
production, 32% of the ponds serve as a source of water for livestock, while 11% are used for agriculture and irrigation. While this may have some health and hygiene implications beyond the scope of the study, the survey also found that some respondents use their ponds for water, sanitation and hygiene (WASH) activities including bathing, washing, and cooking. Around 22% of the respondents use the pond for bathing, 10% for washing and 4% for cooking. The usage of ponds for WASH underscores the challenge of limited fresh water supply in the study area. Using ponds for WASH purposes may have both positive and negative impacts on saline aquaculture production. On the positive side, it may help to improve water quality and provide a source of nutrients for fish if wastewater is being used for irrigation. On the negative side, it may also introduce pollutants or pathogens that could affect fish health and productivity.

As ponds are being used for multiple functions, this highlights the importance of ponds as a multi-use resource which can provide a range of benefits to communities. Integrating WASH and aquaculture activities could potentially provide synergies and benefits for both sectors. For example, using treated wastewater from fish farming for irrigation or vice versa can reduce freshwater use and nutrient inputs, leading to more efficient resource use and improved sustainability.

2.3. General Fish Farming Questions

Farmers were asked a series of yes or no questions related to their fish farming practices (Figure 5). Around one third of farmers across both districts worried about disease outbreaks and nearly 100% observed animals like rodents or birds near their ponds. More farmers in Punjab (32%) than in Sindh (3%) experienced transportation issues to carry their production to the market. Only 3% of farmers in Sindh and none in Punjab have their own fish hatchery for breeding purposes, while 66% in Punjab and 14% in Sindh have a nursery pond next to their production pond. Lastly, 95% of farmers in Sindh reported satisfaction with their pond growth parameters compared with only 80% in Punjab. In Sindh, farmers do not typically provide input for feeding and fish mostly thrive on natural sources of nutrition, such as zooplankton and phytoplankton and other insects in the water. Additionally, only a small number of farmers use fertilizers. This is in contrast to Punjab, where farmers allocate high inputs and anticipate rapid fish growth. As a result, farmers in Sindh tend to be more content with the growth of their fish, often in line with their lower input costs.

Figure 5. *General Fish Farming Questions*



2.4. Pond Water Quality Management

It is important to note that there are many factors that contribute to aquaculture productivity beyond just pond size. Other important considerations include the quality of the water, the type and quality of the feed used, the genetics of the fish being raised, the management practices employed, and the overall economic and regulatory environment. Majority of fish farmers across both districts do not monitor pond water quality. Pond ownership, level of experience and pond size are major factors predicting who is likely to monitor water quality. For instance, 11.4% of farmers who own their ponds said they monitor pond water quality compared to 5% of farmers who lease the ponds. Almost 12% of experienced farmers monitor the water quality compared to 8% of less experienced farmers. The major constraints reported were the lack of technical knowledge and equipment to measure water quality and salinity. Due to these limitations, most of the farmers adopted rudimentary techniques in monitoring the quality of water such as tasting and drinking pond water with their hands.

The farming system in Punjab tends to be more advanced, with some progressive farmers practicing year-round fish farming without changing the water. Progressive farmers actively monitor the water quality of their ponds to ensure optimal conditions for aquatic life. For instance, they utilize a dissolved oxygen (DO) meter to assess the DO levels in their ponds and an electrical conductivity (EC) meter to measure the salinity level of the water. Additionally, some farmers use ammonia kits to test for ammonia levels in the water. These farmers also observe the productivity of pond water by ensuring the presence of sufficient quantities of zooplankton and phytoplankton, essential for the growth of fish. In contrast, in Sindh, this trend was not seen. In Punjab, small-scale farmers often add water to the ponds as needed, but they may lack the instruments for water quality testing or measuring the water volume added. This disparity in practices and resources reflects the varying levels of adoption of advanced techniques and technologies.

Further, only a third of the farmers (40 out of 121) reported implementing some type of special management practice. Among these farmers, species selection is the most common improved management practice adopted (70%), followed by liming (65%) during both the pond preparation and the grow out period. Liming enhances water quality, stabilizes pH levels, promotes nutrient availability for phytoplankton growth, and reduces the toxicity of certain metals, ultimately contributing to the overall well-being and growth of fish in pond management. Other practices, such as maintaining stock densities (12.5%), testing natural food adequacy in the pond (0.05%), post-harvest handling (0.05%), and using quality fish seeds (0.05%) are rarely practiced. Considering the potential benefits that adoption of these management practices can bring to the sustainable development, productivity and profitability of the aquaculture business, there is a need for promoting Better Management Practices (BMPs) among farmers.

2.5. Pond Preparation and Fertilizer Use

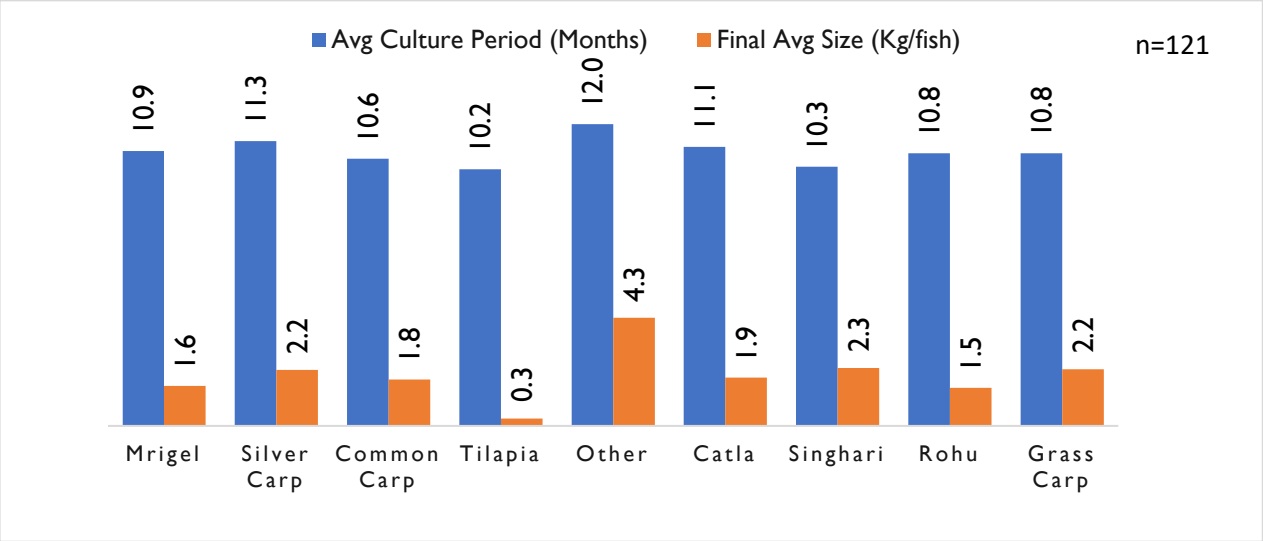
According to the survey findings, only 45% of the respondents applied fertilizer before stocking the fish, whereas approximately 88% applied fertilizer after stocking. In total, about 79% of the respondents reported using some form of fertilizer in their fish farming practices. While the fertilizers applied varied considerably, inorganic fertilizers such as urea (65%), Di-ammonium Phosphate (DAP) (58%) and quicklime (26%) were the most common. Cow dung is the most common form of organic fertilizer, applied by 21% of the farmers. Excessive fertilizer use can negatively affect the pond's water and groundwater quality, and there is typically no monitoring system in place. During the survey, it was observed that most farmers lack a clear understanding of when and how much fertilizer should be applied, highlighting the need for better guidance and education in this regard.

The high cost of fertilizer is another major problem reported by the farmers. Survey estimates established the cost of fertilization at PKR 12,399 (approximately USD 52.5) per acre per year. The price of fertilizers varies with Nitrophos, DAP, and urea being the most expensive fertilizers in the study area.

2.6. Fish Seed, Culture Period and Fish Size

A majority of farmers use fingerlings instead of fries as their fish seed, and the source of fingerlings is mostly from private hatcheries. As noted in Section 2.3, most farmers do not have their own hatchery for breeding purposes and are dependent on external hatcheries for seeds. Around 58% of farms purchased seed from a private hatchery while 29% purchased seed from private nurseries. Only 9% of the farmers source their fish from the Department of Fisheries. Other sources of fish seed are own raised (10%) or gift from friends (1%). As shown in Figure 6 below, the average culture period for common species produced is around 11-12 months, while the final average fish sizes ranged from 1-4 kg/fish.

Figure 6. *Culture Period and Average Fish Size for Common Species*



In terms of growth and survival rates of fish species, in Punjab, Catla and Rohu were reported to have maximum growth rates, while Grass Carp and Silver Carp had the maximum growth rates in Sindh. Further, Rohu and Catla showed the highest survival rates in Punjab, while Rohu and Common Carp had the highest survival rates in Sindh.

Fish sales peak during winter months (Nov-Feb) due to increased consumption, yielding higher demand and prices. In contrast, the summer months (May-Sept) mark the breeding season for indigenous fish like Rohu, Mori, and Thaila. Farmers prepare brood stock during this period, but fewer participate in fish breeding. Additionally, in Punjab, Tilapia fish face mortality in extreme cold, prompting pre-winter sales. Conversely, in Sindh's milder climate, some farmers extend their farming periods.

Upon harvest, the farmers transport their fish to the market for sale. A majority of farmers (84%) sold to wholesalers and 24% of farmers also reported selling directly to consumers. Around 98 percent of the fish sold were raw (fresh), whereas 2% were sold processed. Farmers reported that all fish buyers are male, and that fish is often priced low. The average price of fish in the study was PKR 220 per kg (USD

0.91). Tilapia, Rohu, and Common Carp, and Mrigel were the top species reportedly bringing in the highest revenue per year.

It is important to note that farmers may not have been able to report exact figures and there is a possibility that numbers may be both under and overreported. Long-term studies are needed in order to fully understand the economic returns of different fish species across Sindh and Punjab.

2.8. Incentives for farmers

Farmers were asked their opinion on various topics such as type of support needed in the saline aquaculture sector and the involvement of youth in the sector. They were presented with a series of statements and asked to rate their level of agreement or disagreement with each statement on a scale ranging from strongly agree to strongly disagree.

Majority of farmers (86% Punjab/60% Sindh) agreed or strongly agreed that post-harvest infrastructure needs to be improved to expand marketing of aquaculture products, highlighting gaps in the aquaculture value chain. Specifically, farmers highlighted challenges such as inadequate cold storage facilities, unreliable transportation networks, and limited access to markets, which significantly impact their ability to sell their products efficiently and profitably. Addressing these infrastructure gaps could not only enhance market access for farmers but also contribute to reducing post-harvest losses and increasing overall profitability. In line with this, all farmers strongly agreed that the government can support fish farming by providing farmers with more incentives. For instance, providing farmers with training on better farming practices, offering subsidies for fish seed and water quality testing instruments, and incentivizing pond construction can be effective interventions. Furthermore, subsidizing fertilizers can enhance fish farming sustainability. In the event of losses, the government could consider compensating affected farmers. In Sindh, where many faced losses due to flooding, there was a prevalent sentiment that their losses were not adequately compensated or addressed by the government, citing delays, inadequate coverage, and bureaucratic hurdles in accessing support. Strengthening and streamlining compensation schemes and disaster response to ensure timely and equitable assistance to affected farmers is paramount to enhancing resilience and rebuilding after climate-extreme events. Further, majority farmers agreed that younger generations are interested in fish farming activities, but they need more incentives and an enabling environment to do so. Barriers such as limited access to land, capital, and technical knowledge pose significant challenges for aspiring young farmers. Incentives could also be brought through private sector engagement.

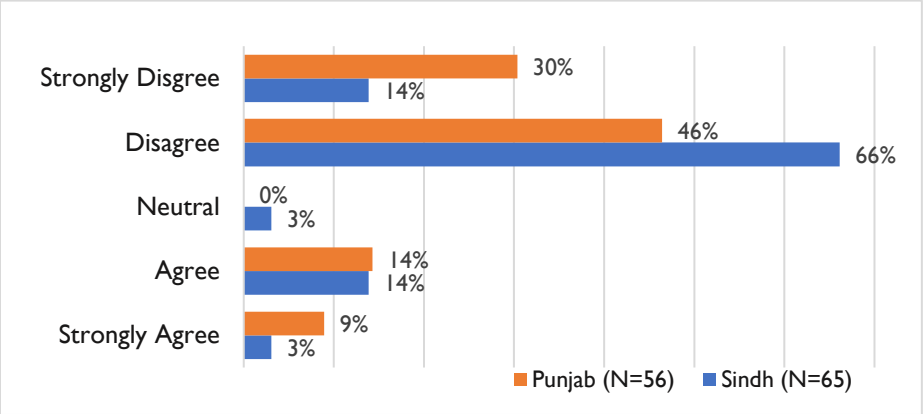
The private sector's role could involve, for example, establishing technology incubators focused on aquaculture innovations. These incubators could provide youth with hands-on training, mentorship, and access to cutting-edge technologies for sustainable aquaculture practices. The private sector could also encourage and fund entrepreneurial ventures within the aquaculture value chain, such as hatchery management, processing, and marketing, to attract youth to the sector. Additionally, private companies could collaborate with financial institutions to create tailored loan programs specifically designed to support young entrepreneurs entering the aquaculture sector, enabling them to invest in innovative and environmentally friendly practices. Such initiatives could not only attract more youth to the sector but also contribute to the sector's overall development and sustainability.

2.9. Women's access to saline aquaculture

Farmers were asked a series of opinion questions on the extent of women's involvement in fish farming activities. To note, only two women were seen across all the districts helping their husbands with fish feeding during the period of data collection. There is a prominent culture of keeping women in *pardah*

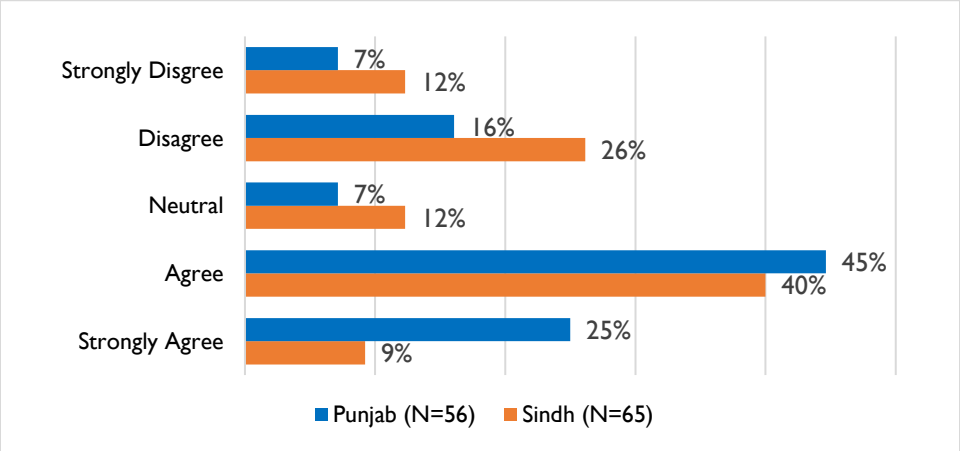
(religious and social practice of segregation of the sexes and women wearing concealing clothing) in Pakistan which may have explained lack of access for the research team in speaking with women in the study districts. The majority of farmers either disagree or strongly disagree that women have access to aquaculture farming equally as men (i.e. they can become farmers) (Figure 7). They also report that women vendors cannot be found in local fish markets, highlighting another gender gap in the marketing value chain. Farmers deemed certain tasks related to fish farming unfit for women, such as entering the pond for netting and keeping guard of the ponds at night. These types of tasks were seen as "man's work" and not appropriate for women due to their risky nature. Further qualitative observations on women's roles can be found in **Annex B.**

Figure 7. *Women have access to aquaculture farming equally as men*



It was reported that women help decide when and how much fish to take home for consumption and sale, as well as how income from fish farming will be used within a household. They are not, however, involved in any other decision-making related to fish farming. Women who do help are involved in tasks such as feeding. These findings fall in line with women's reproductive roles and being responsible for the domestic sphere, thus having a say in how much fish is needed for household consumption and how much money is required for other household expenses. Despite women's positive role in decision-making in this context, overall respondents had mixed views on whether women should work in fisheries or aquaculture industries (Figure 8).

Figure 8. *It is better if women do not work in the fisheries or aquaculture industries.*



While most farmers still hold traditional views that women should not be involved in the aquaculture sector, there are some who are more open to women's participation. One male farmer from Punjab shared that his daughter and wife were actively involved in fish farming activities in his ponds. These "male champions" may exist across Sindh and Punjab but do not comprise the majority male view. It is acknowledged that results may be biased and only provide a partial picture, as the study only includes opinions of male farmers. Further investigation is needed to understand what kind of work in the sector would be seen as "acceptable" for women, as well as what women's interests and priorities are in terms of their involvement in the sector.

Male laborers often find working on fish farms challenging, involving tasks such as entering water for harvesting and ensuring nighttime farm security to prevent theft. There is a perception that these tasks may not be suitable for women. Insights from stakeholder consultations emphasize that women could be better engaged in roles like processing and value addition, which are considered more manageable for them. By providing facilities and opportunities in these areas, women's participation in the fisheries sector could be enhanced, contributing to the overall growth and development of the sector.

2.9.1. Learning to improve women's involvement in SA

A case study from WorldFish is a project[1] in which gill nets were introduced to women for their homestead ponds (WorldFish, n.d.). Gill nets are a low-cost technology which can make fish harvesting more accessible to women and increase household consumption of fish.

Learnings from WorldFish can be applied to the Pakistan saline aquaculture context. For example, similar to Bangladesh, in Pakistan gender-related cultural and religious expectations prevent women from harvesting fish, a job seen as men's responsibility. Women are also unlikely to enter ponds and get their clothing wet. The introduction of gill nets allows women to be able to harvest fish from land and avoid entering the pond at all. This type of intervention allows for improved harvest and sale, as well as pathways to increased household fish consumption and nutrition. As women gain greater access to and control over fish resources, they may exert greater influence over the quantity of fish brought home for consumption and sale, thereby increasing the availability of fish within the household. This expanded access to fish contributes to a more diverse and balanced diet, enriching the household's nutritional intake, especially in regions where access to nutritious foods is limited. Additionally, involving women in fish harvesting empowers them to engage in household decision-making processes regarding food consumption and income allocation. Even if women/households choose to sell the harvested fish rather than consume it directly, the economic benefits derived from selling surplus fish can provide households with additional income, which can be allocated towards purchasing other nutritious foods or investing in health-related expenses.

This aligns with global evidence that women's empowerment has a significant, positive effect on children's nutritional status and that improvements in women's status lead to better nutritional outcomes for households (Berretta et al., 2023; Smith et al, 2003). Therefore, initiatives aimed at enhancing women's participation in fish harvesting not only contribute to gender equality but also have the potential to positively impact household nutrition, thus promoting the holistic well-being of communities in saline aquaculture regions. Additionally, WorldFish adopts gender-transformative approaches in their aquaculture projects (WorldFish, 2017). This means that family members are engaged on the benefits of

[1] A video overview of the case study can be viewed at: https://www.youtube.com/watch?v=eoYCxLISteY.

women working in the sector to ease any tensions and pushback of women conducting aquaculture activities.

Future projects in Pakistan may adopt gender-transformative approaches in design and planning to ensure that women are able to enter the sector and earn an income. As a first step, home ponds could be established for women in line with cultural norms, allowing women to actively participate in aquaculture while managing their responsibilities at home. As their roles expand, women could be engaged in other activities such as participating in community-based training programs, where they receive specialized training in pond management, fish breeding, and aquaculture practices. Extension services tailored for women could also provide ongoing support, ensuring that they have access to valuable information and the skills to succeed in the sector. Extension services can also target men, providing training on inclusive practices and promoting shared responsibilities in aquaculture and domestic tasks. Additionally, as their expertise grows, women may take on various roles within different parts of the value chain, including harvesting, post-harvest processing, marketing, and even assuming leadership positions within women-centric aquaculture cooperatives. This phased approach not only respects cultural norms but also opens avenues for women to progressively contribute to and benefit from multiple facets of the aquaculture sector.

2.10. Nutrition and hygiene

Saline aquaculture practices can have important implications for nutrition and hygiene. Fish consumption can improve nutrition, however, farmers reported eating fewer fish than the recommended minimum requirements from FAO. Further, nearly 90% of farmers reported not consuming any small indigenous fish species (SIS) in the week prior to being surveyed. There is also a high preference for large fish like Rohu (71%) and tilapia (17%), compared to small fishes. These factors indicate an opportunity to improve nutrition via adequate fish consumption, which is not currently tapped.

Participants struggled with access to nutritious foods due to low income, inflation of food prices, unavailability of different food and fruit choices in the market, or due to living in a food desert. Specifically, 94% of respondents in Punjab and 77% in Sindh expressed difficulty in maintaining a balanced diet on a daily basis. Further, respondents had limited knowledge about the nutritional benefits of a healthy and diverse diet. Only 2% of farmers stated they would experience health issues if they do not consume a diverse diet of fish, meat, and vegetables; the remaining farmers (98%) stated that they were unlikely to experience any health issues if they did not consume a diverse diet. This suggests a perception among respondents that dietary diversity, including fish consumption, may not be essential for maintaining good health. However, while there is some cultural disposition against eating fish during certain times of the year and the preference for different sources of protein due to the nature of fish bones, households would still consume fish if it were easily available.

Respondents were also surveyed regarding their handwashing practices, revealing concerning trends. Approximately a quarter of households reported not always washing hands with soap after using the toilet. Additionally, a third reported not washing hands with soap before handling fish, and many neglected to do so before engaging in household chores such as cooking, handling babies, or eating. These findings underscore the pressing need for hygiene training initiatives, emphasizing the health benefits of proper handwashing practices. Improved hygiene not only promotes the health of farmers but also enhances the quality of fish delivered to the market. Better sanitation and hygiene practices were observed to be higher in Punjab due to better socioeconomic conditions (Annex B). While affordability of soap may be a potential barrier, it is likely that respondents' poor handwashing habits stems from a lack of awareness rather an an inability to purchase soap.

2.11. Knowledge Sharing from World Fish

WorldFish had three main deliverables under the SRA: report on survey findings (external document); nutritional guidelines for farmers; and sharing of relevant SA videos of success stories from regional neighbors. Videos shared[2] with IWMI researchers allowed for a review of case studies from similar country contexts and spurred discussion on application for Pakistan.

Nutritional training is a key component of WorldFish aquaculture programs. Communities, particularly women, are given nutritional counseling and tips on how to improve their household meals. Integrated interventions focused on behavioral change in dietary practices can also encourage more fish consumption in Pakistan. It is important that interventions not only focus on hardware or technology of fish farming – though equally important – but also be supplemented by promotion of health and hygiene practices.

WorldFish team has also developed a two-pager nutritional guideline with key message for health and nutrition for small scale aquaculture farmers in Pakistan (**Figure 9**). These guidelines were explained and disseminated in local languages with farmers during the district level stakeholder workshops.

[2] *Videos shared from the WorldFish archive include a video on small fish and nutrition in Bangladesh and nutrition education in Cambodia*

Figure 9. *Nutritional guidelines developed by WorldFish for Pakistan context*

Vegetable and fruit production along pond embankments (pond-dike cropping)

- Plant different types of colored (green, yellow, red) fruits and vegetables that are rich in vitamin A and Iron (e.g. squash, tomatoes, spinach, etc.) to support in improving dietary diversity especially for young children and women of reproductive age.

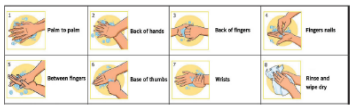
Keeping the environment clean

- Maintain cleanliness at home and the surrounding area by building improved latrines to prevent illnesses like diarrhoea that can lead to undernutrition and death, especially for infants and young children.

Proper Handwashing with soap and water

- It is important to wash hands with soap and water at 5 critical times/occasions; after going to the toilet, before preparing the food, after cleaning the child's bottom, before eating, before feeding the children/family to avoid illnesses like diarrhoea, typhoid, and cholera.

The right way to wash your hands



Good storage and Food handling

- Drinking safe water at all times avoid illnesses. Maintain clean and safe water by covering the container at all times.
- Use clean food containers and other kitchen utensils that are free from faeces, insects, animals, and pesticides that can harm health.
- Always cook food at correct time and temperature to kill harmful parasites that can pose health risks.

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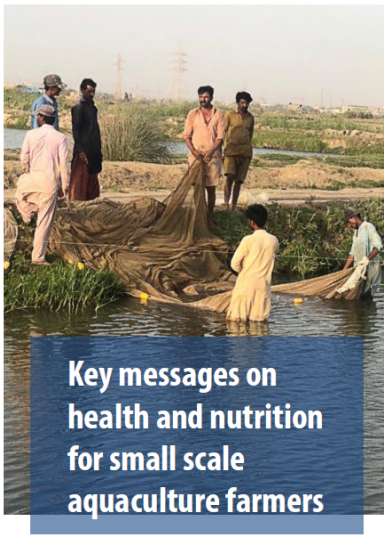


Key messages on health and nutrition for small scale aquaculture farmers

Funded by Australian Government Australian Centre for International Agricultural Research

In partnership with IWMI International Water Management Institute

Exclusive Breastfeeding and Complementary Feeding

- Breastmilk is best for babies, and the only food that a baby needs from 0- to 6-month-old. When the baby reaches 6-month-old, it is time to feed complementary foods at the right frequency, quantity and quality.
- Family members can support women, helping with household chores like cooking and cleaning the house so they can breastfeed their baby.

Nutritional Value of Fish

- Nutrient rich small fish such as mola, swamp barb, lee-gur, Polli (when head and bones intact) has higher nutritional content and easy to divide among household members than large fish species, ensuring good nutrition for the whole family.
- Mothers, fathers and caregivers are encouraged to cook and prepare nutrient-rich small fish in different ways that are acceptable for young children.

Plate 3. Sardines is a good source of micronutrients and essential fatty acids.

First 1000 days of life- the critical period from conception until child reaches 2 years of age

- It is important to observe proper infant and young child feeding practices, visit clinics for antenatal care, bring infants for immunization, observe family planning, and consumption of diverse food, especially for women of reproductive age to break the cycle of malnutrition (see Figure 1); as it can be passed on from generation to generation.
- Fathers, grandparents and caregivers can all have an important role in supporting good nutrition for women during pregnancy, breastfeeding and feeding infants.

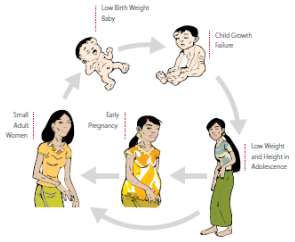


Figure 1.The intergenerational cycle of malnutrition.

- It is recommended to use iodized salt at appropriate amount in daily meals for child's physical growth, brain development and body functions and for pregnant women to prevent complications during pregnancy.

Plate 2. Use iodized salt in recommended amounts 2018)

Basic Food Groups

- Eating a variety of foods everyday helps in achieving good nutrition for the family. It is recommended that a plate has 1) cereals, 2) Meat and pulses (meats/eggs/pulses); (3) Dairy (milk and milk products); (4) Vegetables; (5) Fruits and (6) Fats and oils. Utilize cheap and available food (in season) that are rich in vitamins and minerals (fruits, vegetables, milk, eggs, fish) to ensure good health
- Nutrient-rich small fish (e.g. mola, swamp barb, lee-gur, Polli) when eaten whole (with head and bones) are good source of micronutrients such as vitamin A, iron, calcium, vitamin B12 good for child's growth and development.

Plate 1. A visual representation of a balanced meal in Pakistan (FAO, 2018)

CHAPTER 3: GIS REMOTE SENSING AND MAPPING

This chapter focuses on the physical geography of the study area in Punjab and Sindh, exploring factors such as the groundwater table, soil salinity, groundwater quality, and other climatic aspects. The decline of saline aquaculture in district areas is investigated, and potential hotspots for future growth are identified using GIS techniques and analyses, as well as remote sensing and satellite data processing.

Four significant administrative division bodies of the Punjab and Sindh provinces, which comprise districts (Rahim Yar Khan, Bahawalpur, Bahawalnagar, Rajanpur, Muzaffargarh, Dera Ghazi Khan, Thatta, Badin) with hotspots for major saline areas and represent important regions for saline aquaculture production and economic well-being are examined. Overall, this chapter provides insights into the spatial distribution and dynamics of saline aquaculture in the region and can help to inform future decisions and investment in aquaculture development and food security policy and practice. The mapping analyses and exercise contribute to Objective 1 of the scoping study in developing a resource inventory of saline aquaculture.

Annex C provides a detailed overview of the mapping methodology including the framework used for processing time series of earth observation satellite data to detect and map saline aquaculture at a smaller scale in the study area. Detailed maps of landcover, depth to water table, soil salinity, groundwater quality, soil type, temperature, precipitation, and evapotranspiration are included in the Annex as well as detailed explanation of datasets, sources, and mapping techniques used. This chapter will present the main extent of fish farms in the study areas as well as the suitability for saline aquaculture across Sindh and Punjab.

3.1. Extent of Fish Farms

To calculate the extent of fish farms in the study area, Landsat 5 for 2012 and Landsat 9 for the year 2022 have been used. The process of change detection has been applied which ultimately shows the changes that have occurred in a decade. Water bodies have been extracted using the Landsat 5 and Landsat 9 scenes. The temporal variations between two images have been taken out in the pre-monsoon seasons and the natural water bodies have been delineated using machine learning algorithms. Object based analysis has been applied to extract the fish farms in a more appropriate format on Google Earth engine.

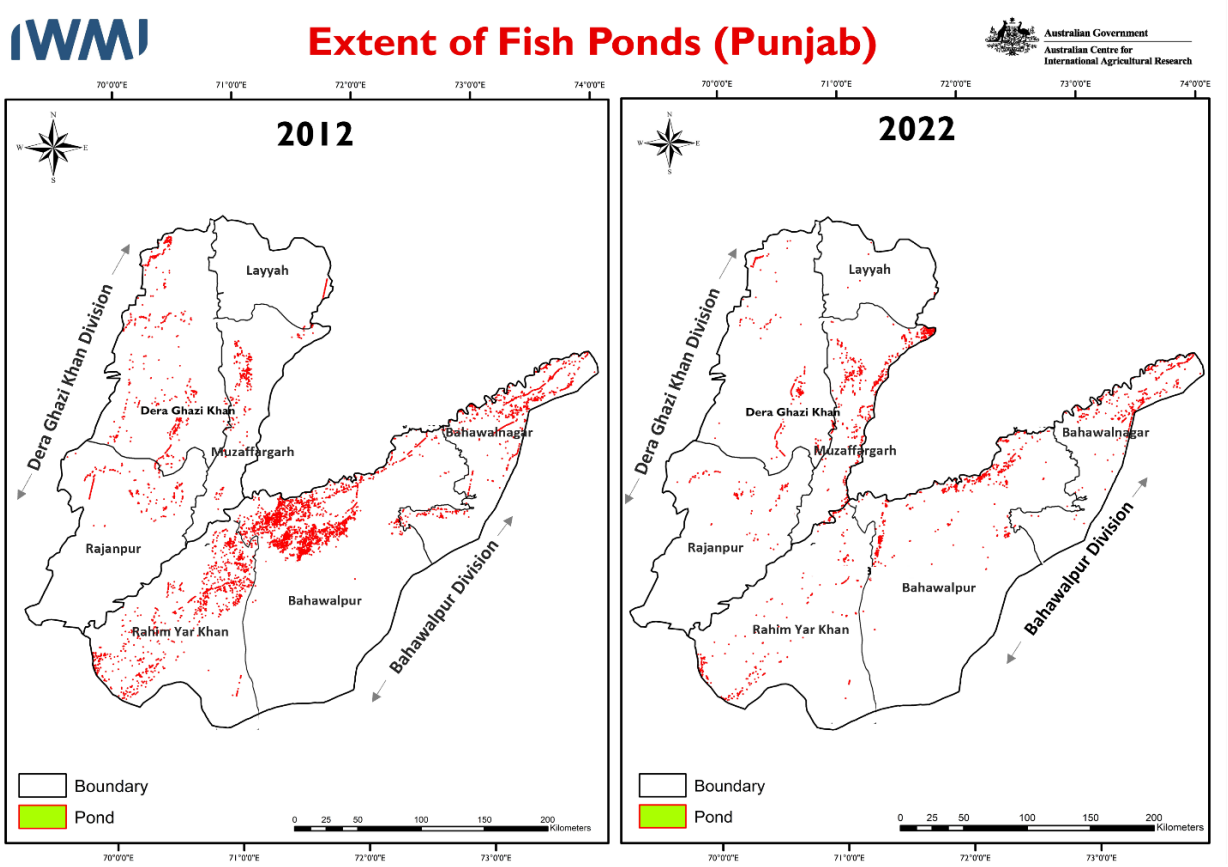


Figure 10. *Map showing the extent of fishponds from 2012 to 2022 in two major divisions of Punjab named Bahawalpur Division and Dera Ghazi Khan Division; these divisions, comprise district boundaries of Rahim Yar Khan, Bahawalpur, Bahawalnagar, Rajanpur, Muzaffargarh, Layyah and Dera Ghazi Khan.*

Year	Fish Ponds	Area (Acres)
2012	3018	5042
2022	1689	3894

Figure 10 illustrates a shift in aquaculture trends in South Punjab districts. In 2012, there was a prevalent engagement in small-scale farming among farmers. However, over time, small-scale farmers faced challenges such as increased salinity of land, issues with water quality, rising feed costs, and difficulties transporting products to larger markets. These difficulties resulted in annual losses, leading to discouragement and eventual abandonment of farming. By 2022, there is a noticeable decline in small-scale fish farming. On the contrary, some farmers involved in larger-scale farming expanded their fish farms. Collaborating with progressive farmers for advice and assistance, they overcame challenges related to selling fish products and managing feed. These farmers successfully transported large quantities of fish to bigger markets, yielding better profits and avoiding significant issues with fish feed or pond management.

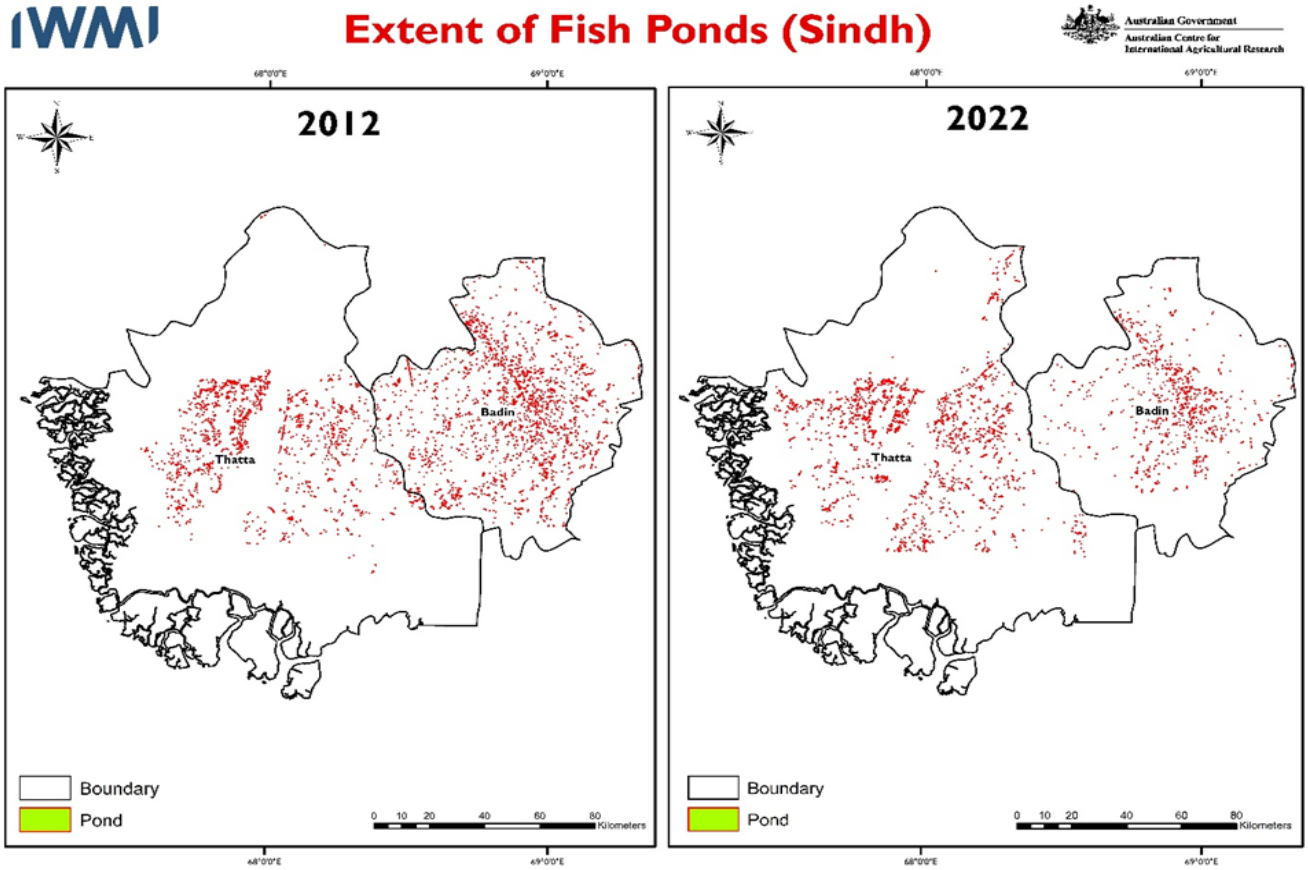


Figure 11. *Map showing the extent of fishponds in Thatta and Badin from 2012-2022*

Year	Fish Ponds	Area (Acres)
2012	3738	5963
2022	2871	4102

In Thatta and Badin, a decreasing trend in small-scale aquaculture over time has been noticed. The primary reasons for this decline include the increasing salinity of the soil and limited availability of saline fish seed. Not all fish species can thrive in highly saline conditions, making the presence of suitable species essential. Many farmers in these areas source saline fish seeds, such as Sea bass, from Nareri Lake in Badin and cultivate them on their farms. It's worth noting that Sea bass naturally breeds in Nareri Lake in Badin District, and there are no specific breeding sites established for them. However, the high demand for these fish seeds has resulted in their elevated cost, leading to financial losses, especially for small-scale farmers. In instances where these losses cannot be recovered, farmers often discontinue their farming activities.

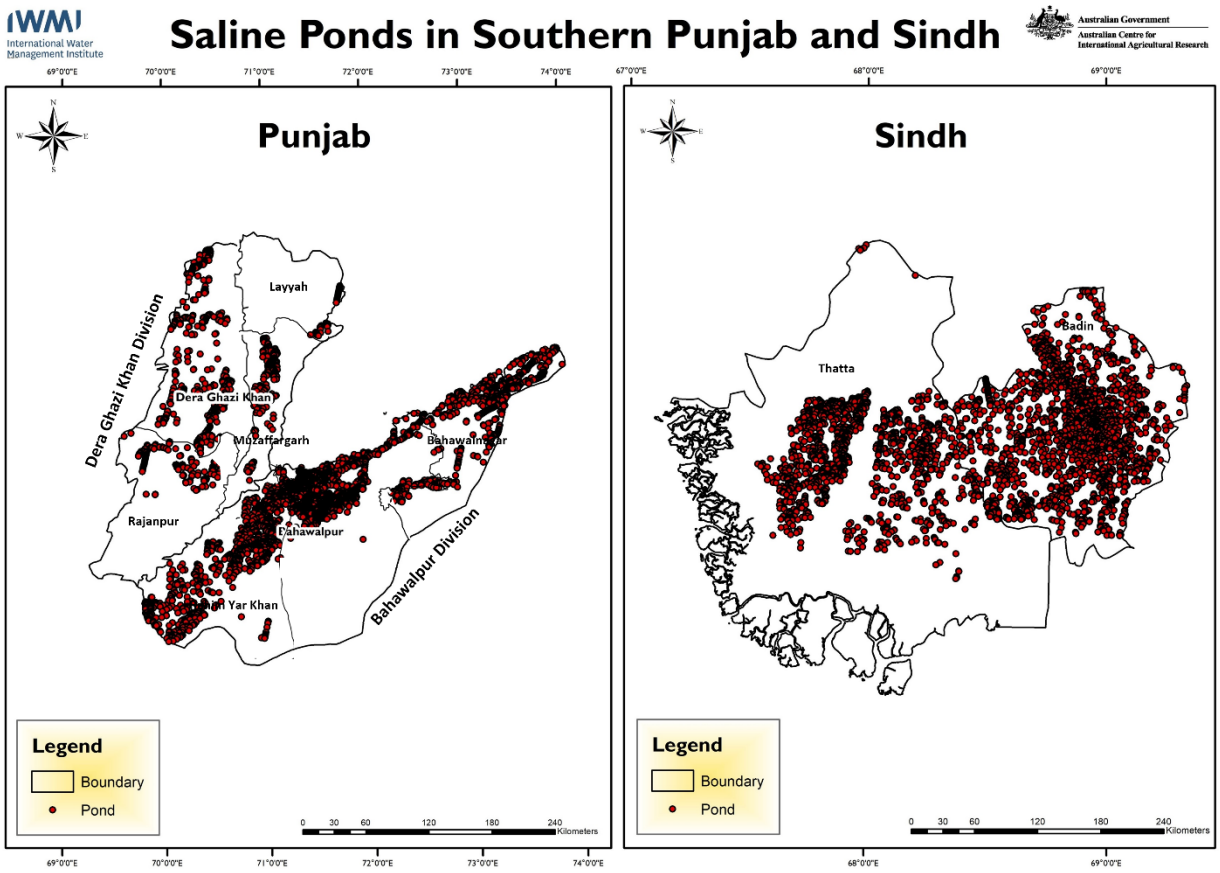


***Figure 12**. Total Saline ponds in Punjab and Sindh, Pakistan (Threshold with greater than 5 Acres)*

Study Area	Fish Ponds	Area (Acres)
Punjab	3646	18230
Sindh	5727	57254

Figure 12 illustrates the cumulative coverage of saline ponds with areas greater than 5 acres (2 ha), specifically showing pond ownership within a 5 acre (2 ha) area in the Bahawalpur and Dera Ghazi Khan divisions, totaling 18,230 acres (7,377 ha) in both Dera Ghazi Khan and Bahawalpur divisions. In contrast, for the Thatta and Badin districts from Sindh, the fishpond areas, influenced by natural environmental development for the fish, resulted in ownership of the pond sizes exceedingly even more than 10 acres (4 ha), where they naturally thrive in an environment conducive to fish growth. The cumulative area covered for Badin and Thatta from Sindh province was assessed at an area cover of 57,254 acres (23,170 ha).

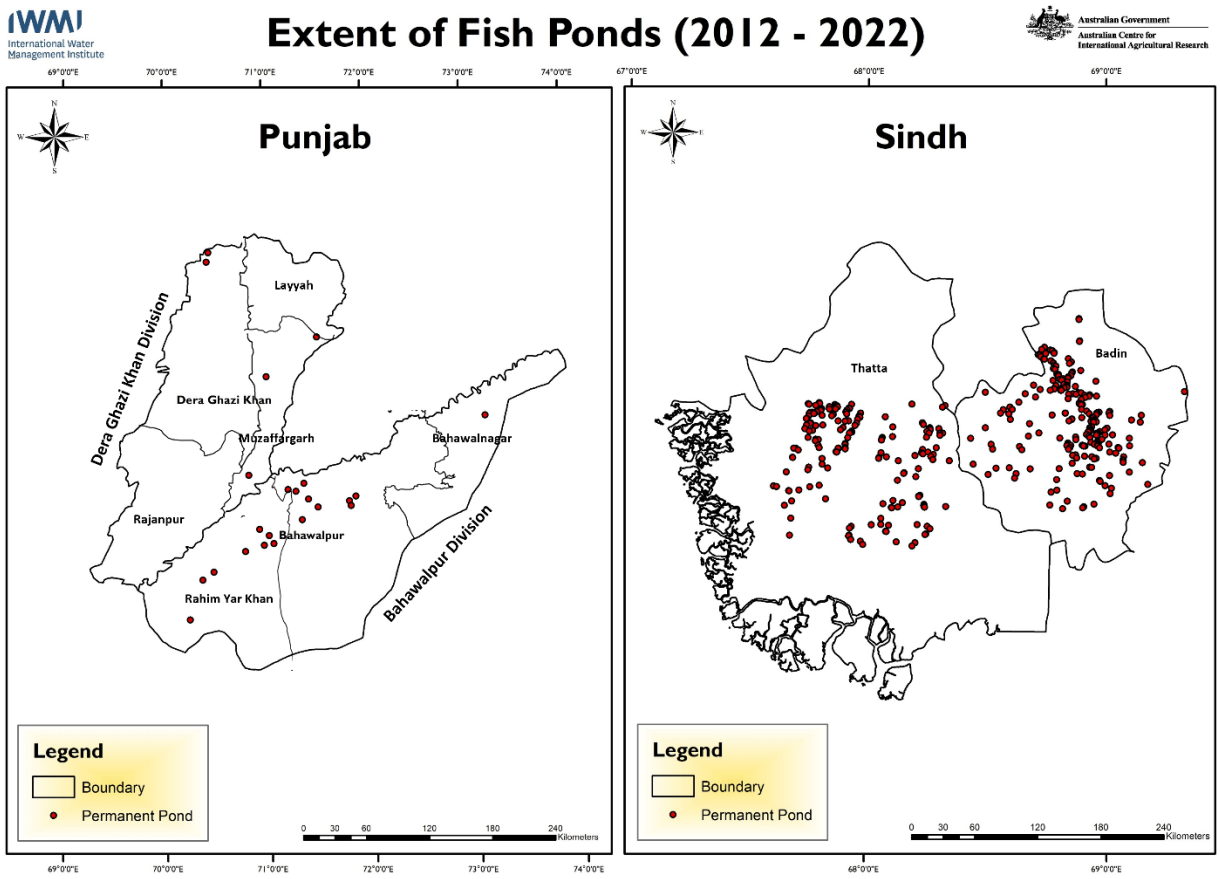


***Figure 13**. Extent of Permanent ponds (threshold 1-5 acre) from 2012-2022 in Punjab and Sindh, Pakistan*

This figure represents fishponds that have been consistently operational from 2012 to 2022, primarily managed by small-scale farmers. The key reason behind their sustained engagement is that these farmers possess the knowledge and strategies to address challenges arising from increasing salinity. They are trained and equipped with techniques to navigate situations where salinity levels rise.

Conversely, other small-scale farmers have discontinued their fish farming activities due to various challenges. These challenges include the unavailability of saline fish seeds, a lack of best management practices and training, and issues related to marketing. As a result, these farmers do not achieve a reasonable profit. Often, the cost of maintaining a fishpond is high, and the products do not fetch a sufficient price in the market, leading to financial losses for the farmers.

3.2. Weighted Overlay Analysis

Weighted overlay has been performed so that several factors of varying importance should be considered to arrive at a final decision. Each thematic layer has been assigned a percentage influence. The cell values are multiplied by their percentage influence, and the results are added together to create the output. The overlay analysis for Punjab and Sindh indicated that in the south-east part, the groundwater had greater depth in the pre-monsoon seasons. See **Annex C** for detailed methodology.

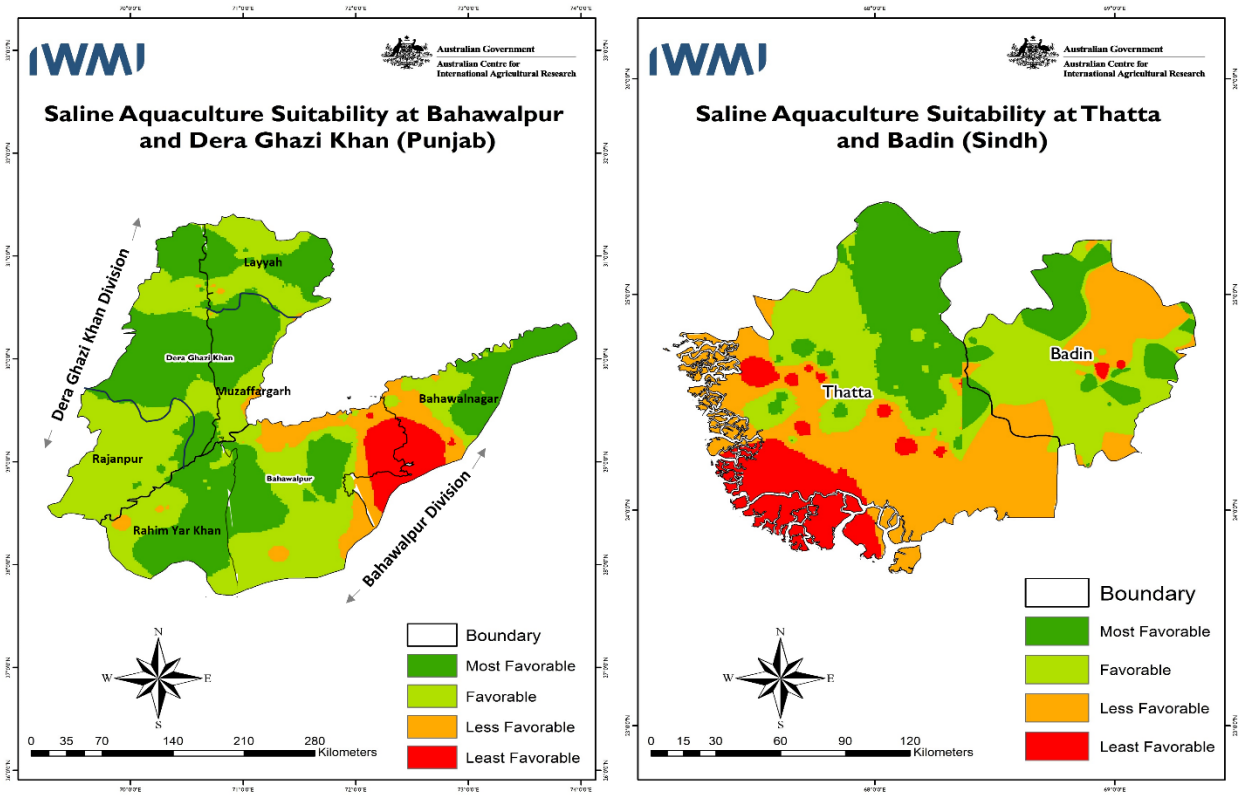


Figure 14. *Map showing the hotspots for Saline Aquaculture in Punjab and Sindh*

3.3. Conclusion

This chapter presented the spatio-temporal variation in fishponds and identification of hotspots for saline aquaculture in Punjab and Sindh Province of Pakistan. The suitable areas were categorized into most favorable, favorable, less favorable, and least favorable areas. It utilized several thematic layers for accuracy in the prediction of aquaculture suitable areas. However, thematic layers indicated increasing trends over the year, with t-state values of 1.324, 0.291 and 0.504, respectively. Marginal improvements in groundwater electrical conductivity (EC), sodium absorption ratio (SAR), and residual sodium carbonate (RSC), and a decrease in groundwater level (GWL), has been observed. The results also indicate that the data of groundwater parameters were spatially autocorrelated over the years. The spatial distribution analysis of groundwater EC indicated that the groundwater quality was fit for saline aquaculture in most of the study area. The groundwater level (GWL) was also higher in the Punjab and Sindh study areas during the pre-monsoon. The higher values of these parameters in groundwater seem to be due to the simultaneous contribution of natural mineralization, the use of unpurified irrigation water, and anthropogenic inputs which make it suitable for aquaculture.

CHAPTER 4. STAKEHOLDER MAPPING

4.1. Validation Workshops and Mapping Exercise Overview

This chapter builds on the previous chapter's focus on the physical geography of the study area and turns to the human geography of Pakistan's saline aquaculture sector. Mapping stakeholders involved in this sector is crucial to understanding the complex social and economic dynamics that shape its development and contributes to Objective 2 of this SRA. This chapter presents the findings from our stakeholder consultation workshops and stakeholder mapping exercise. The stakeholder consultation workshops brought together diverse actors from the government, civil society, and private sector, including surveyed farmers, to share their perspectives and experiences related to saline aquaculture and validate survey findings (Chapter 2).

During these workshops, a stakeholder mapping exercise was conducted with participants to rank stakeholders across three main domains: power, interest, and influence. This allowed us to visualize and analyze the different interests, relationships, and power dynamics among stakeholders. This participatory and inclusive approach to validating survey findings and understanding the stakeholder landscape will help inform policy and practice for developing the sector and promote synergies across stakeholder groups.

A series of 7 stakeholder consultation workshops took place after data collection and analysis were completed. Workshops were held at the district level (Thatta, Badin, Multan, and Rahim Yar Khan), at the provincial level (Lahore and Karachi), and concluding with a national stakeholder workshop in Islamabad. Workshop discussions were organized around four main themes:

1. Challenges and Opportunities to Provide Healthy Seeds and Salt Tolerant Breeds
2. Challenges in Pond Water Management and Disease Control for Better Management Practices
3. Challenges and Opportunities to Provide Quality Fish Feed and Proper Use of Fertilizers to Enhance Production
4. Opportunities and Modern Techniques for Small-Scale Farmers and Women to Promote Saline Aquaculture

Detailed workshop reports can be found for Sindh in **Annex D** and for Punjab in **Annex E**. This chapter will focus on the stakeholder mapping exercise and key discussion points and recommendations from the workshops.

4.2. Stakeholders in the Saline Aquaculture Sector

During the initial stages of this scoping study, the IWMI team identified the following stakeholders listed in Table 3 and mapped them in different categories according to their roles and influences on the overall sector. Stakeholders include government organizations and departments, fish farmers and their collectives, seafood/fish processors, local communities, investors, suppliers of fish seed and feed, academics, researchers, and NGOs.

Table 3. Major Stakeholders in the Saline Aquaculture Sector in Pakistan

Domain	Stakeholders
Government Sector	▪ Pakistan Council of Research Water Resources (PCRWR) ▪ Provincial Fisheries Departments (Sindh and Punjab) ▪ Directorate of Fisheries Sindh Inland, Hyderabad ▪ Ministry of Maritime Affairs, Government of Pakistan ▪ National Institute of Oceanography, Ministry Science and Technology, Government of Pakistan ▪ Fisheries Development Board, Islamabad
Private Sector	▪ Fish Hatcheries ▪ Feed Millers ▪ Fish Feed Processors ▪ Fish Exporters ▪ Fertilizer Producers ▪ Pesticide Companies ▪ Zoologists (Fisheries Extension Service Provider)
Academia *(Related departments to Fisheries and Saline Aquaculture)*	▪ Khwaja Fareed University of Engineering and Information Technology Rahim Yar Khan ▪ Mian Nawaz Sharif University of Agriculture, Multan ▪ University of Veterinary and Animal Sciences, Lahore ▪ University of Education (Faisalabad Campus) ▪ Mehran University of Engineering and Technology Jamshoro ▪ University of Sindh Jamshoro ▪ University of Punjab

4.3. Stakeholder Feedback/Recommendations

In Punjab, Farmers and Punjab Fisheries officials focused on shrimp, Tilapia, and Pangasius farming in saline water due to the availability of seeds and support infrastructure in the private sector. However, the promotion of shrimp in South Punjab has been hindered by lack of government funding. Water chemistry proved to be a major challenge for farmers, resulting in low survival and slow growth of fish. Lack of pond management capacity and water quality monitoring tools were also concerns. Financing, hatchery setup, species-specific feed, and water testing equipment at the farm level were identified as barriers to sector growth. Improved post-harvest handling and marketing were noted as key factors for saline aquaculture success. Carp were used due to a lack of choice but were deemed unsuitable due to higher levels of salinity adversely affecting their growth or, in some cases, leading to increased mortality rates. Fertilizer usage in ponds and drainage systems has been mismanaged. The Punjab Fisheries Department recognized IWMI's role in researching saline water and soil and expressed their willingness to assist farmers. Women representatives suggested that women could work as farm managers and engage in fish breeding, despite societal norms. Developing hatcheries for salt-tolerant species in Sindh and transporting fry to South Punjab was suggested to promote sector growth.

In Sindh, farmers are interested in shrimp and crab farming, but face challenges in obtaining quality seed and specific feed. Lack of infrastructure for shrimp farming and finance to import shrimp seeds were also highlighted as challenges. Farmers also struggle to monitor water quality, temperature fluctuations, and lack proper instrumentation. Carp is not ideal for saline aquaculture, but farmers are limited by the seed available in the market. Officials from Sindh Fisheries Department are willing to facilitate farmers and encourage them to obtain licenses for better government support. Women's participation in fish farming is limited by social and cultural norms and distance from their homes to the ponds. In-depth discussions

with women and youth are necessary to understand their interest in participating in the sector. Specific interventions can be designed with the support and buy-in from the community to address their needs. Stakeholders across both provinces recommended:

1) Raising awareness among farmers through education programs on proper use of saline water, water testing, and recording water parameters for continuous improvement.
2) Using social media to train and educate women and youth about saline aquaculture.
3) Identifying salinity-affected areas through remote sensing and satellite imagery and implementing area-specific interventions, such as pond-dike cropping and other circular economy techniques with zero loss.
4) Improving post-harvest handling and marketing systems, including cold storages, fish handling, packaging, and grading, to help farmers receive the right price for their products.
5) Providing subsidized financing to smallholders to support their initial investments and improve their profitability.

Participants emphasized the need for long-term programs to holistically support Saline Aquaculture by both the public and private sector. Institutions like IWMI and WorldFish could lead the development of such programs and bring in best practices from around the world, including capacity building, introduction of new species and technology. Model and demonstration farms could be established for hands-on training for women on culturing salinity-tolerant fish species like shrimp, tilapia, and pangasius. Additionally, trials could be conducted to introduce high-value shrimp through conditioning, rearing, stocking, and fattening techniques.

4.4. Stakeholder Power, Interest, and Capacity Scoring

As part of the provincial stakeholder consultation workshops held in Lahore and Karachi, a power, interest and capacity scoring matrix was developed to understand the stakeholder perception. The participants were provided with a ranking sheet **(Annex F)** to rank each stakeholders' power, interest, and capacity in the overall saline aquaculture ecosystem. Each stakeholder was ranked on a scale from 1-4, with 1 being low level and 4 being high level. The figures below provide an overall quantitative picture of how the stakeholders ranked different actors. A total of 21 participants completed the sheet for Punjab and 22 for Sindh.

Figures 15 and **16** show the average power, capacity, and interest scores for government stakeholders in Punjab and Sindh. They indicate that while the government sector is perceived to hold substantial power in overall policy and investment decision-making, their relevant interest and capacity scores are lower. This discrepancy might imply that while government stakeholders have the regulatory and decision-making power, there may be challenges or limitations in their willingness or ability to invest resources or efforts into the development and enhancement of the SA sector. It could be reflective of a situation where governmental bodies, despite their influential roles, might not perceive the SA sector as a high-priority area for their active involvement. This highlights the importance of targeted interventions and communication strategies to align government priorities with the goals and needs of the SA sector for sustainable growth and development.

Figure 15. *Government Sector Average Power, Interest, Capacity Scores (Punjab)*

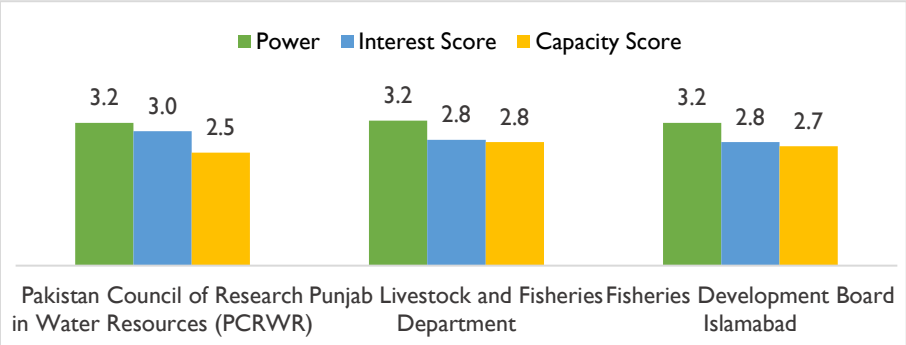
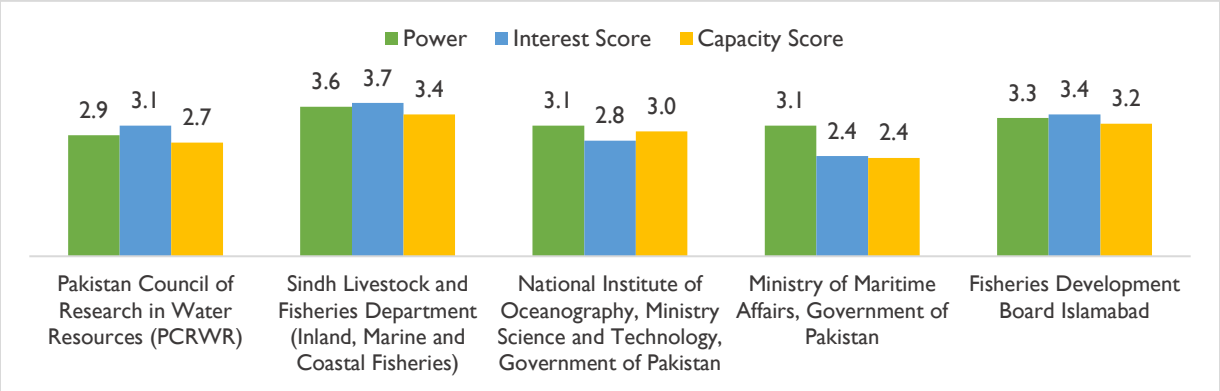


Figure 16. *Government Sector Average Power, Interest, Capacity Scores (Sindh)*



Figures 17 and **18** highlight the influential role of private sector entities across Sindh and Punjab, including fish hatcheries, feed millers, and fisheries extension service providers, in boosting saline fisheries production. It also underscores the strong interest of fish exporters, feed millers, and extension workers, who stand to gain the most if the sector proves profitable. However, there is a pressing need to build the capacity of fish processors, exporters, and fertilizer and pesticide companies to produce specialized products for salt-tolerant fish species. Power, interest, and capacity of hatcheries is also scored highly. This may signify that they have significant control over critical aspects, such as the production and supply of fish seed, influencing the dynamics of the entire sector. Hence the need for development of new hatcheries is paramount to the development of the overall sector.

Figure 17. *Private Sector Average Power, Interest, Capacity Scores (Punjab)*

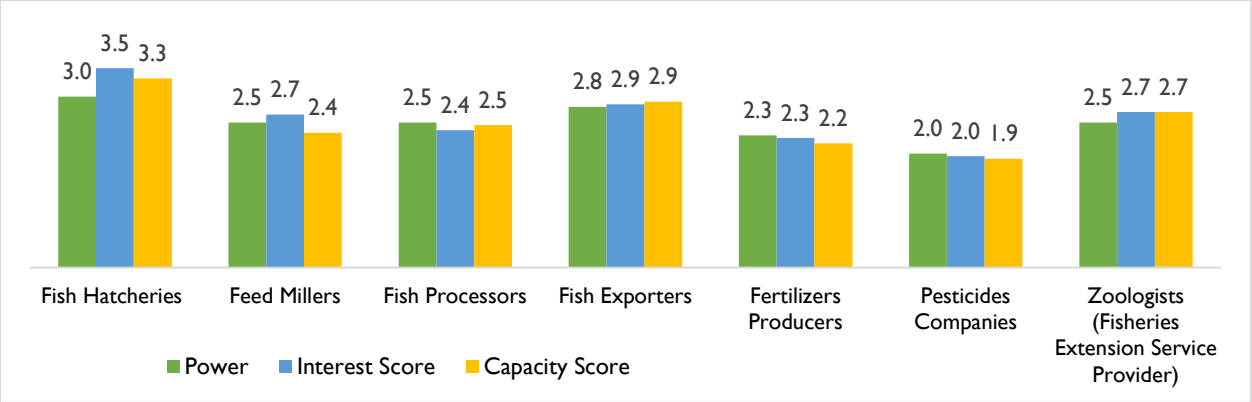
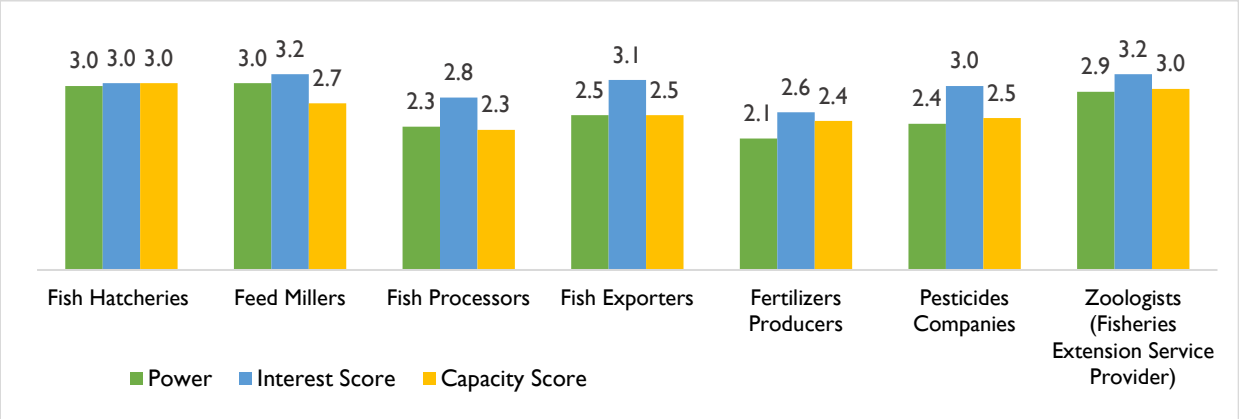


Figure 18. *Private Sector Average Power, Interest, Capacity Scores (Sindh)*



Figures 19 and **20** below provide an overview of the scores for the remaining stakeholder groups. In Punjab, stakeholders believe academic institutions have higher power, interest, and capacity to improve the overall sector as compared to those in Sindh. There is however a missing link that needs to be established to translate that capacity and interest into solutions for the small farmers. The added advantage of this capacity is that any solution that is developed will be customized for local needs and problems.

The other stakeholder groups which includes both small and medium fish farmers shows promising interest scores but relatively lower capacity score, with higher average scores in Sindh than in Punjab. This may be because there is greater scope for fish farming in Sindh. This also suggests the needs for a robust capacity building program for small and medium fish farmers to improve their productivity. Overall, civil society organizations have relatively low interest and capacity in the sector. There may be several reasons why civil society is not as actively engaged, including limited resources, a focus on advocacy and policy-related activities, potential lack of technical expertise, dependency on external funding with conditions that may not align with SA initiatives, minimal direct operational involvement, limited networking opportunities within the sector, competing priorities addressing various issues, and perceived relevance of other sectors like agriculture, WASH, etc. However, stakeholders note that civil society has moderate levels of power in influencing communities; this can be leveraged in future holistic interventions focusing on improved SA, nutrition, and hygiene. Civil society may be engaged to better reach local communities

and help with awareness-raising on the potential of saline aquaculture to address poverty and health concerns, linking the interconnected nature of SA with other sectors that traditionally receive more attention.

Figure 19. *Other Stakeholders Average Power, Interest, Capacity Scores (Punjab)*

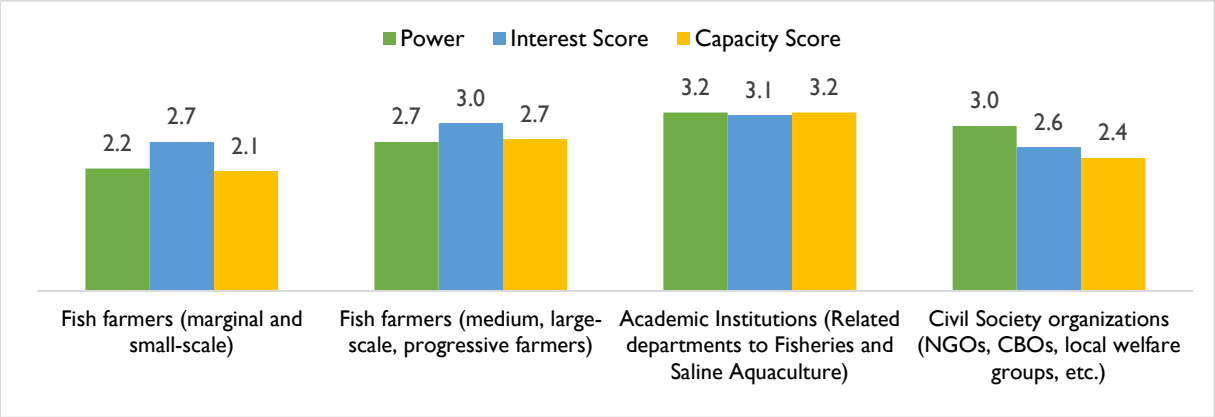
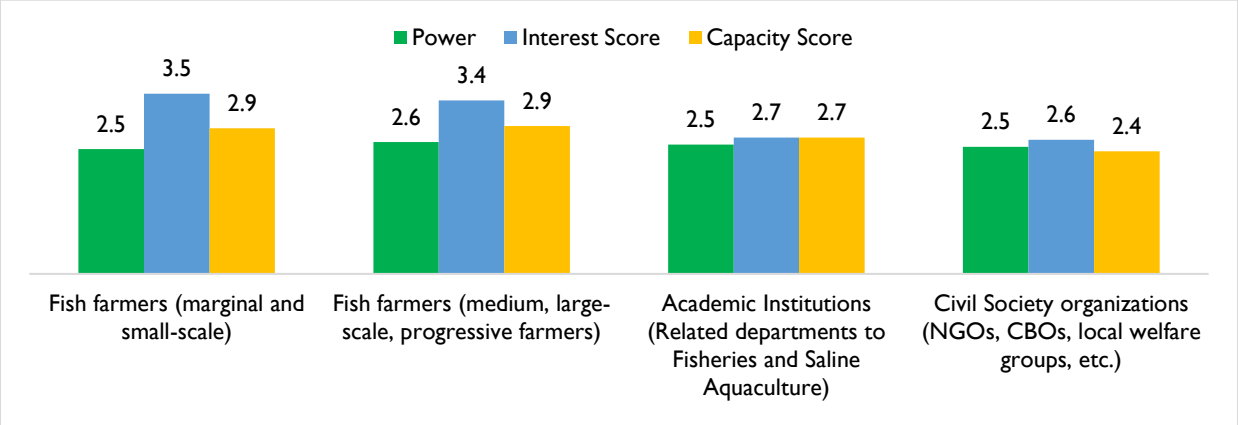


Figure 20. *Other Stakeholders Average Power, Interest, Capacity Scores (Sindh)*



4.5. Discussion

The stakeholder consultation workshops shed light on the potential for further development of SA in Sindh and Punjab. Challenges identified include a lack of environmental awareness, limited resources for farmers and industry players, insufficient processing facilities, and inadequate R&D investment. Despite these challenges, there is optimism, as provincial Fisheries Departments express interest in collaborating with farmers and stakeholders to enhance the SA landscape.

The stakeholder mapping exercise reveals opportunities for improving capacity-building, particularly among farmers and private sector entities. It emphasizes the necessity for stronger partnerships between government and academia to disseminate research findings related to SA and make them locally relevant and accessible to fish farmers. Building engagement with civil society is also crucial, especially in connecting with communities and integrating SA with other sectors like agriculture, WASH, and nutrition.

Results underscore the pivotal role of private sector entities, including fish hatcheries, feed millers, and fisheries extension service providers, in driving saline fisheries production in Sindh and Punjab. While key stakeholders express strong interest, capacity gaps exist for fish processors, exporters, and fertilizer and pesticide companies, necessitating targeted capacity-building efforts. The influence of fish hatcheries, as indicated by high power, interest, and capacity scores, underscores the urgency of developing new hatcheries for sustainable sector growth.

Government stakeholders, despite high power scores, exhibit lower interest and capacity scores, indicating a potential gap in their active engagement in the SA sector. Addressing this discrepancy is crucial for aligning government interests and capacities with the sector's developmental needs, fostering a more effective and sustainable industry.

In summary, the stakeholder workshops were a positive step in further developing the sector as they created a space for networking and building relationships, which can lead to further collaboration and innovation. Through the workshops, farmers gained access to new information, learned about the latest technologies and practices, and received support on how to implement them in their operations. Farmers and experts alike were energized and motivated to continue collaborating and pushing the sector forward. Overall, the workshops were a positive step towards further developing the SA sector. The sense of excitement and support generated by the workshops bodes well for future programs, with stakeholders committed to continuing the work towards realizing saline aquaculture's potential in Pakistan.

CHAPTER 5. WAY FORWARD

Pakistan is one of the most water-stressed countries in the world, with a growing population that places a significant strain on the country's freshwater resources. As a result, there is a pressing need to explore alternative sources of water for agriculture and other uses. Inland saline aquaculture serves as a promising option that can help address this challenge while also creating economic opportunities for the country's rural communities.

While there is significant potential for saline aquaculture in Pakistan, the study conducted by IWMI highlights significant challenges that must be addressed through investments in infrastructure, technical expertise, and sustainable practices. If these challenges are overcome, inland saline aquaculture can help promote economic growth and improve nutrition in the country.

Based on findings from this study, major issues and constraints within the saline aquaculture sector include:

1. **Awareness and Information Gaps**
   - Lack of environmental awareness of salinity and the impacts of climate change on the overall aquaculture sector.
   - Saline aquaculture stock assessment information is not available at a centralized location to make informed decisions about interventions and possible impacts of investments in the sector.
   - Saline water brackish areas have not been scientifically identified, and limited data is available regarding the areas that are salinity-affected. The need for utilization of GIS and Remote sensing can provide full extent of saline aquaculture potential in both Sindh and Punjab.
   - Weak links between farmers, fisheries departments, private sector, and civil society.

2. **Infrastructure and Capacity Challenges**
   - Hatchling and breeding facilities of saline-tolerant species are not available locally, and farmers are forced to use freshwater species in saline ponds.
   - No capacity-building program on technical knowledge is available for Saline Aquaculture except limited service by PFD (South Punjab) through Saline Water Aquaculture Research Centre (SWARC).
   - Lack of R&D facilities in the academic and public sectors has resulted in slow modernization of the domestic industry. Academia has limited resources to do applied research, and the need for private sector investment in R&D can catalyze modernization of the sector.
   - Chemical analysis facilities of soil and water are not available at large, and limited information is available, which impedes decision-making by the public and private sector.
   - Fish disease diagnostic facilities are not available to farmers which affects fish health and production.

3. **Financial and Transactional Barriers**
   - Farmers lack the financial capacity to enter saline aquaculture business as the risks are high compared to investment in freshwater aquaculture.
   - Farmers are at the mercy of middlemen, who exploit them at the time of harvest due to non-availability of cold storage and lack of market information systems to help the farmer make informed decisions on when to harvest the fish for better profitability.

- Farmers are borrowing money from middlemen at high rates of interest to pay for fish seed and farm management, which is a huge challenge for the farmer as the risks are high due to climate change and frequent natural disasters in Pakistan.

4. Processing and Post-Harvest Issues

- Lack of industry-standard processing facilities, and mostly the product is non-hygienic because of a lack of skills and facilities.
- Post-harvest handling is one of the major challenges in expanding the demand for fish by consumers, and lack of hygienic facilities and skills in post-harvest handling have been some of the main challenges.

5. Restrictive norms

- Women continue to be in the shadows of the SA sector due to social norms, despite high involvement of women in regional neighbors like India and Bangladesh.

Despite these constraints, there is significant potential for SA in Pakistan if the following recommendations could be operationalized over the short-, medium- and long-term:

Short-term (6 months to 2 years)

1) Capacity building and training programs

- Develop and implement capacity-building programs for small-scale Saline Aquaculture farmers on technical knowledge in saline aquaculture (with a special focus on women and youth). These programs would include a social and cultural norms component to address norms that hinder women's participation in the sector and provide specific training for women on activities they can be engaged with in the value chain (e.g., pond management, seed handling, feeding, post-harvest processing, marketing and sales, small business development).

- In collaboration with fisheries departments and universities, create a guidebook for saline aquaculture farmers in local language and graphics to provide comprehensive information and practical guidance on managing saline ponds and cultivating fish species based on international best practices. This would include topics such as pond construction and design, choosing suitable fish species, water management, stocking and seed management, feeding practices, disease prevention, and harvesting and post-harvesting, etc.

- Provision of water quality and pH testing equipment to saline aquaculture farmers.

- Exposure visits of small-scale Saline Aquaculture farmers to state-of-the-art private aquaculture farms in Punjab and Sindh.

- Build networks with civil society organizations who work in sectors such as agriculture, Water, Sanitation, and Hygiene (WASH), nutrition, and engage them on the interconnectedness of SA to these sectors. Civil society are strong stakeholders whose power can be leveraged for better community engagement.

2) Expand saline aquaculture database in Pakistan

- Expanding on this study, utilize GIS and remote sensing to identify salinity-affected areas and provide a full extent of saline aquaculture potential in both Sindh and Punjab, along with mapping of saline fish ponds across Punjab and Sindh.
- Develop a centralized database that provides stock assessment information for saline aquaculture species.
- Collect sex-disaggregated data to map out the gender division of labor in saline aquaculture value chains, including paid and unpaid labor, and opportunities to address these challenges.

3) Develop building blocks for a saline aquaculture policy framework in Pakistan

- Building on the capacity building and training programs and the expansion of a saline aquaculture database, continue to initiate research projects or small-scale pilot programs/demonstration sites to generate empirical evidence on the feasibility and effectiveness of potential policy interventions. This approach ensures that policymakers are equipped with solid evidence and insights, increasing the likelihood of informed decision-making.

Medium-Term (2-5 years)

1) Diversification and Innovation through Private Sector Engagement

- Prioritize capacity-building initiatives for aquaculture experts in both public and private sectors, with a specific focus on breeding new salt-tolerant fish varieties. This includes organizing exposure visits to countries like Malaysia and Thailand to gather insights from successful practices and stimulate private sector interest and participation in capital raising and investment
- Demonstrate the market potential and profitability of saline aquaculture ventures to attract private sector investment. This can be done by conducting market analyses and feasibility studies to identify market opportunities for salt-tolerant fish species and products.
- Foster Public-Private Partnerships (PPPs) between government fisheries departments and private sector entities to introduce saline-tolerant species and reduce reliance on freshwater species. These PPPs may take the form of joint infrastructure development (e.g., hatchling and breeding facilities, distribution channels, processing plants, and cold storage facilities) with the government providing land and regulatory support, while private sector partners contribute capital investment, technical expertise, and operational management.
- Support the development of a comprehensive financing strategy to stimulate private sector investment. This could include market-based incentives, such as subsidies or tax breaks to reduce initial project costs. Additionally, financing mechanisms such as venture capital funds and credit facilities tailored to the aquaculture sector can provide investors which access to capital. Lastly, introducing risk-sharing mechanisms like insurance products will encourage more private sector investment. Responsibility for financing initiatives would involve government agencies, finance institutions, private sector investors, and international donors, each contributing regulatory support, capital, and technical expertise.

2) Value Chain Enhancement

- Further engagement with the private sector for processing facilities and provision of training to farmers on post-harvest handling techniques to improve the quality of the product and expand demand for fish by consumers.

3) Policy Development and Strategic Planning

- Building on the evidence base from research projects, initiate consultation on the development of a national and provincial saline aquaculture policy framework and implementation plan.
- Engage with the public sector and civil society to develop inclusive policies and programs to address gender inequalities in the sector and increase the participation of women in saline aquaculture.

4) Research and Infrastructure Development

- Develop chemical analysis facilities for soil and water to provide accurate information for decision-making by the public and private sector.
- Investment to improve aquatic animal health and disease prevention, including investment in skilled personnel/human resources/researchers.
- Establish model demonstration fish farms featuring multi-functional natural infrastructure aimed at enhancing water and land efficiency while mitigating the risk of natural hazards (e.g., flood and drought). These ponds can serve as retention basins during heavy rainfall or floods, reducing downstream flooding and helping prevent soil erosion. Additionally, they can contribute to water management efforts, providing a reliable water source for irrigation and other agricultural activities during periods of drought or water scarcity. Ponds will also offer alternative sources of income and food security, diversifying livelihoods and enhancing community resilience to natural disasters.

5) Sector Modernization and Information Systems

- Engagement with the public and private sector to encourage private investment in R&D to catalyze the modernization of the sector.
- Engagement with the public and private sector to establish market information systems and cold storage facilities to help farmers make informed decisions about when to harvest fish for better profitability.

Long-term (5-10 years)

1) Industry Development

- Engagement with public and private sectors for the development of a functional value chain for saline aquaculture at the national level.
- Engagement with public and private sectors for the enhancement of saline aquaculture exports, specifically from South Punjab and Sindh.

2) Disease Control and Biosecurity

- Adoption of physical disease control measures, including quarantine, vaccinations, recommended stocking density, filtration, and irradiation of inflow water using ultraviolet light.

3) Policy Implementation

- Engagement with public and private sectors for the implementation of a National Policy and Strategy for Saline Aquaculture (including provincial policies for Sindh and Punjab).

Addressing these recommendations will require collaboration among all stakeholders, including governments, private sector entities, academia, and civil society organizations. By working together, it is possible to develop a sustainable and profitable saline aquaculture sector.

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ANNEXURE

ANNEX A. Common Fish Species in Pakistan

In Pakistan, both native and non-native fish species play crucial roles in the country's aquaculture and fisheries industry. Understanding the differences between these two categories is vital for effective resource management and environmental conservation.

Native Fish Species:

Native fish species are those that naturally occur in Pakistan's waters and have adapted to the local ecosystems over a long period. These species are well-suited to the region's environmental conditions, such as water temperature, salinity, and available food sources. Some examples of native fish species in Pakistan include Rohu, Catla, and Mahseer. They are typically hardier and better equipped to withstand local environmental challenges.

Non-Native Fish Species:

Non-native fish species, on the other hand, are introduced from other regions or countries and do not naturally belong to Pakistan's aquatic ecosystems. They are often brought in for aquaculture. While some non-native species have become successful and widely cultivated. These species may compete with or prey on native fish, potentially leading to imbalances in the local aquatic food chain. Nonetheless, some non-native fish species have been successfully cultured like, Tilapia and Carp, in inland farming systems in Punjab and Sindh Provinces of Pakistan without disturbing the ecosystem.

Table 5. Common fish species in Pakistan

Local Name	Common/English Name	Scientific Name	Origin	Cultured in (Water type)
Rohu	Rohou labeo	*Labeo rohita*	Native	Low saline and Freshwater
Catla	Catla	*Gibelion catla*	Native	Low saline and Freshwater
Common carp	Common carp	*Cyprinus carpio*	Non-Native	Low saline and Freshwater
Grass carp	Grass Carp	*Ctenopharyngodon idella*	Non-Native	Low saline and Freshwater
Tilapia	Nile tilapia	*Oreochromis niloticus*	Non-Native	High, medium and low saline water
Moli (ornamental fish)	Common molly	*Poecilia sphenops*	Native	Brackish and Freshwater
Baam fish	Eel fish	*Mastacembelus armatus*	Native	Brackish and Freshwater
Mrigal	Mrigal carp	*Cirrhinus cirrhosus*	Native	Low saline and Freshwater
Silver carp	Silver carp	*Hypophthalmichthys molitrix*	Non-Native	Low saline and Freshwater
Singhari	Giant-river catfish	*Sperata seenghala*	Native	Freshwater
Bighead	Bighead carp	*Hypophthalmichthys nobilis*	Non-Native	Low saline and Freshwater
Dhangri	Barramundi	*Lates calcarifer*	Native	Brackish, Marine and Freshwater
Kaali mundi	Barramundi	*Lates calcarifer*	Native	Brackish, marine and Freshwater

**These species were observed during the data collection field visits.*

ANNEX B. Qualitative Field Observations

FIELD OBSERVATIONS

The following points are (qualitative) observations from IWMI field team during the data collection process which were not necessarily captured through the survey questionnaire.

Field Observations in Bahawalpur (pilot):

- Farmers do not use any instruments to measure the water quality parameters.
- The final harvesting period of all farmers was from November to January.
- Average stocking density was 1000 per acre.
- From January to March, there was a stocking period of fish for all the farmers in this area.
- Mainly the farmers accessed the fish seed from Fisheries department Bahawalpur.
- The disease like lernea was noted but mortality ratio by this disease was very low. In Summer season, due to low dissolved oxygen and less expertise fish mortality was maximum in some ponds.
- The mortality of fish seed was maximum when farmers carry fish seed from hatchery to the ponds.
- The low quality of the fish seed and poor water quality (saline) were the main barriers faced by the farmers.
- All the farmers agreed that the government should support fish farming by providing more incentives for farmers.
- All the farmers agreed that women decide when and how many fish need to take home for consumption and sale.
- Women were not working there.
- People think farm management is a very difficult task, so it is not easy for women to work over there as they must stay overnight to guard their pond.
- Most of the people agreed that their children are interested in fish farming.
- We met three people, their land was not able to cultivate crops because of high salinity, someone suggested them to make a fish farm, now they are happy with their farm.
- Farmers don't have marketing issues because they used to sell their harvest to local community in the village. These farms were located in villages near Bahawalpur, where fish farms were relatively scarce, but the local population was higher. As a result, the fish from these farms was primarily sold within the same village. The residents preferred buying fish from these farms at a good price because it ensured fresh, locally-sourced fish, making it their preferred choice.
- All the farmers observed plants and animals like otter, rodents, kingfishers etc. at their fishpond. It means the ponds provide habitat to organisms to support the ecosystem.

Field Observations in Thatta:

- Farmer don't understand new farming practices.
- They are using old techniques for the aquaculture.
- They don't allow their women to work on the fish farm.
- There are certain restrictions for the women.
- Canal water is the only source of their pond water.
- People seems to be affected by malnutrition.
- Mainly farms are like lakes more than 15 acres.
- Farmers don't use commercial feed for their fishponds.
- We didn't see any woman working on the fish farm.
- Some of the women has been observed working on agricultural land (mainly belong to Hindu community).
- Some of the farmers don't know about facilities, they are happy with it.

- Farmers do not have instruments to measure the water quality parameters. Average stocking density is 300 per acre.
- Mainly farmers accessed fish seed from private hatchery.
- In Summer season, due to low dissolved oxygen or less expertise fish mortality was maximum in some ponds.
- Lerniasis disease was most common there.
- Farmers are not using ground water for their ponds.

Field Observations in Badin:

- Most of the farms were dried out in Badin due to unavailability of water.
- Some farmers were afraid in terms of providing data and were not willing for the interview.
- There was lack of knowledge, as per a person, if we give more water to fish this will lead to swelling of belly and an ultimate death of fish (totally wrong).
- Crops being cultivated by people include rice, sugarcane, and wheat.
- Possibly, Famers were more in number in Thatta as compared to Badin.
- People fed their fish for one time in a month, there were not any daily routine regarding fish feeding.
- One person was applying KMNO4 into his pond for disease treatment.
- In Badin, some farmers consume small indigenous fish species captured from canal.
- There was also a project for famers to construct farm on 2 acres and provide fish seed for it. The purpose of this project to fulfill nutritional requirements in children by consuming the harvest in the household. This project was running by the support of World Bank, Sindh Government and Peace Pakistan (Non-Government Agency).
- Most of the farmers feed fish on poultry wastages.
- Farmers observe more growth of fish when they feed fish with poultry layer bird waste.
- Some farmers were also using food waste from marriage halls for their ponds.
- It has been observed lerniasis as compared to the other disease, cause very low mortality but affects the growth of the fish.
- Farmers stocked Dangri fish seed having high survival and growth rate in high salinity ponds.
- In saline lands, "lao plants" were also observed. They are used in making baskets.
- Farmers said that they fulfill every requirement of their spouse and other female household member, but they did not allow them to work on the farm because it's very difficult for females.
- When the water depth is less in the ponds then jackal, birds and other animal harm the fish.
- Because of scarcity of fresh water or oxygen depletion, fish mortality seems to be high during summer season.
- One person said that the consumption of small indigenous fish species may cause Adenoiditis (inflammation of adenoids)
- Farmers claim that, if the water is like "poison" (undrinkable, very high levels of salt), then dangri and tilapia will be found there which was surprising for us; dangri is a saline fish (they bring from near the sea) but tilapia also grows in fresh water but we were seeing that it was growing in saline ponds too (it was surviving in up to 50 ec ponds and 25 ec ponds)

Field Observation in Dera Ghazi Khan (Dist. Muzafargarh)

- Plenty of water has been extracted from the ground.
- Farmers are extracting ground water for their fish farms.
- Farmers were well known of farming practices, and new farming practices has been witnessed in this district.
- More semi-intensive farming has been observed in this district as compared to the other districts.
- Farmers fed the fish 2 times a day on daily basis.
- People consume large fish; they do not utilize small indigenous fish species in this district.

- Farmers use medicines to treat fish affected by any disease.
- Farmers have ponds on lease (lease cost is 50,000 to 80,000 per acre), most of the farmers have farms more than 5 acers, if they have small farm then they will not be able to meet the expenses.
- The farmers do not feed on any type of the wastage, they are using commercial fish feed and obtaining high output.
- Some of the farmers did not tell us the actual income, saying "we are in loss" but they are increasing their farms. This may imply that they were making a good profit, but they were not willing to disclose or openly acknowledge it.
- Even at the 12 mS/cm of EC level of water, Rohu and Thaila showed optimum growth by feeding them on 25 CP feed.
- Most of the people agreed that their children are interested in fish farming.
- Mainly, women were not working there.
- People think farm management is a very difficult task (during netting and harvesting), so it is not easy for women to work over there.
- All the farmers sell their fish on wholesale to a big city.
- There are also middleman issues during weighing of fish product (announce as less weight).

Field Observation in Rahim Yar Khan (RYK)

- Farmers do not have instruments to measure the water quality parameters.
- The farmers were not aware of farming techniques.
- Farmers have their own solar tube wells to extract water from the ground.
- Semi-intensive farming practices were observed in Rahim Yar Khan District.
- Along with large fish, people also consume small tilapia fish species in this district (people near the lakes of SCARP (Salinity Control and Reclamation Project).
    - The farmers and inhabitants near these lakes consumes small tilapia fish of 100 grams.
    - Highly saline water lakes of SCARP were the best site to culture Tilapia as it was observed there and breed in that water.
    - Saline water from SCARP to the desert acts as defense near the Indian Boarder and site for fish production (Tilapia).
- People think farm management is a very difficult because man stay at night, so it is not easy for women to work over there.
- Most of the people agreed that their children are interested in fish farming, but they have limited resources.
- One fish farm in Fatima Fertilizers was observed obtaining high output on minimum input by providing grass of the gardens and aerated water. They also provide NP alternate of DAP to minimize the cost of fertilizers.
- One woman was observed there. She was working with her husband. She had some basic knowledge of fish species names and feed provided to the fish.
- One woman observed at fish farm in the desert area, she was helping his husband in weighing of fish feed then his husband fed the fishes.

General Differences between Punjab and Sindh Districts:

- Literacy rate was very low in Sindh. Children were illiterate and not able to spell or write their names. They don't go to schools.
- Tobacco consumption was very common between children of Thatta and Badin.
- Stark differences noted between the living standards in districts of Punjab and Sindh.
    - As compared to Punjab provinces Sindh seemed much more poverty-ridden and worse sanitation conditions (e.g., children walking around without shoes, etc.).

    - One of the farmers from Sindh didn't know about soap. He still uses sand and water for his body cleaning.
- Seemed like malnutrition is more prevalent in Sindh; children seen in Punjab seemed healthier than those in Sindh
    - Severe weather conditions and malnutrition in Sindh has caused diseases like fever and cough among the children of very young age. They were skinny and seemed very tanned/sun-burned (skin seemed much darker due to sun exposure, not just their normal skin color)
- While interviewing a farmer in Badin, we came to know that due to his poor living conditions he is not feeding his fish in any way as he could hardly fill his own stomach with food once a day.
- People are more likely to engage in healthy activities in Punjab as compared to Sindh.
- Residents in Punjab have a great desire to prioritize their children's education and hygiene. However, there were few farmers in Punjab who were not able to send their children to schools due to poverty.
- There was a child who eats, plays, sleeps and do all the stuff over the fish farm. There was not any proper housing facility for him.
- Field team noticed that most of the farms visited in Punjab had solar panels while none were seen in Sindh. Speaks to the differences in poverty levels between the provinces; Sindh farmers seemed to be facing more of a financial crisis (unable to even purchase food for their families) so it makes sense they would be unable to purchase solar panels.

Role of Women in Fish Farming

- Women were not involved in either district (save 1 or 2 examples of women helping husbands with ONLY feeding); farmers said fish get stolen at night so men have to keep guard of the ponds, and they get inside the water for netting; "women can't do this type of work."
- Sindhi People had shown a very cold attitude towards meeting with their women. They didn't even allow female IWMI staff to meet them in person:
    - They said that in their Sindhi culture they keep women inside, women have to keep *pardah* and we don't let them outside the four walls of the home.
    - Even adolescent girls were being sent inside to not meet with IWMI female staff member and that their photos are not captured (*They mentioned that in our Sindhi culture, women are traditionally kept within the confines of the home. Our women often remain indoors, and we do not allow them to venture outside beyond the four walls. They even restrict young girls of a certain age from meeting female members of IWMI team or having their photos taken.)*
- We were able to meet and interview a single woman in Rahim Yaar Khan district in Punjab which was also a unique case. The couple were overseeing the fish farm for the actual owner. They were Hindu converts who were disowned by their families so they moved to RYK. The woman helped with only the feeding while her husband took care of all the rest; they lived on the fish farm in a very small shack-type setup, with 3 small children. The woman shared that they don't have a proper washroom facility; she cannot go to the washroom all day and goes at night alone in the dark for privacy; safety and privacy are a big issue. We noticed that next to the fish pond there was an open field with a group of young men playing cricket, illustrating that the area is filled with men and probably why she doesn't feel comfortable going to the washroom anywhere nearby.
- A farmer from Badin said that their females remain busy in watching TV serials, so they don't have any time to come to the fish farm and work over here.
- In RYK Desert, a farmer said that his family eats fish for the whole week whenever they cannot get any access to vegetables, fruits, and meat – they eat fish out of "majboori" (no other option) not because they necessarily want to
    - Another farmer in RYK noted that how could he think about buying fresh fruits and vegetables when income is so low and prices are increasing day by day (June 2022, in the midst of Pakistan's rising inflation costs)

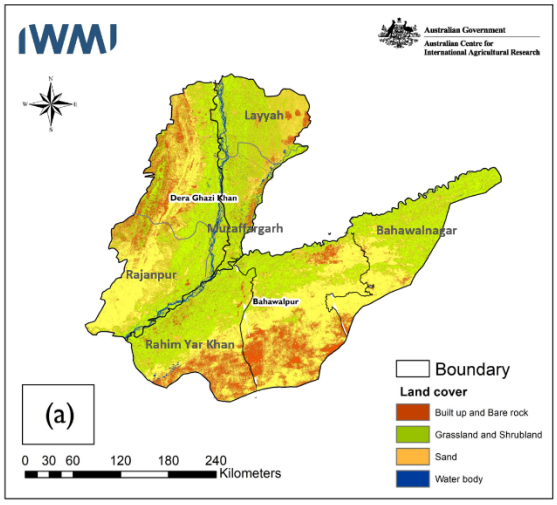
ANNEX C. GIS and Remote Sensing In-Depth Methodology

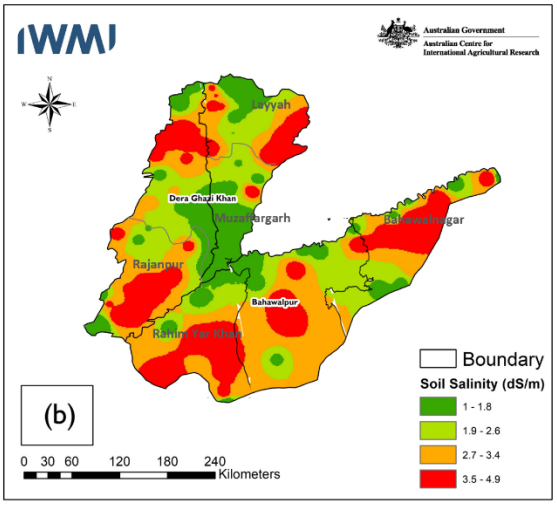
1. Study Area

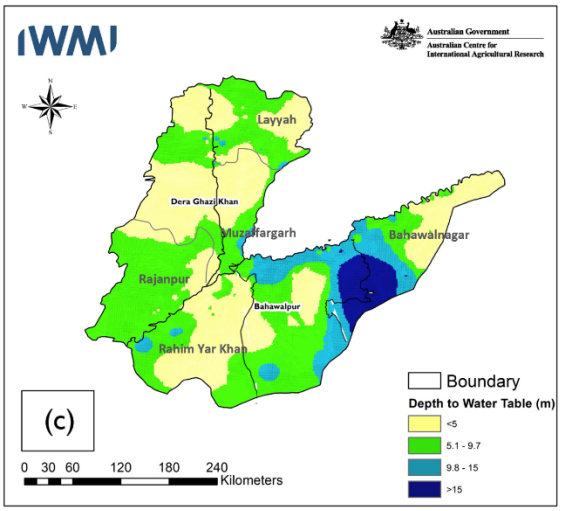
Four districts have been selected from Southern Punjab and Sindh province of Pakistan. Dera Ghazi Khan (30° 28′ 0″ N, 70° 24′ 0″ E) is in the Southwestern part of Punjab lying west of the Indus River and Bahawalpur (28° 50′ 0″ N, 71° 40′ 0″ E) located south of Sutlej river and lies in the Cholistan region of Punjab. Thatta (24° 30′ 0″ N, 67° 50′ 0″ E) lies in the Southern area of Sindh and Badin (24° 39′ 26″ N, 68° 50′ 26″ E) lies east of the Indus River.

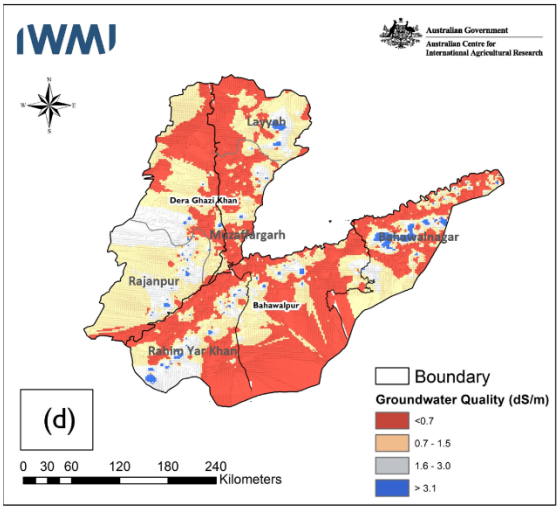
2. Datasets and Sources:

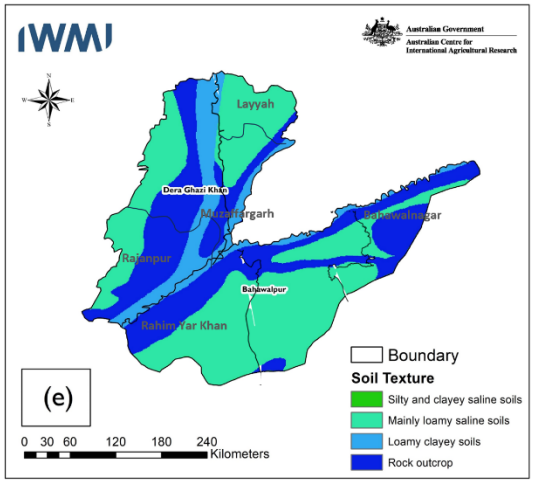
Different types of datasets were used to prepare thematic layers used in this study; this includes remote sensing data, conventional data from existing maps and ground observation data. Based on expert opinion and previous literature, different types of thematic layers were prepared to address the hotspots for saline aquaculture farming.

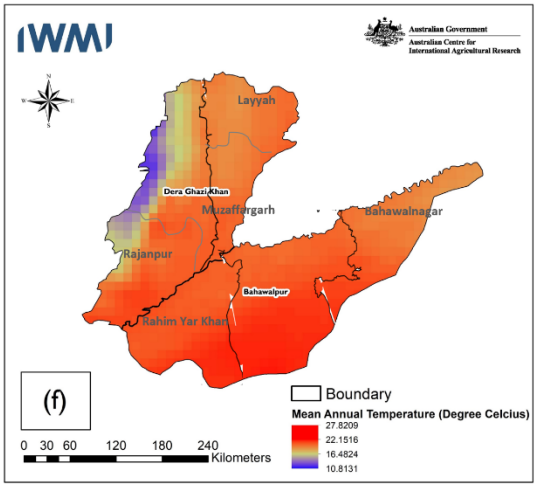









IWMI
Australian Government
Australian Centre for International Agricultural Research
Layyah
Dera Ghazi Khan
Muzaffargarh
Bahawalnagar
Rajanpur
Bahawalpur
Rahim Yar Khan
(e)
Boundary
Soil Texture
Silty and clayey saline soils
Mainly loamy saline soils
Loamy clayey soils
Rock outcrop
0 30 60 120 180 240
Kilometers


IWMI
Australian Government
Australian Centre for International Agricultural Research
Layyah
Dera Ghazi Khan
Muzaffargarh
Bahawalnagar
Rajanpur
Bahawalpur
Rahim Yar Khan
(f)
Boundary
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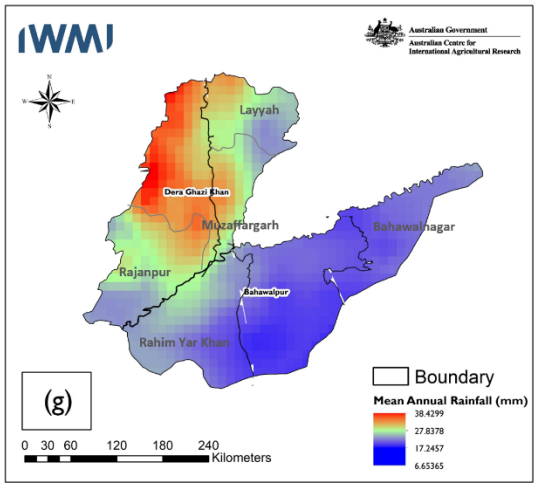
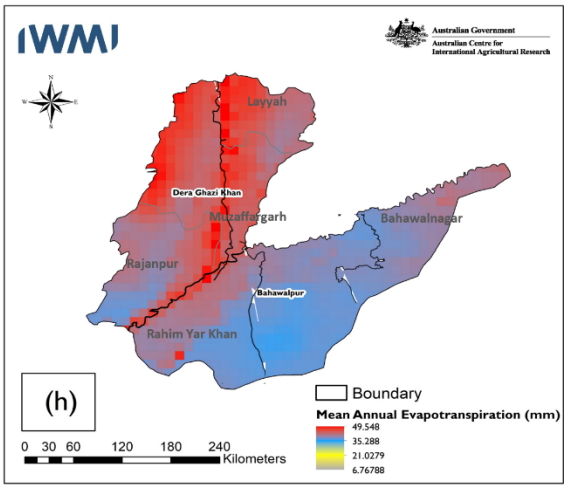
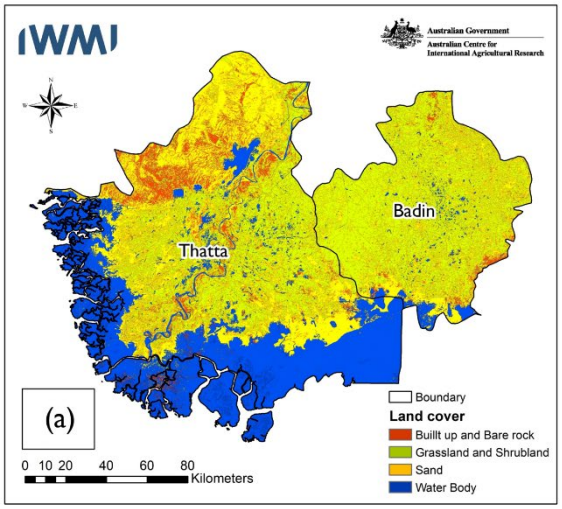
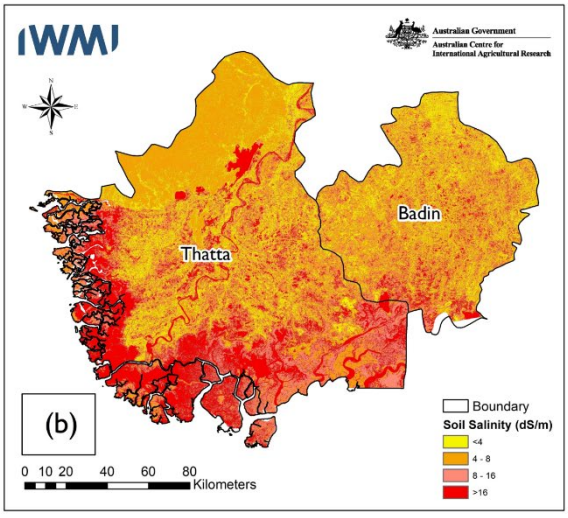
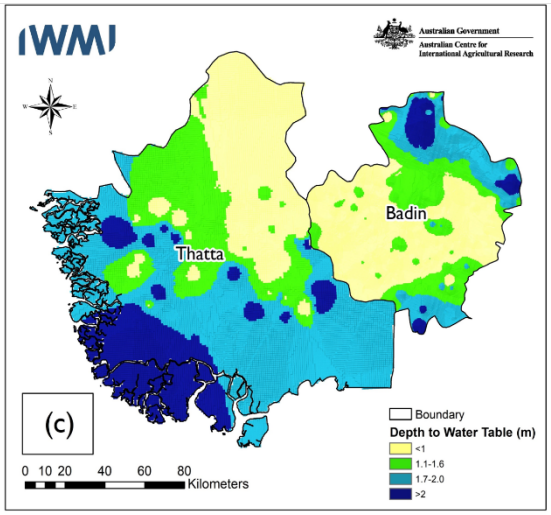
27.8209
22.1516
16.4824
10.8131
0 30 60 120 180 240
Kilometers

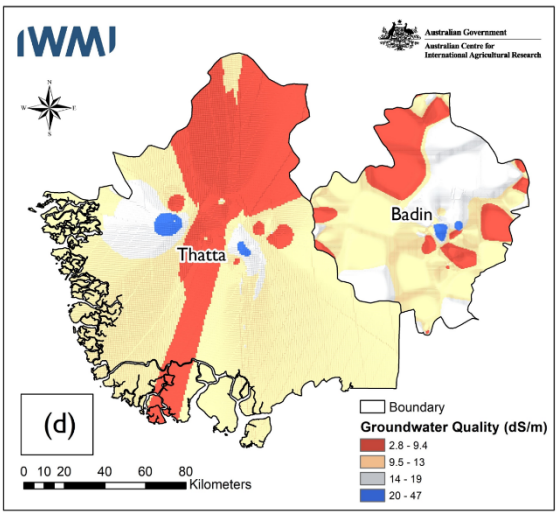

IWMI
Australian Government
Australian Centre for International Agricultural Research
Layyah
Dera Ghazi Khan
Muzaffargarh
Bahawalnagar
Rajanpur
Bahawalpur
Rahim Yar Khan
(g)
Boundary
Mean Annual Rainfall (mm)
38.4299
27.8378
17.2457
6.65365
0 30 60 120 180 240
Kilometers

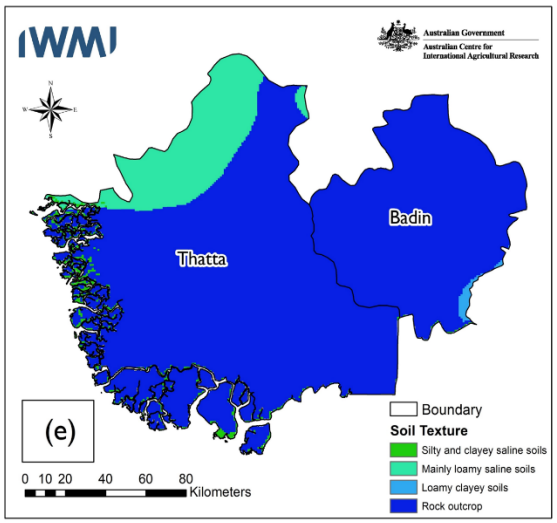

IWMI
Australian Government
Australian Centre for International Agricultural Research
Layyah
Dera Ghazi Khan
Muzaffargarh
Bahawalnagar
Rajanpur
Bahawalpur
Rahim Yar Khan
(h)
Boundary
Mean Annual Evapotranspiration (mm)
49.548
35.288
21.0279
6.76788
0 30 60 120 180 240
Kilometers

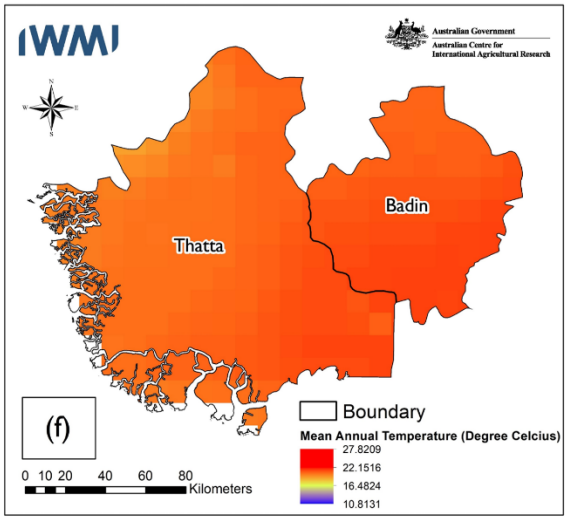

IWMI
Australian Government
Australian Centre for International Agricultural Research
Badin
Thatta
(a)
Boundary
Land cover
Buillt up and Bare rock
Grassland and Shrubland
Sand
Water Body
0 10 20 40 60 80
Kilometers

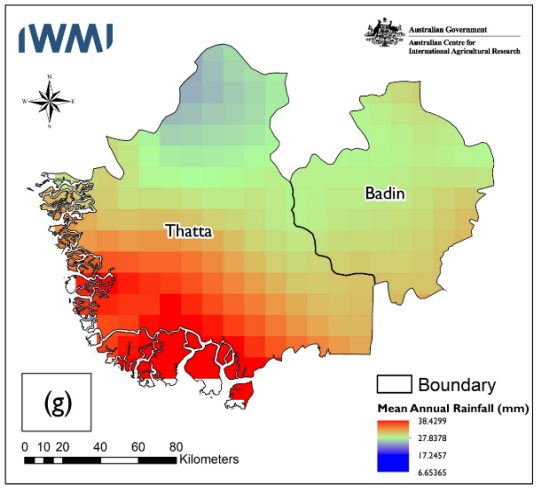

IWMI
Australian Government
Australian Centre for International Agricultural Research
Badin
Thatta
(b)
Boundary
Soil Salinity (dS/m)
<4
4 - 8
8 - 16
>16
0 10 20 40 60 80
Kilometers

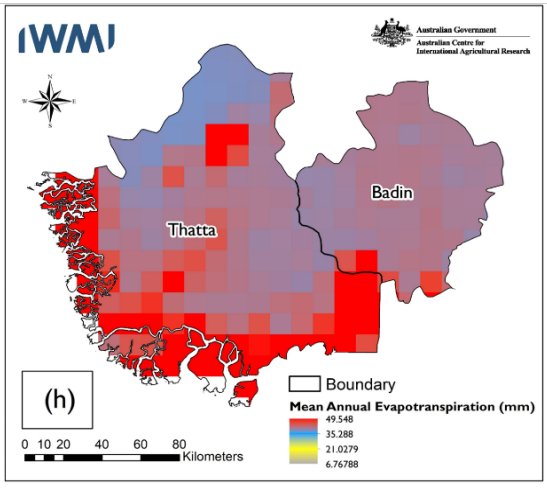

IWMI
Australian Government
Australian Centre for International Agricultural Research
Thatta
Badin
(c)
Boundary
Depth to Water Table (m)
<1
1.1-1.6
1.7-2.0
>2
0 10 20 40 60 80
Kilometers


IWMI
Australian Government
Australian Centre for International Agricultural Research
Thatta
Badin
(d)
Boundary
Groundwater Quality (dS/m)
2.8 - 9.4
9.5 - 13
14 - 19
20 - 47
0 10 20 40 60 80
Kilometers


IWMI
Australian Government
Australian Centre for International Agricultural Research
Thatta
Badin
(e)
Boundary
Soil Texture
Silty and clayey saline soils
Mainly loamy saline soils
Loamy clayey soils
Rock outcrop
0 10 20 40 60 80
Kilometers


IWMI
Australian Government
Australian Centre for International Agricultural Research
Thatta
Badin
(f)
Boundary
Mean Annual Temperature (Degree Celcius)
27.8209
22.1516
16.4824
10.8131
0 10 20 40 60 80
Kilometers


IWMI
Australian Government
Australian Centre for International Agricultural Research
Thatta
Badin
(g)
Boundary
Mean Annual Rainfall (mm)
38.4299
27.8378
17.2457
6.65365
0 10 20 40 60 80
Kilometers


IWMI
Australian Government
Australian Centre for International Agricultural Research
Thatta
Badin
(h)
Boundary
Mean Annual Evapotranspiration (mm)
49.548
35.288
21.0279
6.76788
0 10 20 40 60 80
Kilometers

Figures a-h. Thematic Layers: (a) Landcover, (b) Depth to Water Table, (c) Soil Salinity (d) Groundwater Quality, (e)Soil Type, (f) Temperature, (g) Precipitation, (h) Evapotranspiration (maps for Punjab and Sindh)

3. Thematic Layers

To identify Hotspots, eight thematic layers were prepared; they are Landcover, Depth to the water table (D), Soil Salinity, Groundwater Quality, Soil media (S), Temperature, Precipitation, and Evapotranspiration. The parameters are described below.

3.1. Land use Land Cover

Land use Landcover has been evaluated using the data of COPERNICUS at spatial resolution of 100 m which has been downscaled at 10-meter resolution for better visibility of area of interest. It comprises 4 major classes which are, built up and bare rock, grassland and shrubland, sand, and water body as shown in the (Fig (a)).

3.2. Soil Salinity

Machine Learning Algorithms have been applied and subjected to regression classification analysis of soil samples taken from the field. The data has been subjected to a resolution of 10 meters as shown in (Fig (b)). The rigorous analysis technique is supervised classification in which the results have been evaluated using the given samples in the field which have been used for a validation.

3.3. Groundwater Depth

The depth to groundwater table (D) is prepared from the observation-well data of the Punjab Irrigation Department (available at http://web.irrigation.punjab.gov.pk/groundwater06.aspx).This dataset contains values for latitude, longitude, well number, and depth to groundwater table (m). The map of depth to groundwater table (D) was prepared by interpolating depth data for groundwater measured at certain locations in Punjab and Sindh, using the Kriging technique in ArcGIS as shown in (Fig (c))

3.4. Groundwater Quality

Groundwater quality data have been taken from the PCRWR and interpolated using a method known as kriging as shown in (Fig (d)). The spatial resolution of the layer has been obtained at 10-meter resolution to further subject it into the AHP analysis.

3.5. Soil Types

The data for soil has been obtained from FAO (Food Agriculture Organization) data archive. This data has been further reclassified into 4 major classes for calculating the agro-ecological zones to use it as a thematic layer in AHP analysis as shown in (Fig (e)). The spatial resolution of this dataset was typically 100 meters which has been downscaled at 10 meters for better spatial resolution.

Climatic Parameters

3.6. Temperature

ERA5-Land temperature data has been used at spatial resolution of 9 km which is downscaled at 10 meters in NetCDF format as shown in (Fig (f)).

3.7. Precipitation

ERA5-Land Precipitation data has been utilized with the swath Width of 9 km which is downscaled at 10 meters in NetCDF format as shown in (Fig (g)).

3.8. Evapotranspiration

ERA5-Land Evapotranspiration dataset at 9 km spatial resolution has been used in NetCDF format which is downscaled at 10 meters as shown in (Fig (h)).

Table 1. Score assigned to each thematic layer

Scores	Importance
1	Equally important
3	Moderately important
5	Strongly important
7	Very strongly important
4	Extremely important
2,6,8	Intermediate values between levels of importance

4. Flowchart

A GIS framework has been designed to analyze the variables obtained from the ground and to observe the true conditions in the overall study area. Before approaching the field, the area has been selected based upon the farming practices being conducted. Further, the study area has been specifically defined based on different conditions that farmers face in the same country, but for different provinces based on economic, social, and technical aspects.

The datasets that have been used in this study have been discussed in detail.

Dataset	Technique	Source	Downscaled Resolution
Groundwater Depth	Interpolation	PCRWR	10 m
Groundwater Quality	Interpolation	PCRWR	10 m
Soil Salinity	Regression (Supervised Classification)	PCRWR	10 m
Land use Land Cover	Reclassification	COPERNICUS	10 m
Extent of Fish Farms	Machine Learning Algorithm	Google Earth Engine	10 m
Soil types	Reclassification	FAO	10 m
Temperature	Classified	ERA5-Land	10 m
Precipitation	Classified	ERA5-Land	10 m
Evapotranspiration	Classified	ERA5-Land	10 m

The comprehensive flow diagram of methodology and data analysis is explained in Figure 1. This section describes the different datasets, their pre-processing, and the preparation of thematic layers for addressing brackish and saline aquaculture potential zones/Bright zones.

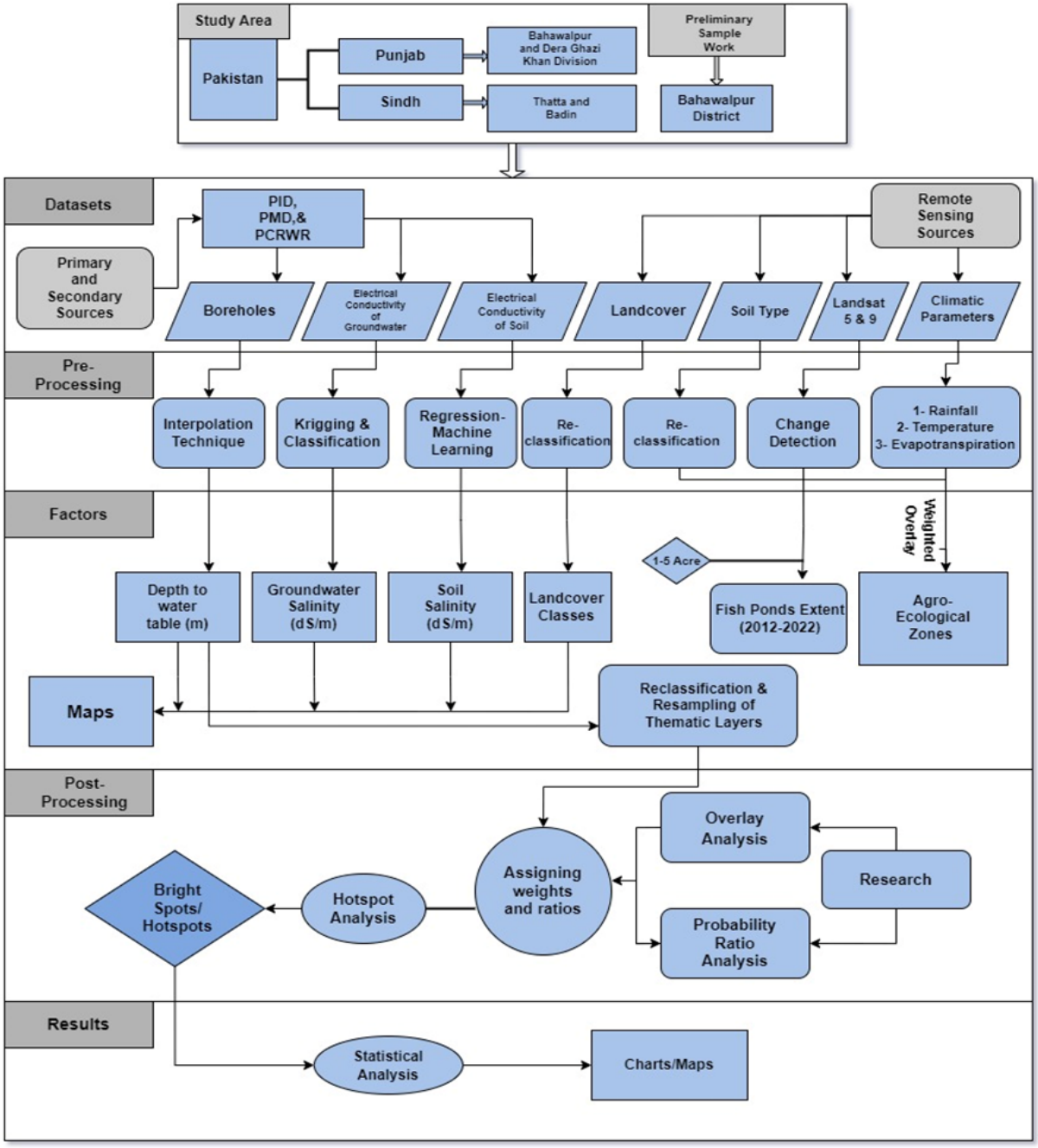


Fig 1, Flowchart diagram describes the process of preparation of layers their sources and analysis of Hotspot Analysis

5. Techniques

5.1. Interpolation
Interpolation predicts values for cells in a raster from a limited number of sample data points. It can be used to predict unknown values for any geographic point data, such as elevation, rainfall, chemical concentrations, noise levels, and so on.

There are two types of interpolation been done:
1. IDW
2. Krigging

5.2. IDW
The IDW tool uses a method of interpolation that estimates cell values by averaging the values of sample data points in the neighborhood of each processing cell. The closer a point is to the center of the cell being estimated, the more influence, or weight, it has in the averaging process.

5.3. Kriging
Kriging is an advanced geostatistical procedure that generates an estimated surface from a scattered set of points with z-values. More so than other interpolation methods, a thorough investigation of the spatial behavior of the phenomenon represented by the z-values should be done before you select the best estimation method for generating the output surface.

5.4. Regression
A statistical method for evaluating the relationship between a single dependent variable and one or more independent variables thought to influence the dependent variable. Regression is used to predict the value of the dependent variable or to determine whether an independent variable in fact influences the dependent variable, and to what extent.

5.5. Change Detection
Change detection is one of the fundamental applications in imagery and remote sensing. It is the comparison of multiple raster datasets, typically collected for one area at different times, to determine the type, magnitude, and location of change. (2012-2022 (to evaluate the extent of fish farms))

5.6. Re classification
Reclassifying attributes is the technique in GIS and other database software of creating a new categorical attribute in a dataset by classifying features based on existing attributes or other criteria, such as location. The uses of reclassification include quickly updating cells when new information is available, compiling data for suitability analyses, and eliminating unneeded information by reclassifying cells as No Data. The goal is often to simplify the output data to aid the interpretation.

6. Tools and Software

6.1. Machine Learning Algorithms
An ML algorithm, which is a part of AI, uses an assortment of accurate, probabilistic, and upgraded techniques that empower computers to pick up from the past point of reference and perceive hard-to-perceive patterns from massive, noisy, or complex datasets.

6.2. Google Earth Engine
Google Earth Engine, an advanced cloud-based geospatial processing platform, is designed mainly for planetary-scale environmental data analysis. It combines a multi-petabyte catalog of satellite imagery and

geospatial datasets, which allow users to visualize, manipulate, edit and create spatial data in an easy and fast way. It incorporates a wide range of spatial manipulation tools which allows scientists, researchers, and developers to detect changes, map trends, and quantify differences on the Earth's surface.

6.3. ESRI ArcMap

ArcMap represents geographic information as a collection of layers and other elements in a map. Common map elements include the data frame containing map layers for a given extent plus a scale bar, north arrow, title, descriptive text, a symbol legend, and so on (ESRI).

7. Extraction of Fish Farm

Water bodies have been extracted using the Landsat 5 and Landsat 9 scenes on Google Earth Engine (GEE). The temporal variations between two images have been taken out in the pre monsoon seasons and the natural water bodies have been delineated using machine learning algorithms. Fish farms have been mapped and displayed at different zoom levels.

Fig 2. Location of Fish Farms in Bahawalpur and Dera Ghazi Khan, Punjab

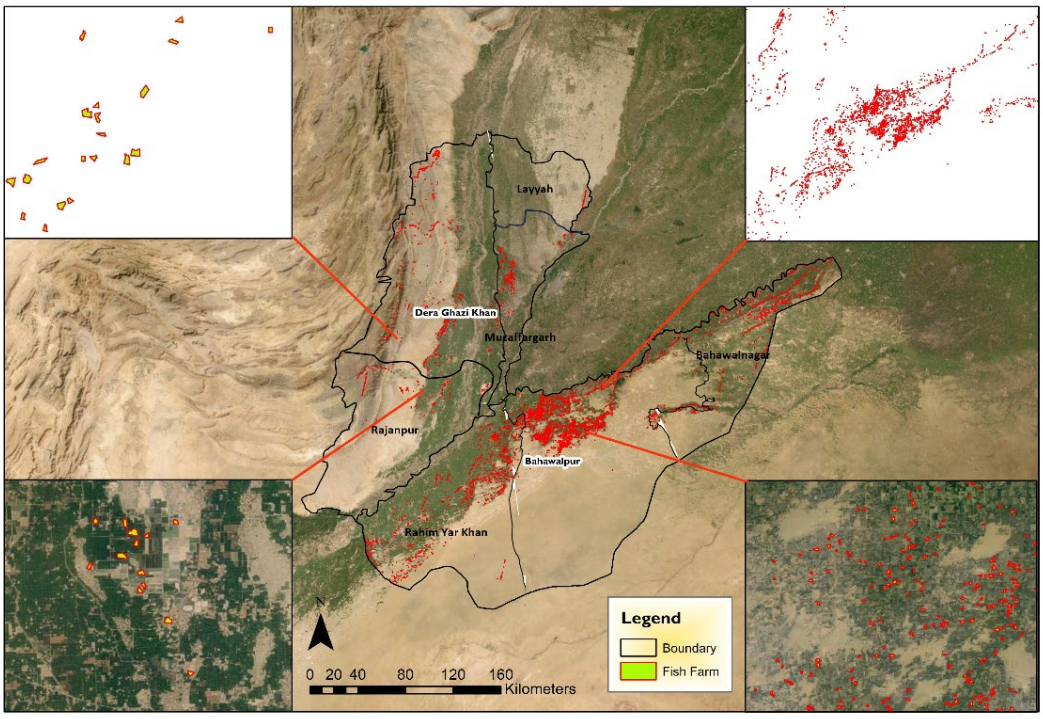
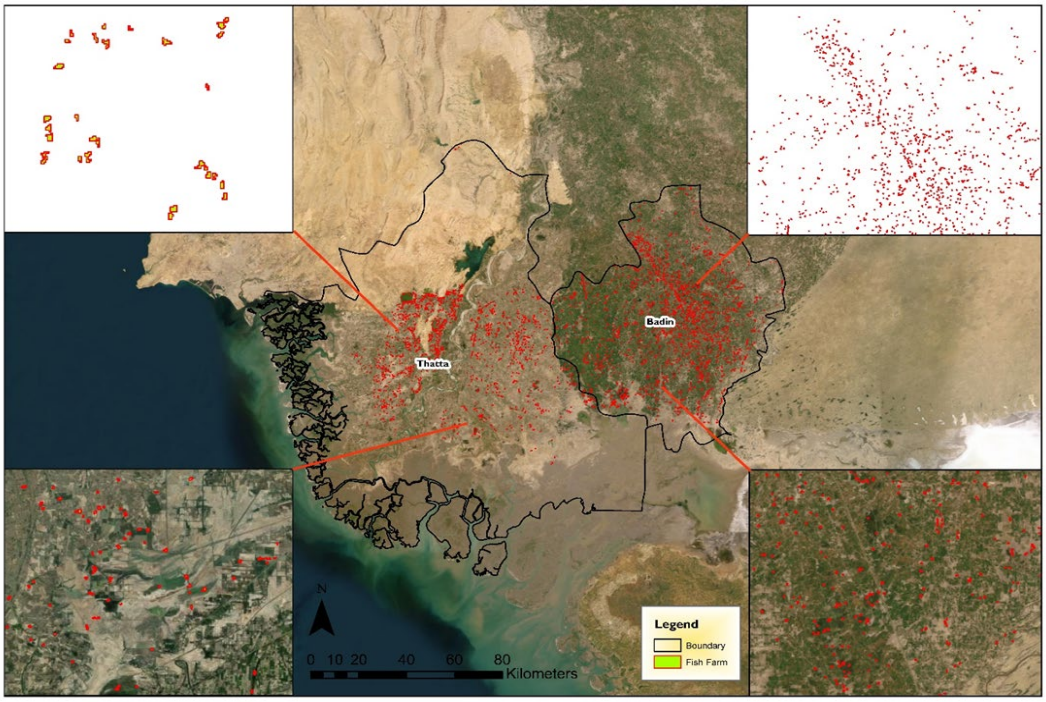


Fig 3. Location of Fish farms in Thatta and Badin, Sindh



8. Conclusion

This Annex presented the spatio-temporal variation in fishponds and identification of hotspots for saline aquaculture in Punjab and Sindh Province of Pakistan. The suitable areas were categorized into most favorable, favorable, less favorable, and least favorable areas. It utilized several thematic layers for accuracy in the prediction of aquaculture suitable areas. However, thematic layers indicated increasing trends over the year, with t-state values of 1.324, 0.291 and 0.504, respectively. Marginal improvements in groundwater electrical conductivity (EC), sodium absorption ratio (SAR), and residual sodium carbonate (RSC), and a decrease in groundwater level (GWL), has been observed. The results also indicate that the data of groundwater parameters were spatially autocorrelated over the years. The spatial distribution analysis of groundwater EC indicated that the groundwater quality was fit for saline aquaculture in most of the study area. The groundwater level (GWL) was also higher in the Punjab and Sindh study areas during the pre-monsoon. The higher values of these parameters in groundwater seem to be due to the simultaneous contribution of natural mineralization, the use of unpurified irrigation water, and anthropogenic inputs which make it suitable for aquaculture.

ANNEX D. Stakeholder workshop report for Sindh

Stakeholder Validation & Consultative Workshop Report for Sindh Province (Dec 6 & 8)

Report compiled by RSN Janjua, Aquaculture Consultant

ACRONYMS AND ABBREVIATIONS

ACIAR	Australian Centre for International Agricultural Research
FDB	Fisheries Development Board
IWMI	International Water Management Institute
SA	Saline Aquaculture
SFD	Sindh Fisheries Department

EXECUTIVE SUMMARY

The International Water Management Institute (IWMI), Pakistan conducted a saline aquaculture scoping study in Badin and Thatta, Sindh Province from April to early June 2022 through field visits and conducting surveys with small-holder Saline Aquaculture (SA) farmers. This study was conducted in the context of the *Opportunities for Brackish and Saline Aquaculture in Pakistan* project funded by Australian Centre for International Agricultural Research (ACIAR). Following the data collection and preliminary analysis, a series of validation workshops were organized in both Badin and Thatta on December 6, 2022 and December 08, 2022 respectively. Representatives from the Sindh Fisheries Department (SFD), Fisheries Development Board (FDB), and surveyed fish farmers attended the workshops. A total of 62 farmers across Badin and Thatta attended.

Overall, a good turnout was observed and enthusiasm was shown by both farmers and government officials with excitement about the opportunities to develop the saline aquaculture sector in Sindh, as the sector has not been given due attention from the government as well as development sector.

The validation workshops provided an opportunity to the stakeholders to think collectively and share ideas on ways to capitalize on the opportunities and resources available in the saline aquaculture landscape. The main challenges highlighted were lack of technical skills and equipment and financial issues. It was also observed that there is no concept of saline aquaculture on scientific basis in Sindh (more focus on aquaculture), coupled with lack of initiatives by international organizations and public sector.

All stakeholders showed willingness and commitment to support future initiatives by IWMI. Farmers are keen to participate in future initiatives to tackle their issues in the sector, such as poor water quality and quantity, lack of technological instruments, availability of fish feed, and financial constraints. They are looking forward to engage in pilot projects as demonstration sites to be developed in both Badin and Thatta for capacity building, including initiatives for women and youth as an alternate livelihood and economic opportunity.

All participants were of the opinion that green farming technologies such as using solar or wind power for saline aquaculture on earthen ponds, raceway systems, and bio flock systems can be used for fish farming because of lack of power supply infrastructure.

There are many opportunities for women and youth to be involved in the SA sector given a proper enabling environment; farmers shared that at present their female family members do not play an active role though they agreed that women could be offered training and be facilitated more in the sector.

In Sindh, freshwater resources both for domestic and agricultural use are constantly depleting and crop yields suffer from a steady increase in soil salinity, especially in the arid and semi-arid areas. Salinization has become a grim challenge for agriculture in Sindh and salinity is the most severe problem for the communities living in the coastal areas. It is important to explore opportunities in saline aquaculture as an alternative form of livelihood for farmers in growing saline conditions.

Way forward

- The agriculture lands affected by salinity and abandoned by farmers can be utilized for saline aquaculture and other aquaculture activities.
- Better understanding of SA potential as an alternative livelihood for farmers in waterlogged areas.
- Establishment of model demonstration sites with state-of-the-art farm structures to improve water and land efficiency as well as to decrease the risk of natural disasters (e.g., monsoon floods).
- Modern saline aquaculture farms can be used for both training and production purpose by using technologies and exotic saline water species.
- Provision of multi-meters at farm level to check pH, salinity, dissolved oxygen, and temperature of pond water to keep fish stock in optimal water quality needed for optimal growth.
- Introduction of feeding mix that reduces overall expense and improves per acre production and revenue.
- Introduction of circular economy concept to improve the income levels of farmers.
- Further detailed application of GIS and Remote Sensing to identify bright spots for Saline Aquaculture opportunities in Pakistan. (Mapping/Zoning).
- Development of practical guidelines for improving the productivity of Saline Aquaculture.
- Improving the quality of extension services provided by the public sector, and public-private partnership modes.
- Seminars, conferences, and exhibitions focusing specifically on Saline Aquaculture in Pakistan
- Capacity building of farmers in fry, fingerlings stocking period, source of breeds, and local hatcheries for community level breeding of fish.
- Community level capacity building of farmers, aggregators, and service providers on improving fish farming practices, production, storage, distribution, and value addition of the produce.
- Collaborate with the private sector for the introduction of new and improved species, best suited for the local environment and market needs.
- Collaboration with international organization like WorldFish and other international Saline Aquaculture research institute in bringing the best practices from around the world in Saline Aquaculture and developing co-learning activities from the best models and technologies across the world.
- Missing point?

1. INTRODUCTION

1.1. Saline Aquaculture Context in Sindh Province

In Pakistan, Saline or Brackish Aquaculture did not formally exist until the past decade. The climate of Pakistan is arid and semi-arid with scarce and irregular rain fall particularly in Sindh. Most of its land is affected with salinity and waterlogging along with underlain water that is brackish. Soil salinity is a major issue affecting the agriculture sector in Sindh province.

The Sindh province has significant waterlogged and saline areas that are no longer suitable for crop (agriculture) production but can be developed for fish farming. A study[3] was conducted to analyze the growth and instability of inland fish production during two different periods in Sindh i.e., Period-I (1975-1988) and Period-II (1989-2002). It was found that in Period-II, the growth rate of fish production in the inland waters of Khairpur, Larkana, Hyderabad, Badin, Thatta and Sindh increased positively and significantly, while in the Sangar and Tharparkar regions, it decreased significantly. The study also confirms that Period-I shows moderate growth in most areas with less volatility in inland fish production compared to Period-II. The study also shows that none of the districts experienced a consistent increase in the relative share in any period. It is also explored that 78% of the groundwater is saline as the areas of fresh groundwater is confined only to a narrow strip along the river Indus in Sindh.
In addition to the deterioration of traditional agriculture in areas affected by salinity, the situation with freshwater aquaculture is also not encouraging, mainly due to the scarcity of fresh water. On the other hand, the state of wild stocks is well known due to overexploitation. Habibullah and Javed conducted a survey in 2019 in Sindh on sea water intrusion. It was found that there are reports of sea intrusion from 30 to 50 km deep in some coastal areas of Sindh province. According to a survey carried out by the Sindh Coastal Development Authority in 2011, in Badin district about 35,785 acres were fully eroded by seawater, where an area of 44,046 acres was partially affected. The delta has resulted in high seawater intrusion at the coastal shores of Sindh, which has severely affected the livelihood sources of local people. According to the researchers' findings, substantial losses in land and means of livelihood have been brought about by the intrusion of seawater, which has finally led a change in focus to fishery. The ever-increasing fishing activity combined with unsustainable fishing practices has resulted in the devastation of the natural fisheries resources that are on the brink of collapse. At the moment these diminishing fisheries resources are not enough to support a large dependent population anymore. Saline areas can be used for aquaculture which will act as a tool for the desalinization of the soil through brackish water fish farming.

Sindh coastline is spread over 350 km despite its short area, Sindh's coast is rich in terms of fish resources because the Indus Delta is classified as the fifth largest delta of the world, which comprises 17 major and numerous minor creeks. Among some of the major creeks are Chhan, Daboo, Danpora, Haamro, Kajhar, Kanhar, Khai, Khober, Patinai, Phitti, Shahjee Wari, Turishan, Khuddi, Kharak and Sir Creeks, etc. The coast is stretching eastward from Hub River in Balochistan to Sir Creek.

Due to the building of huge irrigation and hydropower networks in the Indus basin, the delta gets an inadequate amount of fresh water to maintain the ecosystem of the delta. As a result, the ecosystem of the delta is under serious threat. The area was once famous for its prosperity but is now counted as one

[3] *Wasim, M. P. (2007). Issues, growth and instability of inland fish production in Sindh (Pakistan): Spatial—Temporal Analysis. Pakistan Economic and Social Review, 203-230.*

of the poorest areas of the country. The local people are migrating from their native places to safe areas in search for shelter and food. Shortage of freshwater flow in the river and intrusion of the saline water from the Arabian Sea into the delta are reported as the main causes of the deterioration of the Delta.

Following are the Coastal Areas:

- Coastal Talukas of Thatta District: Mirpur Sakro, Ghorabari, Keti Bunder, Kahro Chan Costal Talukas of Badin District: S. F Rahu and Badin
- Coastal Talukas of Sujawal District: Shah Bunder and Jati
- Coast Districts of Karachi: Distt. Mali, Distt. Korgani, Distt South and Distt. Kemari

Due to seawater intrusion and high level of ground saline water, fertile lands are being degraded, the area under vegetation cover as well the production/yield is decreased significantly. That has ultimately affected the ecosystem and livelihood of the people living in the delta and socio-economic conditions of the people living the deltaic area are being badly affected.

1.2. Purpose of Workshop

The main purpose of the Validation Workshops was to share and validate the findings from the SA survey conducted by IMWI Team, and to gain further insight on farmers' and other stakeholder perspectives. The workshop discussions were organized around four main themes:

1. Challenges and Opportunities to Provide Healthy Seeds and Salt Tolerant Breeds
2. Challenges in Pond Water Management and Disease Control for Better Management Practices
3. Challenges and Opportunities to Provide Quality Fish Feed and Proper Use of Fertilizers to Enhance Production
4. Opportunities and Modern Techniques for Small-Scale Farmers and Women to Promote Saline Aquaculture

2. WORKSHOP PROCEEDINGS

2.1. Overview of Survey

IWMI team carried out consultations with stakeholders to identify marginalized saline areas where saline aquaculture could be improved. After district selection, bright spot and groundwater level mapping was conducted using GIS and remote sensing. Farmers were selected from areas with collaboration from government agencies like PCRWR, Fisheries Department, and local universities. The selection criteria for the surveys were 1-5 acres pond size and pond salinity >2 mS/cm. Several challenges requiring investment needs were identified, including high cost of feed and seeds, lack of fresh water, poor technical knowledge and equipment, challenges with post-harvest handling, poor disease diagnostic facilities leading to high fish morbidity, and supply chain and marketing issues. Poor water quantity and low water quality are also major issues affecting production. Further, social and cultural norms have prevented women from being involved in fish farming, but there is an openness from farmers that women can and should be trained on breeding techniques within their homes.

Several investment opportunities were identified, including a need for development of species tolerant to temperature and salinity variation. Further studies focusing on other areas will be required to inform policy and decision makers and investors on interventions for sustainable development of aquaculture in Pakistan. Mr. Janjua, Consultant Aquaculture was the lead of holding and conducting the series of Workshops with support of dedicated IWMI team.

2.2. Stakeholder validation of results

Stakeholders actively participated in the discussion themes, summaries of which are below:

Theme 1: Challenge and Opportunities to Provide Healthy Seeds and Salt Tolerant Breeds

Challenges	Opportunities	Breeds
• Land near costal area having chances of increase in salt concentration in water (unable to maintain salinity) • Shallow Pond/water depth creates issues e.g. increased salinity and drop in temperature during winter, leading to fish mortality • Mostly pond depth low between 2.5 - 3 feet • Thermal shock to fish during hot weather when water temperature is high. • Low depth of water is an issue because seabass (dangri) require more space to move freely in the pond. • Despite the existence of the hatcheries, no saline fish seed availability. • Lack of availability of Micro Finance/Finance to set up hatchery/ breeding at the district level. • Finance for purchasing the seed in Thatta District • High cost of quality fish seed • Limited number of public and private hatcheries but producing fresh water species • Lack of expertise in breeding of saline water fry fish. • Cost of fish feed is high	• Suitable able weather for saline fish culture in district Thatta • Large land holdings • Availability of leased land for fish farming • Availability of Saline water • If canal water is used, then it takes 3-4 months to become salty. • Both winter and summer are suitable crab farming • Delta of Indus is hub for saline aquaculture • Fish seed can be available from the sea, but it is seasonal or natural catch with limited numbers • Opportunities to use brackish water for SA • Limited opportunities to breed sea species	• Seabass (Dangri) • Crab • Cobia • Grouper • Milk fish • Shrimp

Theme 2: Challenges in Pond Water Management & Disease Control for Better Management

Challenges	Opportunities
• Excessive use of fertilizer affects pond water • Lack of knowledge about proper use of fertilizers • Poor drainage system i.e., when, and how much water needs to be removed from the pond. • Farmers need extra pumping to exchange their pond water • Water supply issue during low tide when farmers face oxygen deficiency and high tide when they need to maintain their pond structure. • Unavailability/lack of water testing/diagnostic instruments /tools • Limited disease diagnostic facilities • Lack of skills for using the instruments/tools • Traditional way of checking salinity through tasting by mouth • Lack of quarantine and quality check	• Availability of land and water resource (if proper pond management techniques are used) • Low and high tide system seemed to be important for crab culture because it provides salty water. • Willingness for best salinity testing tools to replace indigenous method of checking water • Availability of fertilizers year-round like cow dung and poultry waste

Theme 3: Challenges and Opportunities to Provide Quality Fish Feed and Proper Use of Fertilizers

Challenges	Opportunities
• There is a challenge to produce feed specifically for salt tolerant fish. • Lack of species- specific feed availability • Low feed purchasing power • Lack of capacity to calculate required feed conversion ratio (FCR) to improve probability • Lack of feeding management	Availability of fertilizers year-round like cow dung and poultry waste • Capacity building of balanced feed manufacturing as per industry standards • Small fish which are not used in the market due to low weight can be used for crabs • Wasted fish and their remains can be used as a feed for crabs • Natural feed is also available in high tide which is consumed by fish

Theme 4: What are the Opportunities and Modern Techniques for Small Scale Farmers and Women to Promote Saline Aquaculture

Challenges	Opportunities
• Social and cultural norms have prevented women from being involved in fish farming • The distance between the farmers' homes and the pond is another major problem for women to work at the fish farm. • Low education levels of women and girls • Cultural taboos of bringing a woman into the field (social pressure on male) (*"Why is this man brining his wife to the field?"*) • "*Log kya kahenge*?" i.e., what will people say • Women are scared of fish farming particularly with crab • Lack of awareness about fish farming practices	• Farmers are open to the idea that women can learn about modern production methods like bio floc and rearing fish techniques in the comfort of their homes • Backyard fish farming with kitchen waste • Women can help in manual processing of fish. • Women can make value addition of fish (cooked food and fish skin handy crafts). • Women can be trained for breeding. • Women's Saline Aquaculture Groups can be formed

Additional Discussion Theme 5: Fish Market and Value Chain

Challenges	Opportunities
• Farmers sell their fish through middlemen who exploit farmer production when it is brought to the market • They have to pay money for it. Farmers didn't have capacity to stock fish for a long time. They have to sell whatever the price of the fish. • Farmers lack finances to be able to carry their product to the market • Lack gadgets for proper processing • Fish product is non hygienic because lack of skills (packaging, preservation, etc.) • There is need to improve market intelligence system. Sometimes fish product prices are very high and sometimes low - no balance • Lack of facilities and skill in post-harvest handling • Lack of hygiene at fish markets resulting in poor quality fish products. • Lack of equipment in handling fish from farm to market.	• There is good demand for saline water fish products, particularly shrimps and crabs in local market • There is good demand for exporting saline fish particularly crabs and shrimps etc. • Products for export are available. There is need to improve the post-harvesting structure. • Human resource available to be trained for post-harvest handling. • Fish markets are available for their capacity building • A large number of fish processors are available in Karachi to buy saline water aquaculture. • Local customer demand is increasing

3.2. Stakeholder feedback/recommendations

The farmers showed interest in shrimp and crab farming subject to availability of both quality seed and feed. At high salinity the survival and growth of carp (what they are predominantly growing) is compromised.

Fish farmers in Badin and Thatta shared a few difficulties connected with their cultivating practices i.e.,

financial issues in buying fish seed, feed and instruments for water testing. Farmers do not monitor the quality of water during high or low tide from the sea. They cannot monitor temperature fluctuations in water due to lack of proper instrumentation. It was also highlighted in the workshop that carp are not the appropriate option for saline aquaculture. High salt tolerant fish species would be the best option. They experienced problems getting seeds for salt tolerant breeds. The seed for shrimps is the seasonal or natural catch. Lack of infrastructure for shrimp farming and finance to import shrimp seeds are also challenges. Because of the area's ideal climate and proximity to the sea, Thatta District is the best place to grow crabs if seeds are available. Farmers see a delta of saline water as a hub for crab or shrimp culture if they access the seed. Farmers accepted that the use of fertilizers in the pond and the drainage system has been improperly managed.

Social and cultural norms have prevented women from being involved in fish farming. The distance between the farmers' homes and their ponds is another major problem for women to work at the fish farm. However, farmers are open to the idea that women can learn about modern production methods like bio floc and rearing fish techniques in the comfort of their own homes. It is important to note that farmers were sharing opinions of their female relatives' interests based on their own (male) perspective. For any future intervention it will be important to have in-depth discussions with women and first gauge their interest in participating (if at all) in the saline aquaculture sector, and in what capacity.

Support by the Government in Saline Aquaculture

Director of the Sindh Fisheries Department Aijaz Memon underlined that the department is here to facilitate the farmers and he urged farmers to tour their hatchery and see how contemporary breeding, rearing, and bio floc techniques work to inspire the female population to get involved in improving their income potential. He also encouraged fish farmers to obtain licenses for their fish farming so that they can receive better support from the government.

This recommendation stems from the prevalence of extensive farming activities in saline areas, posing challenges for the department to visit every farm and provide necessary technical guidance. Encouraging farmers to register themselves with the Fisheries Department ensures that they become integral parts of the system. By doing so, farmers position themselves within the department's loop, enabling them to receive ongoing support and guidance. This collaborative approach not only streamlines communication but also facilitates the government in efficiently delivering facilities and assistance to farmers, fostering a more effective and mutually beneficial relationship.

3. CONCLUSION

Saline Aquaculture can revitalize the salinity-affected regions of the country and accelerate the economic recovery of the rural economy through the use of salinity-affected agricultural land for aquaculture. This will help fight poverty and create jobs in areas currently living in extreme poverty.

Under these circumstances the prospects for artisanal fisheries growth and traditional agriculture in the salinity hit areas in the country are diminished and the opportunity for rearing of the freshwater fish species is also no longer available due to shortage of freshwater. Thus, the development of inland saline aquaculture is essential if we are to address declining capture fisheries and deteriorating traditional agriculture in salinity hit areas.

In this situation, farmers need to be aware of how to live in saline conditions using saline land and water economically, and this is entirely possible by introducing saline aquaculture. Proper capacity building interventions need to be introduced, along with full support and facilitation from government departments and private sector stakeholders. Fish ponds in saline lands can also serve as sacrificial pools (or salinity sinks) for neighboring lands to recover from salinization, as is already practiced in many places in saline and waterlogged areas. Inland saline aquaculture provides an opportunity to convert liability into a valuable resource and provides diversification of agricultural productivity through integrated systems. This can revitalize the salinity-affected regions of the country and accelerate the economic recovery of the rural economy through the use of salinity-affected agricultural land for aquaculture. This will help revitalize the economy and improve livelihoods of low-income farmers.

Sindh has advantages touching coastal areas and favorable weather conditions for fish farming as compared to Punjab province and other areas of Pakistan for practicing aquaculture and the possibility of two crops per year can be produced in Sindh.

We now have a strong understanding of the main problems that fish farmers deal with as a result of the workshops in Sindh, and we have identified numerous areas of opportunity. Going forward, specific interventions that cater to the needs of the saline aquaculture community can be designed, keeping in mind the capacities and needs of all stakeholders and, most importantly, with the support and buy-in of the community. There is an urgent need for utilizing saline or brackish water resources available in Sindh Province to produce marine fish and shrimp, along with certain vegetables (integrated fish-vegetable) in aquaponics systems. This will serve the purpose of securing food supply in areas where conventional agriculture is not suitable.

ANNEX

ANNEX A. Workshop Agendas

Australian Government
Australian Centre for International Agricultural Research

IWMI International Water Management Institute

WorldFish

Challenges and Opportunities for Saline Aquaculture in Pakistan

Stakeholders Validation Workshop on Opportunities for Brackish and Saline Aquaculture in District Badin, Pakistan

Date: 8 December 2022 from 09:30 AM - 14:00 PM
Venue: Munnu Gymkhana Makli, District Thatta

AGENDA

Time	Topic	Facilitator
09:30 – 10:00 AM	Participants' Arrival & Registration	
10:00 – 10:05 AM	Recitation of the Holy Quran	Mehtab Shah
10:05 – 10:15 AM	Opening Remarks & Purpose of Workshop	Najeeb Ullah
10:15-10:30	Welcome remarks and Sindh Fisheries Dept Perspective	Sindh Fisheries Department Representative
10:30 – 11:00 AM	Overall Summary of Badin Survey Results Feedback/Comments from Farmers and Stakeholders on Survey Results (Q&A)	Najeeb Ullah and Mr. Mehtab Shah (IWMI)
11:00 – 11:30 AM	**Tea Break and Group Photo**	
11:30 – 12:00 PM	Discussion Theme 1: Challenge and Opportunities to Provide Salt-Tolerant Breeds	RSN Janjua
12:00 – 12:30 PM	Discussion Theme 2: Challenges in Pond Water Management and Disease Control	RSN Janjua
12:30 – 13:00 PM	Discussion Theme 3: Challenges and Opportunities to Provide Fish Feed/ Fertilizers to enhance production	RSN Janjua
13:00 – 13:30 PM	Discussion Theme 4: Opportunities and Modern Techniques for Small Scale Farmers and Women to Promote Saline Aquaculture	RSN Janjua
13:30 – 13:45 PM	Final remarks and feedback from farmers and stakeholders	Participants
13:45 – 14:00	Closing Remarks	Representative of District Administration/Fisheries Department
14:00 – 15:00 PM	**Lunch and Prayer Break**	

Australian Government
Australian Centre for International Agricultural Research

IWMI International Water Management Institute

WorldFish

Challenges and Opportunities for Saline Aquaculture in Pakistan

Stakeholders Validation Workshop on Opportunities for Brackish and Saline Aquaculture in District Badin, Pakistan

Date: 6 December 2022 from 09:30 AM - 14:00 PM
Venue: Munnu Bhai Thalassemia Diagnostic & Research Centre District Badin

AGENDA

Time	Topic	Facilitator
09:30 – 10:00 AM	Participants' Arrival & Registration	
10:00 – 10:05 AM	Recitation of the Holy Quran	Mehtab Shah
10:05 – 10:15 AM	Opening Remarks & Purpose of Workshop	Najeeb Ullah
10:15-10:30	Welcome remarks and Sindh Fisheries Dept Perspective	Sindh Fisheries Department Representative
10:30 – 11:00 AM	Overall Summary of Badin Survey Results Feedback/Comments from Farmers and Stakeholders on Survey Results (Q&A)	Najeeb Ullah and Mr. Mehtab Shah (IWMI)
11:00 – 11:30 AM	**Tea Break and Group Photo**	
11:30 – 12:00 PM	Discussion Theme 1: Challenge and Opportunities to Provide Salt-Tolerant Breeds	RSN Janjua
12:00 – 12:30 PM	Discussion Theme 2: Challenges in Pond Water Management and Disease Control	RSN Janjua
12:30 – 13:00 PM	Discussion Theme 3: Challenges and Opportunities to Provide Fish Feed/ Fertilizers to enhance production	RSN Janjua
13:00 – 13:30 PM	Discussion Theme 4: Opportunities and Modern Techniques for Small Scale Farmers and Women to Promote Saline Aquaculture	RSN Janjua
13:30 – 13:45 PM	Final remarks and feedback from farmers and stakeholders	Participants
13:45 – 14:00	Closing Remarks	Representative of District Administration/Fisheries Department
14:00 – 15:00 PM	**Lunch and Prayer Break**	

ANNEX B. Photo Gallery

Group photographs: L-R: Mr. Mansoor Zafar, Director, Shrimp Hatchery; Mr. Rana Shahid, Retired Director, Special Assistant to DG; R.S.N. Janjua; Dr. Asim Karim, Director, Marine; Dr. Ali Muhammad Mastoi, Director General, Marine and Costal Development; Mr. Aijaz A. Memon, Director, Coastal Development, Sindh Fisheries Department. Mr. Janjua had a meeting with them explaining the purpose of the validation workshops, and Mr. Memon was nominated to represent SFD at both workshops, Nov 14, 2022

Mr. Najeeb, IWMI, briefed about project study and RSN Janjua had discussion on four themes with participants at Badin, Dec 6, 2022

Group photograph of IMWI Staff (Mr. Najeeb Ullah, Ms. Aqsa Aslam, Ms. Sidra Khalid) with Mr. Zafar Ali Nazamani, Director, FDB, Mr. Aijaz M. Memon, SFD, Mr. Aslam Ansari, Director, Chillya Hatchery (Inland), SFD, Mr. Munwar Lal, DD, Hatchery-Badin, Dec 6, 2022

Group photograph: IWMI Validation Workshop participants Thatta, Dec 8, 2022

R.S.N. Janjua, IWMI Consultant Aquaculture and Aijaz A. Memon, Director (Coastal), Sindh Fisheries Department addressing participants in Thatta, Dec 8, 2022

Group Photograph: IWMI Validation Workshop participants Badin, 6 Dec 2022

Photo: R.S.N. Janjua, IWMI Consultant Aquaculture is interacting with participants, Dec 6, 2022

ANNEX E. Stakeholder workshop report for Punjab

Stakeholder Validation & Consultative Workshop Report for Punjab Province (Dec 13 & 15)

Report compiled by RSN Janjua, Aquaculture Consultant

ACRONYMS AND ABBREVIATIONS

ACIAR	Australian Centre for International Agricultural Research
AD	Assistant Director
ADF	Assistant Warden Fisheries
DG (SP)	Director General (South Punjab)
IWMI	International Water Management Institute
KFUEIT	Khawaja Fareed University of Engineering and Information Technology
mha	Million hectares
PFD	Punjab Fisheries Department (South Punjab)
ppm	Parts Per Million
ppt	Parts Per Thousand
RA	Research Associate
RYK	Rahim Yar Khan
SA	Saline Aquaculture
SAB	Saline Aquaculture Business
SWARC	Saline Water Aquaculture Research Centre (South Punjab)

EXECUTIVE SUMMARY

The International Water Management Institute (IWMI), Pakistan conducted a saline aquaculture scoping study in Rahim Yar Khan and Dera Ghazi Khan, Punjab Province in June 2022 through field visits and conducting surveys with small-holder Saline Aquaculture (SA) farmers. This study was conducted in the context of the *Opportunities for Brackish and Saline Aquaculture in Pakistan* project funded by Australian Centre for International Agricultural Research (ACIAR). Following the data collection and preliminary analysis, a series of validation workshops were organized in Rahim Yar Khan and Multan on December 13, 2022 and December 15, 2022 respectively.

The workshop in Rahim Yar Khan was held in collaboration with Khawaja Fareed University of Engineering and Information Technology (KFUEIT). Faculty related to the subject were also present as well as participants from Punjab Fisheries Department and invited fish farmers. The workshop in Multan was attended by Dr. Anser M. Chatta, Director General, Wildlife & Fisheries South Punjab along with his staff, as well as several surveyed farmers and progressive farmers who were invited.

Dr. Chatta welcomed the participants at the workshop in Multan and complemented IWMI's efforts to advance brackish and saline aquaculture. He noted that IWMI's survey findings were in line with the department's own knowledge and observation of saline aquaculture practices in the region. He called attention to substantial salinized areas available in South Punjab that could be used for saline aquaculture and promised that the Fisheries Department would provide all possible cooperation as needed.

Due to certain cultural, social, and religious traditions, women are not always appropriately involved in farming. Female staff members from the PFD complained about the challenges being faced in male dominating society and advised that after getting a formal education, women could be involved as farm supervisors, within hatcheries, overseeing quality assurance, marketing, and other tasks along the value-added supply chain. One fish farmer shared proudly that his female relatives actively help him in fish farming, including feeding and catching of fish. Such male champions may be identified to help encourage other farmers to also give women opportunities to enter the sector.

Fish farmers and stakeholders highlighted their major challenges which included difficulty in breeding certain fish species for SA, lack of available quality seed and feed for SA, lack of proper disease diagnostic facilities, lack of water testing tools and skills to use water kits by farmers, and flow of finance as a bottleneck to business expansion because limited harvesting time (once a year).F

Overall, the discussion concluded that the introduction of salt-tolerant fish varieties like tilapia, pangasius, sea bass, milk fish, crab and shrimp could be successful, provided the seed of these varieties be produced locally. Another observation and recommendation was that hatcheries of the above-mentioned varieties would be more feasible if established in Sindh Province, due to longer weather windows and sea water availability. Fry could be produced in Sindh and then transported to South Punjab for further production and processing.

Famers took great interest in the discussion and participated in sharing their issues and ways to improve saline aquaculture. The participants also appreciated IWMI for organizing the validation workshops and acknowledged its efforts to provide an opportunity to learn about the issues of saline aquaculture as well as network among key stakeholders.

Punjab Fisheries Department has also initiated a Saline Aquaculture Project in South Punjab and the Saline Water Aquaculture Research Centre (SWARC) has also been established in South Punjab; South

Punjab has more favorable weather conditions and suitable farming land. As an added benefit, it can be used to reduce the amount of salt in the groundwater, leading to improved use of surrounding land for agriculture. Due to its nature, it is only commercially possible in areas with large saline groundwater resources.

The workshop participants discussed in detail the lack of opportunities for females in the saline aquaculture landscape and how to overcome this issue and create opportunities for an active role of women and youth in the development of this sector. Female officials of Punjab Fisheries Department at both workshops in Rahim Yar Khan and Multan showed frustration with their limited role and having lack of a conducive environment and opportunities to work in the SA sector.

Way forward

- The agriculture lands affected by salinity and abandoned by farmers can be utilized for saline aquaculture and other aquaculture activities.
- Establishment of model demonstration sites with state-of-the-art farm structures to improve water and land efficiency as well as to decrease the risk of natural disasters e.g. monsoon floods.
- Modern saline aquaculture farms be used for both training and production by using technologies and exotic saline water species and for better understanding of Saline Aquaculture potential as an alternative livelihood for farmers.
- Application of GIS and Remote sensing to identify bright spots for Saline Aquaculture opportunities in Pakistan. (Mapping/Zoning)
- Capacity building of farmers in fry, fingerlings stocking period, source of breeds, and of local hatcheries for community level breeding of fish.
- Provision of multi-meters at farm level to check pH, salinity, dissolved oxygen, and temperature of pond water to keep fish stock in optimal water quality needed for optimal growth.
- Development of practical guidelines for improving the productivity of SA.
- Improving the quality of extension services provided by the public sector, and public-private partnership modes.
- Seminars, conferences, and exhibitions focusing specifically on Saline Aquaculture in Pakistan.
- Community level capacity building of farmers, aggregators, and service providers on improving fish farming practices, production, storage, distribution, and value addition of the produce.
- A formal platform or network for stakeholder collaboration can be developed.
- Post harvesting handling technologies and practices be introduced to improve the supply chain.
- Establishment of Model Fish Markets.
- Role of women be defined in all policies and development programs for Saline Aquaculture with implement in true letter and spirit.
- IWMI can play an advocacy role for SA in provincial and federal policies and programs by bringing sector attention to the relevant government stakeholders.

1. INTRODUCTION

1.1. Saline Aquaculture Context in Punjab Province

The agriculture sector supports Pakistan's economy in provision of food for the 227 million and growing

population. It contributes around 24%[4] of Gross Domestic Product (GDP) and is a source of livelihood of millions of people across the country (half of the employed labor force).

Saline aquaculture is a relatively new concept in Pakistan, but it has the potential to significantly reduce poverty and food insecurity in the country. The arid and semi-arid climate of Pakistan makes it difficult to grow crops, and salinity in the soil makes land unsuitable for cultivation. This has led to the practice of "inland saline aquaculture" on lands not suitable for crop cultivation. The practice of fish farming in earthen ponds and community reservoirs was introduced in the 1960s by the provincial fisheries departments. Since the 1980s, both Indian carp and Chinese carp are farmed in polyculture with other species in the two provinces. The mentioned carp species are known for their adaptability to low saline levels in water. However, when exposed to high salinity levels, these carp species may exhibit mortality. Salinity, the concentration of dissolved salts in water, can have a significant impact on the health and survival of aquatic species, including carp. Although carp species are often thought of as freshwater fish, they may thrive in conditions with low salinity and are not well adapted to high salinity. Despite the huge potential of saline aquaculture, the characteristics of the production systems in Pakistan are still unknown due to data deficiency, making it difficult to understand investment needs that will help in the sector's development (Khan et al. 2016). Soil salinity is also a major growing problem within the agriculture sector in Punjab province. It is estimated that at least 6.53 million acres land is affected by saline and brackish water. Saline water commonly known as salt water is water that contains a high concentration of dissolved salts, which is usually expressed in parts per thousand (PPT) or parts per million (ppm). Inland saline aquaculture is the farming of aquatic animals and plants using inland (i.e., non-coastal) sources of saline groundwater rather than the more common coastal aquaculture practices in Sindh.

The usefulness of salt water for agriculture has long been experimented, but cost-effective and practical solutions are rare, as almost all terrestrial crops are primarily dependent on fresh water. The saline aquaculture in inland waters has enormous potential for income generation and diversification and offers the opportunity for potentially productive use of saline lands that can no longer support traditional agriculture. It holds the promise of solving hunger and ensuring food security in countries threatened by freshwater and in areas affected by drought. In Pakistan, inland groundwater reserves are saline over a large area of the country, and the area of saline land in the irrigation zone exceeds 8.2 million hectares throughout Pakistan.[5] In 2019-20, the total agriculture waste land in Pakistan was 8.19 million hectares (mha) with province wise distribution as follows: Punjab1.46 mha (17.83%); Sindh 1.6 mha (19.54%), KP 1.31 mha (16.0%); and Balochistan 3.82 mha (46.64%).[6]

Land salinization associated with the use of poor-quality groundwater in the provinces of Punjab is a serious threat to the agricultural sector with low yields and, as a result, higher resource requirements, as such the sustainability of the agricultural system and the country's ability to feed its growing population is a foreseen problem. In this situation, farmers need to be aware of how to live in saline conditions using saline land and water economically, and this is entirely possible by introducing saline aquaculture. Fish ponds in saline lands can also serve as sacrificial pools (or salinity sinks) for neighboring lands to recover

[4] https://www.pbs.gov.pk/content/agriculture-statistics

[5] GOP (2022). Economic Survey 2021-22

[6] www.pbs.gov.pk/sites/default/files/tables/agriculture_statistics/table_3_land_utilization_statistics.pdf

from salinization, as is already practiced in many places in saline and waterlogged areas. Inland saline aquaculture provides an opportunity to convert liability into a valuable resource and provides diversification of agricultural productivity through integrated systems. This can revitalize the salinity-affected regions of the country and accelerate the economic recovery of the rural economy through the use of salinity-affected agricultural land for aquaculture.[7] This will help fight poverty and create jobs for people currently living in extreme poverty.

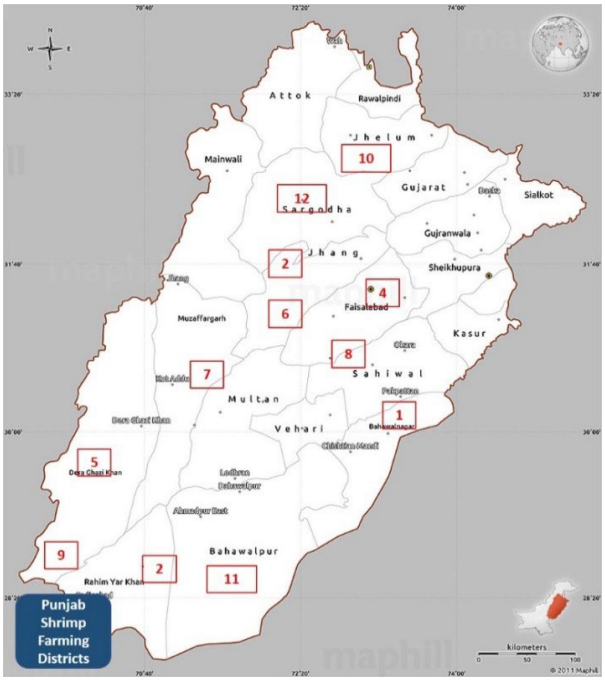
In year 2019, Punjab Fisheries Department conducted a survey of more than 100 fish farms under a development project titled "Development of Fisheries in Saline and Brackish Waters of Southern Zone of Punjab" in Districts Bahawalpur, Muzaffargarh including Rajanpur, Dera Ghazi Khan (Taunsa, Chotti Zerin) and Rahim Yar Khan. Parameters such as pH, dissolved oxygen, conductivity, TDS, Salinity (ppt) were tested, and Tilapia was found to be the main species which survived. Punjab Fisheries Department has established the SWARC in South Punjab which is not fully functional yet but has conducted some initial research on shrimp trial production.

The Punjab Fisheries Department has also initiated a project entitled "Pilot Shrimp Farming Cluster Development" from 2019-20 to 2023-24. Under this project the following interventions are proposed:

- Shrimp farm development financial support for 2500 Acres (75:25 on 1st crop and 50:50 on 2nd crop) (Govt.: Farmer) with subsidy of 75% of the actual total cost of shrimp seed and feed (per acre) or PKR 2-300.000 per acre.
- Establishment of Saline Water Aquaculture Research Center (SWARC) in Muzaffargarh city
- Value chain development (fish/shrimp hatcheries (04), fish/shrimp feed mills (02) & fish/shrimp processing plants(02)).
- Up-gradation of training sub centers in Bahawalpur and Rawalpindi.

Two farmers exhibited successful shrimp farming before Covid-19 in Muzaffargarh in water with salinity levels of 7-10 mS/cm.

[7] *Aslam, M. U., Nadeem, N., Baig, I. A., & Ahmed, U. I. (2020). Economic Analysis of Fish Farming in Punjab, Pakistan. Review of Economics and Development Studies, 6(3), 625-637.*



Shrimp Farming in Punjab: Following Districts Identified by Punjab Fisheries Department:

1. District Bahawalnagar
2. District Khushab
3. District R.Y. Khan
4. District Faisalabad
5. District D.G. Khan
6. District Jhang
7. District Muzaffargarh
8. District Toba Take Singh
9. District Rajanpur
10. District Jhelum
11. District Bahawalpur
12. District Sargodha

***Muzaffargarh**: most suitable and attractive out of 12 districts, because of established fish farming and existence of local fish hatcheries

1.2. Purpose of Workshop

The main purpose of the Validation Workshops was to share and validate the findings from the SA survey conducted by IMWI Team, and to gain further insight on farmers' and other stakeholder perspectives. The workshop discussions were organized around four main themes:

1. Challenges and Opportunities to Provide Healthy Seeds and Salt Tolerant Breeds
2. Challenges in Pond Water Management and Disease Control for Better Management Practices
3. Challenges and Opportunities to Provide Quality Fish Feed and Proper Use of Fertilizers to Enhance Production
4. Opportunities and Modern Techniques for Small-Scale Farmers and Women to Promote Saline Aquaculture

2. WORKSHOP PROCEEDINGS

2.1. Overview of Survey

IWMI team carried out consultations with stakeholders to identify marginalized saline areas where saline aquaculture could be improved. After district selection, bright spot and groundwater level mapping was conducted using GIS and remote sensing. Farmers were selected from areas with collaboration from government agencies like PCRWR, Fisheries Department, and local universities. The selection criteria for the surveys were 1-5 acres pond size and pond salinity >2 mS/cm.

Saline aquaculture plays many roles for respondents, including providing an alternative source of livelihood to farmers whose land is not suitable for agriculture. It also provides fish for direct consumption and soil nourishment because of irrigation. Despite its potential, the production of saline aquaculture is very low and limited to few species, such as tilapia and carp.

Several challenges requiring investment needs were identified, including high cost of feed and seeds, lack of fresh water, poor technical knowledge and equipment, challenges with post-harvest handling, poor disease diagnostic facilities leading to high fish morbidity, and supply chain and marketing issues. Poor water quantity and low water quality are also major issues affecting production. Further, social and cultural norms have prevented women from being involved in fish farming, but there is an openness from farmers that women can and should be trained on breeding techniques within their homes.

Several investment opportunities were identified, including a need for development of species tolerant to temperature and salinity variation. Further studies focusing on other areas will be required to inform policy and decision makers and investors on interventions for sustainable development of aquaculture in Pakistan. A detailed report with the study findings will be published by IWMI in March 2023. Mr. Janjua, Consultant Aquaculture was the lead of holding and conducting the series of Workshops with support of dedicated IWMI team.

2.2. Stakeholder validation of results

A large number of stakeholders participated at the workshop and provided their inputs. They travelled from Zai Pir, Sadiqabad, Bahawalpur, Rahim Yar Khan, Multan, Muzaffargarh, Khaniwal, and Mian Channu.

The workshop was moderated by R.S.N. Janjua who guided stakeholder discussion along the 4 themes. Stakeholders actively participated in the discussion themes, summaries of which are below:

Theme 1: Challenge and Opportunities to Provide Healthy Seeds and Salt Tolerant Breeds

Challenges	Opportunities	Breeds
• Shortage of water in area • Groundwater is deep • Higher salinity range observed by PFD (e.g., 12-16 ppt in RYK. • Breeding is challenge for saline species • Seed availability is an issue • There is no hatchery for saline water aquaculture • Lack of management skills to handle saline aquaculture • Carp farming not practicable at salinity 2.5 ppt • Wild tilapia have entered ponds due to poor screening management • Lack of predators handling in ponds • Lack of availability of Micro Finance/Finance to set up hatchery/ breeding at the district level • High cost of quality fish seed • Limited number of public and private hatcheries but producing freshwater species • Lack of expertise in breeding of saline water fry fish • Cost of fish feed is high	• Suitable weather for saline fish culture in Rahim Yar Khan and Multan Division. • Availability of saline water and canal water • Availability of saline land • Large land holdings • Availability of leased land for fish farming • Most of the land is barren due to saline water in both Rahim Yar Khan and Division Multan • Where canal water is available, it can be used to reduce salinity. • Limited opportunities to breed saline water species • Shrimp can be grown as it was grown in Muzaffargarh by PFD and private farmers • Market for saline fish is better as compared to freshwater fish produced in terms of better price and export opportunity.	Following species were identified for Saline Aquaculture • Shrimp • Pangasius • Seabass (Dangri) • Crab • Cobia • Grouper • Milk fish Tilapia, Pangasius and Shrimp were mostly demanded by participants

Theme 2: Challenges in Pond Water Management & Disease Control for Better Management

Challenges	Opportunities
• Lack of knowledge about proper use of fertilizers • Excessive usage of fertilizer increases cost and increases green algae in return depleted dissolved oxygen of water in pond • Fish cannot grow at high density with high dose of fertilization • Most farmers have poor pond drainage system i.e., when, and how much water needs to be removed from the pond. • Poor canal water screening management allow wild fish to enter ponds and high inbreeding of tilapia reported • Farmers need extra pumping to exchange their pond water, resulting in high electricity bills • Unavailability/lack of water testing/diagnostic instruments tools • Limited disease diagnostic facilities in districts. • Lack of skills for using the instruments/tools • Lack of facilities for disease diagnosis at large scale level except limited disease diagnostic and medication facility in Muzaffargarh district. • Lack of quarantine and quality check facility • Lack of disease control and management practices • Farmers do not maintain record keeping	• There is availability of saline water for salt resistant fish culture • Availability of land and water resources (if proper pond management techniques are used) • PFD have disease diagnosis labs in RYK, Multan, Bahawalpur, and DG Khan Districts • Recently PFD introduced mobile disease diagnosis lab in Multan Division • PFD claims to provide lab experts doing soil sample and water analysis report and recommendation • Farmers willing to experience new tools through a pilot program

Theme 3: Challenges and Opportunities to Provide Quality Fish Feed and Proper Use of Fertilizers

Challenges	Opportunities
• High price of feed is issue because 65 to 70 percent is the feed cost (low purchasing power) • Lack of species- specific feed availability • Lack of capacity to calculate required feed conversion ratio (FCR) to improve probability • Poultry waste is available but there are some diseases associated with the waste. • Lack of feeding management • Prices of raw material for feed is high • Season shortage of raw material and mostly imported raw material (sustainable supply is main challenge) • Usage of raw material by both poultry and dairy feed is higher leaving fish feed manufacturing at risk	• Availability of extruded floating feed • Availability of fertilizers round the year like cow dung and poultry waste • Capacity building of balanced feed manufacturing as per industry standards • Poultry waste is available in summer but not frequently used; it may be used in Feb and March • Farmers use more poultry waste as compared to fertilizers because of its high prices (e.g., price for one truck of cow dung and poultry waste are 9000 and 35000 respectively) • Preference towards poultry is due to its quality as a substitute of fertilizers. But issues also related to the fish health

Theme 4: What are the Opportunities and Modern Techniques for Small Scale Farmers and Women to Promote Saline Aquaculture

Challenges	Opportunities
• Religious, social and cultural norms prevent women from working on fish farms • Security threat/harassment for women at farms if alone • Women feel hesitation towards fish due to the smell • It is difficult for women to capture fish • Certain tasks considered men's job (e.g., catching fish by net) • Need awareness and outreach programs. • Lack of training for women to get involved in aquaculture • Distance between farmers' homes and the pond is barrier for women's involvement • Low education levels of women and girls • Lack of awareness about fish farming practices • Inadequate financial opportunity for women to invest in aquaculture business	• Women can work as farm supervisors • If financial support and home-based activities are available, women can work (e.g., bio floc system to culture pangasius. • Women can be involved in fish feeding • Job opportunities for women in PFD, but limited to desk work, laboratory and research instead of field work • Farmers are open to the idea that women can learn about modern production methods like bio floc and rearing fish techniques in the comfort of their homes • Backyard fish farming with kitchen waste • Women can help in manual processing of fish. • Women can make value addition of fish (cooked food and fish skin handy crafts). • Women can be trained for breeding • Women's Saline Aquaculture Groups can be formed.

3.2. Stakeholder feedback/recommendations

Farmers and PFD officials were mainly interested in shrimp farming as well as Tilapia and Pangasius farming in saline water. They understand that soil chemistry can be controlled but water chemistry is major challenge to control. Farmers understand these issues and have experienced low survival with high mortality of carp and slow growth in survived fish.

Fish farmers discussed a few concerns related to their farming methods, such as fish mortality owing to poor management caused by a lack of water tools to monitoring of water quality. The necessity for salt-tolerant varieties like tilapia and shrimp was acknowledged by all farmers, Fisheries Department officials, and other stakeholders in the District of Rahim Yar Khan, Muzaffargarh and Multan. If issues with financing, hatchery setup, species-specific feed, water testing equipment at the farm level, and marketing issues can be handled, the saline soil and water of the aforementioned districts have a significant potential to raise salt-tolerant fish species. The workshop also emphasized the fact that carp are not a good choice for saline aquaculture. Farmers acknowledged that the usage of fertilizers in their ponds and the drainage systems have been incorrectly managed.

Ameer Nawaz Khan, the Assistant Director of the Fisheries Department, congratulated IWMI for taking the initial step in research on utilizing natural resources, such as saline water and soil, that have been underutilized. He emphasized the Fisheries Department's role in assisting farmers. Ms. Saman Ayaz, representative from the Fisheries Department RYK, recommended that women can work as farm managers and engage in domestic tasks like fish breeding, despite societal and cultural standards that impede them from entering in aquaculture business.

Dr. Riaz-ud-Din, Director SWARC suggested that hatcheries for salt-tolerant species be developed in Sindh and fry can then be transported to South Punjab. If a collaborative mechanism can be established between the provinces then the SA sector can thrive in both areas.

Other final feedback and discussion points included:

- Need for awareness programs for farmers in terms of proper use of water and water testing and record
- Social media can also be utilized to educate women and youth and give them basic training and awareness about SA
- Appropriate saline areas to be identified through further water and soil sampling and analysis; after which SA practices with vegetation along pond embankments (pond-dike cropping) of saline aquaculture can be established
- Timely replacement of outdated marketing system is needed
- Farmers do not have initial investment required to enter into SA and financial support may be provided to eligible farmers to establish Saline Aquaculture Businesses (SAB)

Participants were of the opinion that a long-term program for Saline Aquaculture should be initiated by both public and private sector and IWMI can take the lead in the development of such a program, which should include capacity building and introduction of new species and technology. Model and demonstration farms may be established for hands-on training for women on culturing of high salinity tolerant selected fish species like shrimp, tilapia and pangasius. Trials can also be established introducing high-valued shrimp for culturing through conditioning, rearing, stocking and fattening techniques.

3. CONCLUSION

Salinity is one of the important environmental factors affecting fish survival and growth. The optimal salinity levels for growth, survival and reproduction competence are often species-specific. In South Punjab, current marginal productivity from saline aquaculture has resulted in poor livelihoods for the fish farming community.

The major issues and limitations in the SA sector are summarized below:

- Lack of environmental awareness and impacts of climate change.
- Saline Aquaculture stock assessment information is not available.
- Hatchling of saline tolerant species is not available locally.
- No capacity building program on technical knowledge is available for Saline Aquaculture except limited service by PFD (South Punjab) through SWARC.
- Farmers have no initial investment to enter in saline aquaculture business (SAB).
- Farmers are the mercy of middleman who exploits produce of farmer when it is brought to market.
- Borrowing money from middleman at high rate of interest is another challenge for farmer to run their business.
- Farmers do not have capacity or bargaining power to stock market ready fish for a long time.
- Lack of gadgets for proper processing and mostly the product is non hygienic because lack of skills.
- There is need to improve market intelligence system. Sometime fish product prices are very high and sometime low, no balance.
- Post harvesting handling is one of the major challenges in expanding the demand of fish by consumers. Lack of hygienic facilities and skills in post-harvest handling and recently two processing plants rather cold storages are established in Muzaffargarh and Sargodha and large store chains like Cash and Carry (Metro).
- Lack of hygiene at fish markets resulting in poor quality fish products.
- Lack of equipment in handling fish from farm to market with few exceptions.
- Lack of R&D facilities in the public sector for industry development (or existing facilities being underutilized).
- Academia institutes have limited resource to do applied research which can help SA industry.
- Saline water brackish areas have not been scientifically identified and limited sampling of areas were conducted. No GIS data available giving full extent of saline aquaculture potential.
- Chemical analysis facilities of soil and water are not publicly and only limited information is available.

Tilapia can be a good option for the SA sector in Punjab:

- Tilapia has been well adopted to saline water with high growth and survival rate
- Fast growth and resistance to disease.
- Tolerance of wide range of environmental conditions including high temperature, low dissolved oxygen, etc.
- Tolerate wide range of salinity can be farmed in fresh, brackish and even in sea water environment
- Reproductive system is simple and frequent
- Globally accepted, good potential as food
- Considered as boneless meat and good taste
- Can be grown at little investment

The need for improved management, introduction of better salt-tolerant species, capacity building, and technology in the SA sector is crucial to improve efficiency and means for improved livelihoods.

ANNEX

ANNEX A. Workshop Agenda

Australian Government
Australian Centre for International Agricultural Research

IWMI International Water Management Institute

WorldFish

Challenges and Opportunities for Saline Aquaculture in Pakistan

Stakeholders Validation Workshop on Opportunities for Brackish and Saline Aquaculture in District Rahim Yar Khan, Pakistan

Date: 13th December 2022 from 09:30 AM - 14:00 PM
Venue: Executive Club, Khwaja Fareed University of Engineering and Information Technology Rahim Yar Khan

AGENDA

Time	Topic	Facilitator
09:30 – 10:00 AM	Participants' Arrival & Registration	
10:00 – 10:05 AM	Recitation of the Holy Quran	Mehtab Shah
10:05 – 10:15 AM	Opening Remarks	Mr. Najeeb Ullah (IWMI)
10:15-10:30	Welcome remarks	Prof. Dr. Muhammad Suleman Tahir (VC of KFUEIT)
10:30 – 11:00 AM	Overall Summary of Badin Survey Results Feedback/Comments from Farmers and Stakeholders on Survey Results (Q&A)	Mr. Najeeb Ullah and Mr. Mr. Mehtab Shah (IWMI)
11:00 – 11:30 AM	**Tea Break and Group Photo**	
11:30 – 12:00 PM	Discussion Theme 1: Challenge and Opportunities to Provide Salt-Tolerant Breeds	RSN Janjua
12:00 – 12:30 PM	Discussion Theme 2: Challenges in Pond Water Management and Disease Control	RSN Janjua
12:30 – 13:00 PM	Discussion Theme 3: Challenges and Opportunities to Provide Fish Feed/ Fertilizers to enhance production	RSN Janjua
13:00 – 13:45 PM	Final remarks and feedback from farmers and stakeholders	Technical Expert
13:45 – 14:00	Closing Remarks	Representative of Fisheries Department
14:00 – 15:00 PM	**Lunch and Prayer Break**	

Australian Government
Australian Centre for International Agricultural Research

IWMI
International Water Management Institute

WorldFish

Invitation

Challenges and Opportunities for Saline Aquaculture in Pakistan

You are cordially invited to please attend

Stakeholder Validation Workshop on Opportunities for Saline Aquaculture in District Muzzafar Garh and Multan, Pakistan

Date: 15 December 2022 from 09:30 AM - 14:00 PM
Venue: Hotel Avari Xpress, Old Bahawalpur Rd,
Opposite High Court, Gillani Colony, Multan, District Multan

AGENDA

Time	T	Facilitator
09:30 – 10:00 Hrs	Participants' Arrival & Registration	
10:00 – 10:05 Hrs	Recitation of the Holy Quran	Mehtab Shah
10:05 –10:15 Hrs	Opening Remarks & Purpose of Workshop	Najeeb Ullah
10:15-10:30 Hrs	Welcome Remarks	Dr. Anser M. Chatta, DG, Wildlife & Fisheries South Punjab
10:30 – 11:00 Hrs	Overall Summary of Muzaffar Garh Survey Results. Feedback/Comments from Farmers and Stakeholders on Survey Results (Q&A)	Najeeb Ullah and Mr. Mehtab Shah (IWMI)
11:00 – 11:30 Hrs	**Tea Break and Group Photo**	
11:30 – 12:00 Hrs	Discussion Theme 1: Challenge and Opportunities to Provide Salt-Tolerant Breeds	R.S.N. Janjua
12:00 – 12:30 Hrs	Discussion Theme 2: Challenges in Pond Water Management and Disease Control	R.S.N. Janjua
12:30 – 13:00 Hrs	Discussion Theme 3: Challenges and Opportunities to Provide Fish Feed/ Fertilizers	R.S.N. Janjua
13:00 – 13:30 Hrs	Discussion Theme 4: What are the Opportunities and Modern Techniques for Small Scale Farmers and Women	R.S.N. Janjua
13:30 – 13:45 Hrs	Final remarks and feedback from farmers and stakeholders	Mr. Zafar Sindhu, Mr. Rana Shamshad, Mr. Saeed
13:45 – 13:55 Hrs	Closing Remarks	Dr. Riazuddin, Director, SWARC, PFD, South Punjab
13:55 - 14:00 Hrs	Vote of Thanks	R.S.N. Janjua
14:00 – 15:00 Hrs	**Lunch and Prayer Break**	

ANNEX C. Photo Gallery

Group Photographs: IWMI staff and Staff of Punjab Fisheries Department (RYK) and Fish Farmers at Validation Workshop, Khawaja Fareed University of Engineering and Information Technology (KFUEIT), RYK, 13 Dec 2022

Mr. Ameer Nawaz Khan, AD, PFD, RYK and R.S.N. Janjua, Consultant IMWI at concluding remarks, 13 Dec 2022

Group Photograph: Participants at Validation Workshop in Multan dated 15 Dec 2022

Group photograph: Najeeb Ullah, and R.S.N. Janjua, IWMI with Dr. Riaz, Director, SWARC and female staff of Punjab Fisheries Department (South Punjab) at Validation Workshop, Multan, 15 Dec 2022

ANNEX F. Stakeholder Scoring Sheet

Provincial Stakeholder Consultation Workshop on Opportunities for Brackish and Saline Aquaculture in Pakistan

STAKEHOLDER MAPPING EXERCISE

IWMI Pakistan is mapping stakeholders to identify the key players within the saline and brackish aquaculture sector. We would like to get input from stakeholders themselves to understand their interests and views, and to ensure we have the right representation of voices in future interventions. This short stakeholder mapping activity will enable us to better understand the stakeholder ecosystem and how best all stakeholders can come together for sustainable solutions in the saline aquaculture sector in Pakistan.

Instructions:

Below is a table with a list of key stakeholders relevant to the saline and brackish aquaculture sector in Pakistan. Please go through the table and rank each stakeholder group across the 3 domains listed: Power/Influence, Interest, and Capacity.

Please rank stakeholders on a scale from 1-4, as follows, under each domain:

- **Power/Influence within the saline/brackish aquaculture sector (to enact change, to get buy-in for projects, etc.)**
  1 = No power at all
  2 = Low level of power
  3 = Moderate level of power
  4 = High level of power

- **Interest to support and engage with saline/brackish aquaculture projects and research activities**
  1 = No interest at all
  2 = Low interest
  3 = Medium interest
  4 = High interest

- **Capacity to implement and engage with saline/brackish aquaculture projects (knowledge, skills, awareness, technical capacity, etc.)**
  1 = No capacity
  2 = Low capacity
  3 = Moderate capacity
  4 = High capacity

Stakeholder Group	**Power Score** (Rank 1-4)	**Interest Score** Rank (1-4)	**Capacity Score** Rank (1-4)
Government Sector			
Pakistan Council of Research in Water Resources (PCRWR)			
Punjab Livestock and Fisheries Department			
Sindh Livestock and Fisheries Department (Inland, Marine and Coastal Fisheries)			
National Institute of Oceanography, Ministry Science and Technology, Government of Pakistan			
Ministry of Maritime Affairs, Government of Pakistan			
Fisheries Development Board Islamabad			
Private Sector			
Fish Hatcheries			
Feed Millers			
Fish Processors			
Fish Exporters			
Fertilizers Producers			
Pesticides Companies			
Poultry/Fish Feed producers			
Zoologists (Fisheries Extension Service Provider)			
Other stakeholder groups			
Fish farmers (marginal and small-scale)			
Fish farmers (medium, large-scale, progressive farmers)			
Academic Institutions *(Related departments to Fisheries and Saline Aquaculture) (e.g., University of Veterinary and Animal Sciences, Dept of Fisheries and Aquaculture; Nawaz Sharif University of Agriculture, Multan; University of Sindh; Khwaja Fareed University of Engineering and Information Technology, Rahim Yar Khan; University of Punjab, etc.)*			
Civil Society organizations *(NGOs, CBOs, local welfare groups, etc.)*			

Any other comments you'd like to share:

ANNEX G. Survey Tool

BRACKISH AND SALINE AQUACULTURE CHARACTERIZATION STUDY IN PAKISTAN

FARMER QUESTIONNAIRE

Introduction and Consent:

- AoA. My name is [*Enumerator Name*] and I am from IWMI. IWMI works on improving water and land resources for farming communities, and we are here today as part of a research study to learn more about your experiences as an aquaculture farmer.
- This research study is being conducted by IWMI's Pakistan office under the guidance of Principal Investigator Dr. Mohsin Hafeez.
- The purpose of this study is to learn more about fish farming practices in this area and the risks and opportunities for farming communities. For example, we will be asking questions related to the type of ponds you farm, the quality of water, fish species feed and harvest, and general problems you face in your farming.
- You have been selected to participate in this study because you are a fish farmer in this area and would have a good understanding of the issues farmers like yourself face in this community and we are interested in your valuable expertise.
- Your responses will help IWMI learn more about the fish farming situation and practices in this area and what issues and opportunities are possible for farmers. This will help inform improvements and better investments related to aquaculture farming systems in the future.
- Whatever information you provide today will be kept strictly confidential, and your name and all personal information will be kept anonymous. None of your information will be shared with anyone outside of the research team.
- Taking part in this study is voluntary. You are free to not answer any questions or withdraw at any time without any negative repercussions. You may choose not to take part in this study, or if you decide to take part, you can change your mind later and withdraw from the study, at which point your data will be deleted.
- Our discussion will last approximately 30-45 minutes. There are no risks to you from participating in this research. The information you give us will help inform future programs to improve farmers' livelihoods in this area. There will be no costs for you to participate in this research study, nor will you be paid for taking part in this study.
- If you have any questions about this research study or about IWMI that you may wish to clarify later, or if you wish to express any concerns or complaints, you may contact Dr. Mohsin Hafeez (IWMI Pakistan Country Representative at +92-423-529-9504
- We will only continue with the interview if you are interested in participating and provide your verbal consent. Do I have your permission to proceed? [*Wait for verbal consent before beginning interview*]
- See **Annex 1** for Verbal Consent Participant Table

Instructions for the Enumerator

The respondent should be the main fish farmer of the household (i.e., the person who most understands the ins and outs of the farm and makes most of the decisions for the farm).

	Question	Response	Instruction/Skips
SECTION 1: General Socio-Demographic			
1.	Interview Date (dd/mm/yyyy)		*Auto generated*
2.	Name of interviewer		*Text*

3.	Respondent Code		*Text*
4.	District/Area		*Text*
5.	What is your gender?	1 – Male 2 – Female 3 – Transgender	*Single Select*
6.	Marital Status	1 – Married 2 – Divorced 3 – Separated 4 – Widowed 5 – Single/Never Married	*Single Select*
7.	Who is the primary breadwinner of the household?	1 – Self 2 – Spouse 3 – Self and spouse equally 4 – Male relative (father, brother, uncle, father-in-law, son, grandfather) 5 – Female relative (mother, sister, aunt, mother-in-law, daughter, grandmother)	*Single Select*
8.	Who is the head of the household (primary decision-maker in your household)?	Code: 1-5 as above	*Single Select*
9. A. 9.B	What is the level of education of the household head?	1 – Illiterate 2 – Can sign 3 – Primary 4 – Middle 5 – Secondary 6 – Higher Secondary 7 – Graduation and above	*Single Select*
10.	How many family members do you have in your household (including respondent)?	1 to 10 number of adults (age >14) and children (age =<14) Number of females / Number of males	*Single Select*
11.	How many years have you been fish farming?	1 – 0-2 years 2 – 3-5 years 3 – 6-10 years 4 – more than 10 years	

SECTION 2: GENERAL QUESTIONS ABOUT SALINE FISHPONDS ***I'd like to begin by asking some general questions about your fishponds***		
1.	Are you satisfied with the growth parameters in ponds having a high level of salinity?	0 = No 1 = Yes 2 = Not Applicable
2.	Have you ever seen waterlogged or saline land near your fishpond?	
3.	Do you have nursery pond beside your production pond?	
4.	Do you have a fish hatchery for breeding purposes?	
5.	Do you have any vehicle or road issues to carry your product to the market?	
6.	Have you ever observed animals like otter, rodents, kingfishers etc. at your fishpond?	
7.	Do you worry about disease outbreaks in saline/brackish water ponds?	

	If yes, can you please list what are 3 major diseases you observed	
8.	Which fish species have the maximum growth rate in saline water at your pond?	1 – Rohu 3 – Grass Carp 2 – Tilapia 4 – Other (Specify)
9.	Which fish species show the maximum survival rate in saline water at your pond?	1 – Rohu 3 – Grass Carp 2 – Catla 4 – Other (Specify)
10.	What type of fishing nets do you use frequently?	1 - Cast fishing net 3. Gillnets 2 - Portable fishing net 4. Other (Specify)
11.	Who is your primary/major buyer?	1 – Wholesaler 2 – Retailer 3 – Wholesaler-Retailer 4 – Processor 5 – Consumer 6 – Financier 7 – Other (Specify) 8 – No buyer
12.	Is your primary buyer male or female usually?	1 – Male 2 – Female

SECTION 3: AQUACULTURE PRODUCTION SYSTEM (production, commercialization, knowledge)														
1. For each pond capable for aquaculture, BUT NOT currently use for aquaculture and for For each pond **USED FOR AQUACULTURE please provide the following information.**														
Pond ID	Is the pond permanent/perennial or seasonal? 1= Permanent/perennial 2=Seasonal	Ownership (CODE A)	Pond for aquaculture (CODE B)	Pond Area (Acres)	Pond Depth (Feet)	Water source 1. River 2. Irrigation canal 3. Groundwater 4. Multiple sources	Usage for household activities (please pick all that apply) 1= washing, 2= bathing, 3= water for cooking	Water depth (Feet)	Do you monitor the quality of water in this pond? 0= No 1= Yes If yes,	What water quality parameters do you monitor? 1=Water temperature 2=Dissolved oxygen 3=Water pH 4=Turbidity / transparency 5=Ammonia 6=Carbon	Measured Electrical Conductivity I (mS/cm)	Electrical conductivity of groundwater (mS/	Is there any special management practice implemented for pond "n" (No=0 / Yes =1)?	If yes, please specify this practice 1=Testing natural food adequacy in water 2=Maintaining stocking density 3=Species selection 4=Liming (during pond preparation and during the grow-out period) 5=Providing antibiotic-free supplementary feed 6=Feed must not contain

							4= agriculture, 5= livestock, 6= irrigation 7= Other (specify) 8= Not used for other activities		then go to the next Question	dioxide 7=Conductivity 8=Other (Specify)		cm)		unsafe levels of biological, chemical, and physical contaminants 7=Proper post-harvest handling 8=Use quality fish seeds 9=Location of aquaculture ponds 10=Drugs and chemicals usage
Pond1														
Pond2														
Pond3														
Pond4														
Pond5														

Code A: 1=Owned by respondent, 2= Owned by Husband/Wife, 3= Joint ownership (with Husband/Wife), 4= Father-in-law, 5= Mother-in-law, 6= Leased in, 7=Share, 8= others (Specify)

Code B: 0= Pond capable for aquaculture, but not currently use for aquaculture, 1= Pond used for aquaculture

SECTION 4: AQUACULTURE PRODUCTION, HARVEST, CONSUMPTION, AND EXCHANGE									
For each of the Pond "n", please provide the following information about the production, harvest, consumption, and exchange of fish-by-fish species in the previous production cycle/2021									
Species (for ponds)	Final Harvesting Month?	Average culture period (months)	Final average size (Kg/fish)	Total amount of fish **HARVESTED** in 2021 (Kg) Including the amount of fish REMAINED in the pond (Kg)	Total amount of fish **SOLD RAW** in 2021 (Kg) This should contain all fish sold **FRESH** from this pond.	Total amount of fish **SOLD PROCESSED** in 2021 (Kg) This should contain all fish sold **AFTER ANY FORM OF PROCESSING** from this pond.	Total amount of money received from **ALL FISH SALES** (PKR)	Total amount of fish **CONSUMED WITHIN HOUSEHOLD** in 2021 (Kg)	Total amount of fish **GIFTED** in 2021 (Kg)
Rohu									
Catla									
Mrigel									
Grass Carp									
Common Carp									
Silver Barb									
Mola									
Tilapia									
Pangas									
Mixed Sex									
Mono Sex									
Catfish (local and exotic)									
Anabas/									
Snakehead									
Small Indigenous Species (SIS)									
Other (Specify)									
Other (Specify)									

SECTION 5: FISH SEED USED IN PONDS											
Please answer the following questions regarding the fish seed used in ALL ponds in 2021											
Species (if one fish is not stocked then move to the next)	What type of fish seed did you stock in your pond last season? 1=Fries 2=Fingerlings 3=Both 4=Not stocked *If not stocked, skip to Section 6*	What was the 1st stocking date?	What was the total number of fish seeds stocked?	What was the average fish seed size (Inch)?	What was the cost per fish piece (PKR)	What is the main source of fish seed used in 2021? 1= Private hatchery 2= DOF hatchery 3=Private Nursery 4=DoF nursery 5= NGOs 6= Other farmer 7= Own raised 8= Wild 9=Others (Specify)	Who in the household accessed the seed? (Check all that apply) 1=Male Household head 2=Female household head 3=Male partner 4=Female partner 5=Fish farmer 6=Other (Specify)	Who in the household takes the decision on seeds? (Check all that apply) 1=Male Household head 2=Female household head 3=Male partner 4=Female partner 5=Fish farmer 6=Other (Specify)	What is the survival rate of fish seed (%) (share of the number of carry over fish in fish seeds)	Feeding quantity per time (Kg/ha)	Feeding frequency (times per day)
Rohu											
Catla											
Mrigel											
Grass Carp											
Common Carp											
Silver Barb											
Mola											
Tilapia											
Pangas											
Mixed Sex											
Mono Sex											
Catfish (local and exotic)											
Anabas/ Snakehead											

Small Indigenous Species (SIS)											
Other (Specify)											
Other (Specify)											
Other (Specify)											

SECTION 6: FISH FEED IN ALL THE PONDS					
Please answer the following questions regarding feed used **in ALL PONDS** in 2021?					
Type of feed	Did you use any of these feeds? (0=No, 1=Yes)	Amount used in Pond		Total cost (PKR) if purchased	What is the source of this feed? 1=Feed Miller 2=Oil Mill 3=Feed Trader 4=Rice Mill 5= Other specify _____
		Own	Purchased		
Rice bran (Kg)					
Groundnut cake (Kg)					
Cotton seed cake (Kg)					
Rape seed cake (Kg)					
Sesame oil cake (Kg)					
Mustard oil cake (Kg)					
Soybean meal cake **b**(Kg)					
Rape seed meal (Kg)					
Feather meal (Kg)					
Corn gluten meal (Kg)					
Vitamins (Ml. Gram)					
Amino acids (Kg)					
Fish oil (Kg)					
Minerals (Ml. Gram)					
Pellets from commercial feed mills (floating) (Kg)					
Pellets from commercial feed mills (sinking) (Kg)					
Cooked rice (Kg)					
Sun flower cake (Kg)					
Other (specify)					

SECTION 7: INPUT USE AND COST FOR POND PREPARATION					
What were your input use and cost for pond preparation for **ALL PONDS** in 2021?					
Input	Did you use any of these inputs? (0=No, 1=Yes)	Pre-stocking period		Post-stocking period	
		Amount	Total cost (PKR) if purchased	Amount	Total cost (PKR) if purchased
Cow dung *(Kg)*					

Poultry droppings *(Kg)*					
Goat dung *(Kg)*					
Compost *(Kg)*					
Other organic fertilizer (specify) *(Kg)*					
Urea *(Kg)*					
TSP *(Kg)*					
MoP *(Kg)*					
Quick lime *(Kg)*					
Slaked lime *(Kg)*					
Lime stone *(Kg)*					
Gypsum *(Kg)*					
Dolomite *(Kg)*					
Rotenone (g)					
Bleaching powder (Kg)					
Other input (Specify, input and unit)					

SECTION 8: LAND OWNERSHIP					
1. Do you own or rent any land?			0 = No 1 = Yes **If yes, answer the questions in the table below**		
1a. Does your household own or have access to any of the following land categories? *If the same plot contains multiple uses, please ask the respondent to divide the areas in the responses.*					
Type	What is the size of this land (Acres)?	Total land for aquaculture	Cultivated agricultural land	Other purposes	

SECTION 9: EVALUATION OF FISH DISEASE SAMPLES AND GROWTH RATES IN HIGH-LEVEL SALINITY PONDS									
Did you observe any fish disease samples, if yes, then answer the following questions: Mention disease samples having maximum disease attack in a saline pond.									
Fish species	Stocking density	Did you observe any **Fin rot** sample	Did you observe any **Gill rot** sample	Did you observe any **Fungus** sample	Did you observe any **Abdominal dropsy** sample	Did you observe any **Saprolegniasis** sample	Other disease (Specify)	Approximate % of disease	What is the growth rate of this fish at your fishponds? 1=Very low, 2=Low, 3=Medium/Average, 4=High, 5=Very high
Tilapia									
Bighead carp									
Singhari									

Pangasius									
Rohu									
Thaila									
Mrigal									
Grass carp									
Common carp									
Silver carp									
River catfish									
Mullet									
Sole									
Snakehead Murrel									
Mahaseer									
Shrimp									
Crab									
Lobster									
Prawn									

SECTION 10: KNOWLEDGE, ATTITUDE, AND PRACTICE ON IMPROVED AQUACULTURE PRACTICES AND BETTER MANAGEMENT PRACTICES (BMPS)			
Have you faced any of the following list of challenges related to aquaculture? Please rate their effect to aquaculture production,			
	Barriers/Challenges	A. Have you experienced any of these challenges? 1=Yes, 0=No *If No, ask Question B*	B. How does this challenge affect the level of your aquaculture production? 1=Very low, 2=Low, 3=Medium/Average, 4=High, 5=Very high
1	Access to fingerlings		
2	Price of fingerlings		
3	Quality of fingerlings		
4	Access to fish feed		
5	Price of fish feed		
6	Quality of fish feed		
7	Selling price of fish in markets		
8	Access to fish markets		
9	I am unaware of any new technology		
10	I cannot get credit needed to adopt new technologies		
11	I do not own the land where I raise fish.		
12	My fish farming operation is too small.		

13	Availability/access to water (if so, is it continuous or seasonal)		
14	Poor water quality (specify type of issue if possible)		
15	Fish health/incidence of disease		
16	Bird's infestation you have observed at your fishpond		
17	Vegetation diversity at your fishpond		
18	Other challenge (Specify)		

SECTION 11: GENERAL OPINIONS

I'd like to end the survey with some final general questions about the aquaculture sector. There are no right or wrong answers, we are just interested in your general opinion.

	Question	Response					
1.	Aquaculture activities face more challenges as compared to agriculture activities. (for example, higher taxation, higher energy/power tariff, higher interest rates, higher water charges, and higher cargo charges)	1	2	3	4	5	6
2.	Post-harvest infrastructure should be improved to expand the marketing of aquaculture products	1	2	3	4	5	6
3.	The younger generations are interested in fish farming activities	1	2	3	4	5	6
4.	Women have access to aquaculture farming equally as men (i.e. they can become farmers)	1	2	3	4	5	6
5.	*You can easily find women vendors in local fish markets.*	1	2	3	4	5	6
6.	*The government should support fish farming by providing more incentives for farmers*	1	2	3	4	5	6
7.	*Women help decide when and how many fish to take home for consumption and sale*	1	2	3	4	5	6
8.	*Women help decide how income from fish farming will be used within a household.*	1	2	3	4	5	6
9.	*It is better if women do not work in the fisheries or aquaculture industries*	1	2	3	4	5	6

1 – Strongly Disagree, 2 – Disagree, 3 – Neither Agree nor Disagree (Neutral), 4 – Agree, 5 – Strongly Agree, 6 – Don't Know

Thank you for taking the time to answer all our questions. Your responses will help this research study tremendously!

ADDITIONAL FEEDBACK

You are welcome to provide any additional information you would like to share about any issues you face related to saline aquaculture policies and practices.

Verbal Consent Participant Table

Name of participants	Date	Agreed to be part	Did not agree

Signature Project Staff	Signature Authority Staff	Date

**This table needs two signatures: Of the Project staff who obtained the verbal consent and of a Governmental representative who was part of the process or can verify that the project has been introduced, participants know their rights, and consent has been obtained.*

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