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Summary of Co-Inquiry Research Experiences with Salinity-Affected Communities along the Malwah Distributary

Abdul Latif Qureshi, Kazi Suleman Memon, Arjumand Zehra Zaidi, Asmat Ullah, Benazir Kumbhar, Babar Zaman

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Executive Summary

Soil salinity is a challenge for irrigated agriculture in Pakistan, threatening food security and the livelihoods of salinity-affected farming communities. Numerous research and development projects and technology initiatives introduced over the past few decades have not yielded the desired results to arrest soil salinity. Climate change is further aggravating the situation. A core gap contributing to the ineffectiveness of past strategies and programs has been inadequate opportunities for salinity-affected farming communities to participate in decision-making processes.

The “Adapting to Salinity in the Southern Indus Basin (ASSIB)” project of ACIAR has sought to respond to this gap. It involves selecting and engaging farming communities associated with salt-affected landscapes in the co-design of the research to be undertaken in co-inquiry mode with the participation of researchers and other stakeholders. Using pre-defined criteria, we selected a *bright spot* salinity-affected farming community of small farmers in the village Mitha Khan Dharejo, located in the middle reach of the Malwah distributary in Tehsil Qazi Ahmed of district Shaheed Benazir Abad, Sindh. The Malwah farming community (men and women), researchers from Mehran University of Engineering & Technology (MUET), a team of community engagement experts from the Society of Facilitators and Trainers (SOFT), and stakeholders representing agriculture research and extension, water management, and other technical expertise constituted an interdisciplinary team for co-design and co-inquiry investigations.

The Stakeholder Engagement for Research and Learning (SERL) model (Heaney-Mustafa et al., 2023) facilitated the engagement with the Malwah farming community. SERL uses an asset-based community development (ABCD) approach to analyse available and required resources and identify and prioritise problems, a SWOT analysis to appraise identified issues, leading to the development of a co-inquiry action plan through a stakeholder consultative process.

Three SERL workshops were held over the project’s duration of three years (2021-22 to 2023-24) to co-design interventions and participate in co-inquiry investigations with active involvement of the Malwah farming community (men, women and youth), researchers and other stakeholders. The workshop process led to a prioritisation of the most promising and workable ideas to serve as potential interventions suited to their situations. The process generated farmer interest and participation in that they identified the interventions and even the training needs for their capacity building. The scope of activities went outside the usual course of research investigations. The findings were discussed before initiating the next round of co-inquiry activities. Women farmers and youth were actively involved in all these activities, with positive implications for improved livelihood sources and food security.

The consultative SERL workshops suggested several interventions, including the performance assessment and identification of high-yielding brassica and wheat varieties suited to variably saline soils, evaluating the benefit of using low doses of gypsum, ridge versus flatbed planting of wheat using different varieties under limited water supplies, vegetable cultivation on saline soils for livelihood, trialling mulching to assess its benefits, and capacity building through training in various areas of interest and need.

The project outcomes clearly indicate that the Malwah farming community is better equipped to design and investigate future adaptation options to live with the salinity. Given below is a summary of the project outcomes and associated benefits:

- A visible sense of ownership among the Malwah farming community, men and women, in what they have already trialled, experienced and equipped themselves with.
- A continuing urge to explore new ideas and strategies for identifying high-yielding crop varieties suited to their salt-affected landscape.
- Kitchen gardening has provided organic vegetables throughout the season for the participating farm families with the number of women farmers opting to grow vegetables is increasing. Vegetables grown with mulch provided better yields in most cases, besides many other associated benefits, with the farmers involved participating in TV programs to promote cultivation and use of fresh vegetables for better health and nutrition.
- The participating farmers were delighted with the outcomes, including easy and constant access to fresh and healthy vegetables, the pleasure of sharing their produce with neighbours and friends and even selling the excess providing an added source of income. Growing fruit trees and procurement of

nursery and vegetable seeds from nearby markets represented another positive outcome for the Malwah community.

- Farmer linkages were established with service providers in the agriculture sector (local representatives of agriculture extension, research and water management), soil salinity experts, fertiliser companies (Engro, FFC), seed suppliers in public and private sectors, soil testing and analysis facilities
- The farmers illustrated their capacity and confidence by organising and conducting a farmer-to-farmer workshop to share their learnings from the ASSIB project with neighbouring farming communities, identifying and inviting the farmers themselves and facilitating the entire activity with confidence.
- Finally, the farming community is better connected socially, including being well-placed to take advantage of the benefits of social networking.

We propose that the ASSIB approach should receive due attention for continuity in future to sustain the benefits beyond the bright spots. The Malwah community's farmer facilitators are enthusiastic to disseminate the ASSIB learnings to other farming communities. Besides, future projects should provide an in-built mechanism for institutionalisation of this approach for adoption by the agriculture and irrigation departments.

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1. Introduction

Soil salinity is a challenging issue of irrigated agriculture in Pakistan. Many nationwide research and development projects and technology initiatives have been introduced over the past few decades with little or no success in addressing the issue (Ashraf et al., 2022; Ali, 2023). Climate change and extreme weather events further aggravate the situation and threaten the livelihood of farming communities and food security. One of the core gaps contributing to the ineffectiveness of past strategies and programs is the need for more participation opportunities in decision-making processes for salinity-affected farming communities (Ashraf et al., 2022).

Such a call for action requires the pursuit of an integrated and holistic approach to actively engage farming communities and other stakeholders in implementing available adaptation options (Ali, 2023). Implicit components of such an action are using a systems approach to understand the farmers' situations and circumstances and identifying economically and socially viable adaptation options by actively involving farming families throughout this process. This includes an assessment of the nature and extent of the soil salinity problem, water source, quality and availability, cropping systems, existing crop production practices and socio-economic status, and identification of adaptation options most suited to the situation.

Realising the need for a practical and holistic approach and collaborative action, the Australian Centre for International Research (ACIAR) funded the project "Adapting to Salinity in the Southern Indus Basin (ASSIB)." This project aimed to pilot the participatory investigations with the support of partner institutions, including the Mehran University of Engineering and Technology (MUET), Jamshoro, Sindh.

Unlike traditional biophysical approaches with no or minimal involvement of salinity-affected communities in decision-making, the ASSIB approach considers farmer and other stakeholder participation as a foundation stone in determining the success of the adaptation investigations. It uses a community-driven approach involving the co-design of suitable interventions. It starts with problem identification through a stakeholder consultative process, then planning and prioritising appropriate interventions on these farmers' lands. The farmers participate as co-researchers in the investigations.

The Stakeholder Engagement and Research Learning (SERL) model (Heaney-Mustafa et al., 2023) provided a practical way of engaging farming communities in co-designing on-property salinity adaptation interventions in an integrated and inclusive way. Using an asset-based community development (ABCD) approach and Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis, the SERL workshops help farmers identify and prioritise problems with specialist researchers and other stakeholders. Remarkably, this approach includes an in-built element of capacity building for farming communities, including men, women, and youth, to identify suitable adaptation options compatible with on-ground realities. An important value-adding component of this approach is an opportunity to address associated livelihood and food security issues.

This report presents the results of the ASSIB research project conducted with a farming community of Mitha Khan Dharejo village, associated with the Malwah distributary in Tehsil Qazi Ahmed, district Shaheed Benazirabad, Sindh, Pakistan. The SERL model enabled the participation of concerned stakeholders (including farmers, researchers, and staff from agriculture extension and other service providers) to co-design the interventions that were implemented in co-inquiry mode. The interventions identified through the SERL model investigated a wide range of topics, including high-yielding wheat and brassica variety selections suited to local soil and water conditions, use of small doses of gypsum in salt-affected and normal soils, ridge cultivation of wheat under limited water supply, mulching in vegetable production, income diversification with women involvement in kitchen gardening activities, and farmers' capacity building training. This approach has built confidence and experience, enhanced capacity, and inculcated ownership among the target farming community. As a result, they have taken on the role of facilitators, enthusiastically scaling out the ASSB approach to the neighbouring farmers in a farmer-to-farmer workshop.

2. Methods

2.1. Site Selection and Background

ACIAR-funded scoping studies conducted during the development of the ASSIB project identified a portfolio of eight ‘bright spot’ communities with the participation of partnering institutions, including Mehran University of Engineering and Technology (MUET) (Mitchell et al., 2020). Among other criteria, the selection process prioritised communities residing at a feasible distance, demonstrating a willingness to collaborate, possessing established community interaction, showing high adaptability potential, and actively involving women and youth. The Malwah community, as one of the eight listed 'bright spots,' had strong connections with MUET and other stakeholders due to their involvement in the previous ACIAR's LWR/2015/036 Project, "Improving Groundwater Management to Enhance Agriculture and Farming Livelihoods in Pakistan,” implemented during 2015-2020 (Punthakey et al., 2021).

The Malwah bright spot is located in the middle reach of the Malwah distributary in Tehsil Qazi Ahmed of district Shaheed Benazirabad, Sindh, Pakistan (Figure 1). The distributary is 31.7 km long with a culturable command area of 17,590 hectares. The farming communities living on the right side of the Malwah distributary in village Mitha Khan Dharejo (Latitude: 26° 14' 43" N, Longitude: 68° 3' 52" E) and its surroundings were selected for co-design and co-inquiry investigations. The distance from MUET to the ‘bright spot’ community is 139 km.

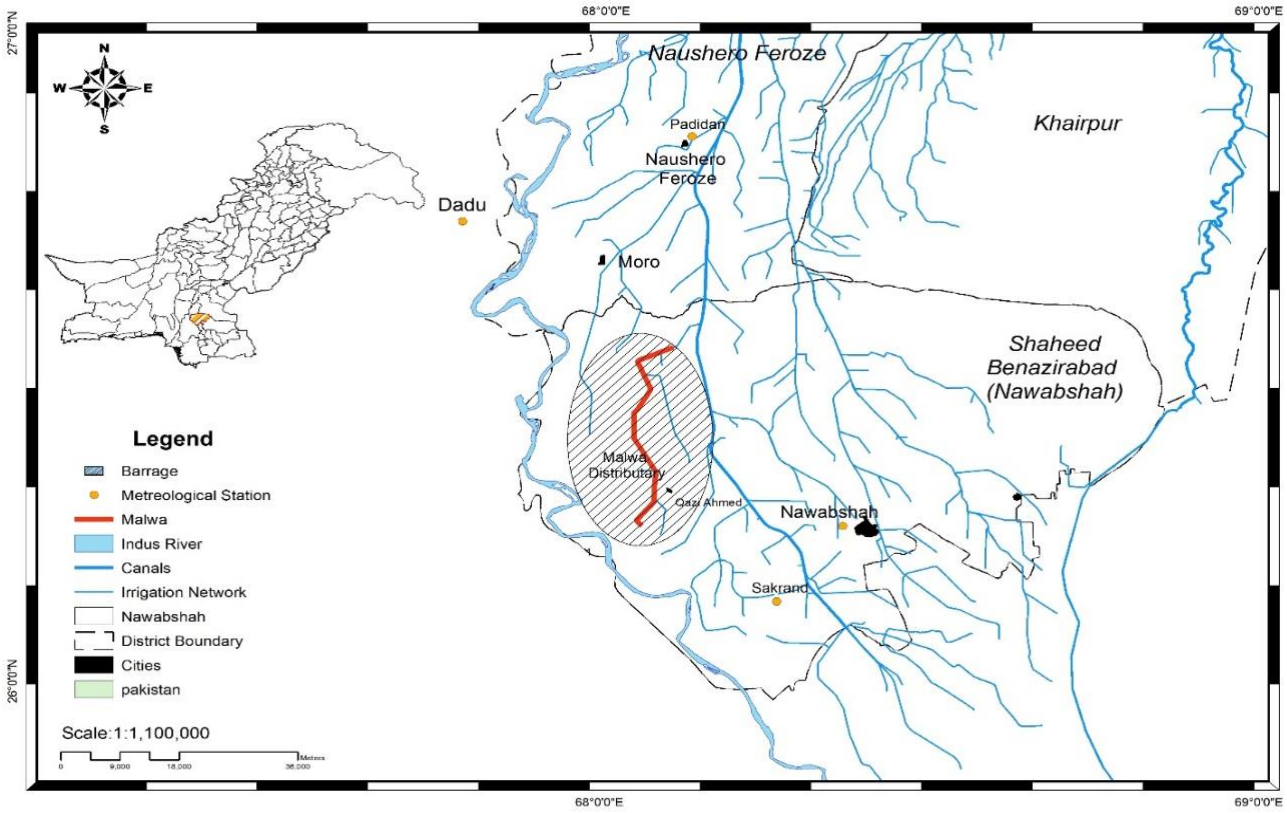

Figure 1. Location of the Malwah Distributary in Tehsil Qazi Ahmed, district Benazirabad, Sindh

2.2. Salient Features of the Site Selection

Initial profiling of the Malwah farming community showed that most farmers were either tenants or small landowners cultivating between 2 and 18 acres (0.8 and 7.3 hectares) of land using canal water and, in some cases, tubewell water. The shortage of canal water is one of the main issues, mainly during the dry Kharif

season. Hence, many farmers cannot cultivate their lands in Kharif, except those with access to tubewells to pump groundwater for irrigation.

An Electrical Resistivity Survey (ERS) of the Malwah distributary command area (Figure 2) found that the underlying groundwater is mostly marginal saline with patches of highly saline water on its eastern side and marginal fresh to fresh groundwater in the southwest near the Indus River (Hussain et al., 2021).

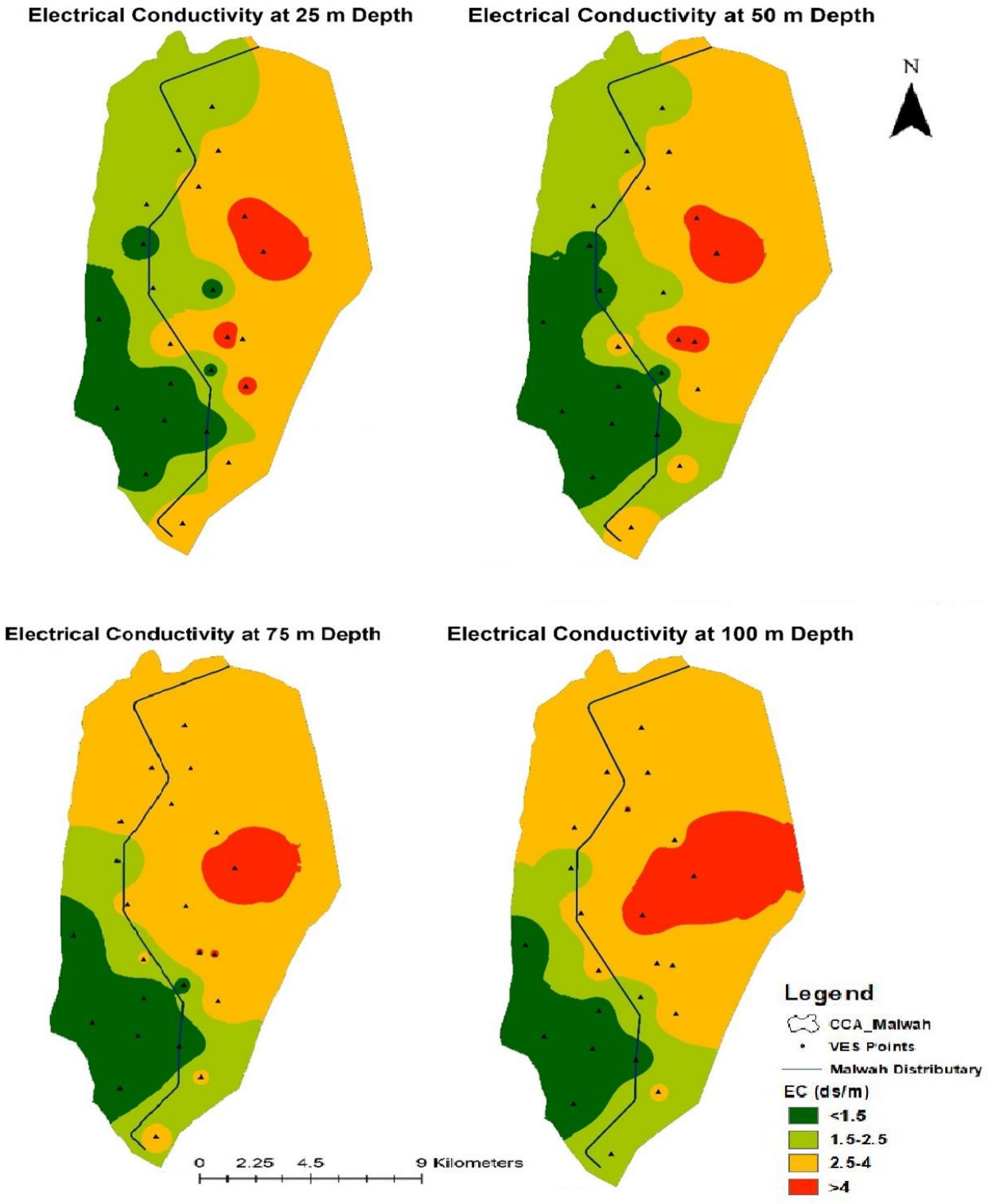

Figure 2. Groundwater of Malwah command area (Hussain et al., 2021)

The warmest months in the study area are April to June, with temperatures rising above 45 degrees Celsius, and January is the coldest month, with temperatures falling below 10 degrees Celsius. The area receives an average annual rainfall of 135 mm, mainly during the monsoon season. It could manifest as drought with minimal precipitation or, conversely, as intense rainfall leading to floods, such as those experienced in 2010, 2011, and 2022.

Agricultural land is affected by secondary salinisation to varying degrees mainly due to limited and unreliable surface water supplies in the middle and tail reaches of the distributary and increased dependence on poor-quality groundwater. Soil characteristics generally show heavy soil texture, alkaline pH, and low organic matter under limited or no use of organic amendments.

The main crops grown in the area are wheat and brassica during Rabi (winter) and cotton and sugarcane in Kharif (summer) seasons. The cultivation of seasonal vegetables was almost non-existent.

The primary source of livelihood in the area is agriculture, with additional income from diverse sources like poultry, livestock rearing, etc. Women also help their families in such activities. In addition to their household responsibilities, women take care of the livestock, handling tasks ranging from feeding and milking to harvesting grasses for animal fodder. They also do some handicrafts in their leisure time, but a more organised system for income generation out of this craft is needed. Most farmers have attained education up to primary or middle school levels, and there is a noticeable interest in ensuring education is provided for their children. The farming community is well-knit and well-connected, but no farmer organisations exist. The previous ACIAR groundwater project served as a source of strengthening farmer-to-farmer contacts. However, linkage with service providers was limited at the start of the current ASSIB project.

2.3. Co-Designing Interventions

The ASSIB approach involves co-designing interventions that are implemented in a co-inquiry mode with the participation of the stakeholders, including the 'bright spot' farming community. A stakeholder forum is established, which participates in the SERL workshops for the co-design of interventions, followed by co-inquiry investigations.

2.3.1. Establishment of Stakeholder Forum

The objective of establishing the stakeholder forum (SHF) was to promote collaboration, share knowledge, establish linkages with technical experts/researchers and service providers in public and private sectors, and assist in the co-design of interventions through mutual consultations while addressing common challenges associated with limited water supply and soil salinity issues. The Malwah SHF was established prior to holding the SERL workshop to co-design the interventions. The SHF (Appendix 1) included Malwah farmers (men and women), area agricultural extension, research and water management officials, technical experts representing the field of agronomy, agricultural economics and soil science, soil salinity experts and analytical lab officials, community engagement officers from the Society of Facilitators and Trainers (SOFT) and researchers from MUET.

2.3.2. SERL Workshops

The engagement with the farming community was facilitated through a workshop process initially referred to as the Rural Research Engagement and Learning Model (R^2EaLM), built on the previous Farmer Integrated Learning Model (FILM). Given the ASSIB project's experience of working with R^2EaLM, we revised the name of the process to Stakeholder Engagement for Research and Learning (SERL). Referring to stakeholders, the SERL acknowledges that all those who have a stake in further improving rural livelihoods and agricultural practices and policies are to be actively engaged in both learning and teaching each other about how these improvements can be achieved (Heaney Mustafa et al., 2023).

SERL uses an asset-based community development (ABCD) approach to analyse available and required resources and identify and prioritise problems, followed by a SWOT analysis to help appraise the solutions identified to deal with the prioritised problems, considering internal strengths and weaknesses and external threats and opportunities. This process helps confirm the most promising and workable ideas to serve as potential interventions, which are then developed into an action plan through a stakeholder consultative process. The action plan details tasks, timelines, locations, and assigned responsibilities to ensure its implementation. The SERL workshop approach is summarised in Appendix 2.

It was essential to align interventions with research questions formulated through joint consultations. In the case of Malwah, the two overarching research questions were: (1) What management options are available for the salt-affected landscape? (2) What crop species and varieties are suited to salt-affected landscapes, and what is the impact of soil salinity on crop yields and economic benefits? Numerous sub-questions were also developed, such as 'What factors contribute to the salinity problem, and how can salinity intensification be avoided?' A complete listing of these questions and sub-questions is given in Appendix 3.

The first two-day SERL workshop was conducted in August 2021, which determined research interventions for Rabi 2021-22 in co-design mode with specialist researchers and other stakeholders. In keeping with the social norms, two separate SERL workshops were held simultaneously, one for men and one for women. The SERL workshops were repeated in 2022 and 2023 for reassessment and adjustments in the activity plans as needed for Rabi 2022-23 and Rabi 2023-24, respectively. A list of the three sets of SERL workshops is shown in Table 1, with photographs of two of the SERL workshops (one with women, one with men) shown in Figure 3.

Table 1. List of SERL workshops conducted at Malwah 2021-2023

Year	Date	Women participants	Men participants
2021	30-31 August	34	23
2022	17 March	30	16
2023	6 August	23	22

Figure 3. Malwah farmers and other stakeholders participating in SERL workshops

2.3.3. Co-Inquiry Research

Brassica

Traditionally, Malwah farmers obtained brassica seeds from different sources, including nearby seed supply dealers, open markets, farmer-to-farmer sales, and their own saved seed from the previous year's crop. Their criteria for selection of the best seed and variety were based on their experience with the yield performance of the variety/seed planted by different farmers in the community. Their exposure to formal seed supply sources in the public and private sectors was almost negligible. During the SERL workshops, open discussions highlighted the necessity for pure seeds of a promising variety from a reliable source with high yield potential, ideally suited to the specific soil conditions in Malwah.

The co-inquiry trials conducted at Malwah for the Rabi 2021-22 season used three varieties, two sourced from the public sector (Sindh Raya and Mehran New) and one (Khanpur) from a private seed company. Four farmers participated in a comparative assessment of these brassica varieties. All farmers planted Khanpur and compared it with their variety (represented as 'F'); two of these farmers additionally planted Sindh Raya and Mehran New.

Through the SERL process, Malwah farmers highlighted three problems: soil salinisation over time, shortage of canal water, and quality seeds of promising varieties not available in local markets. As the groundwater is already marginal fresh to marginal saline, most farmers prefer to irrigate with canal water. Traditionally, farmers

plant brassica on marginal/relatively saline soils, and wheat is grown on normal to slightly saline soils, subject to the availability of canal water. With limited canal water supplies, farmers leave some land fallow, where salt accumulate on the soil's surface over time through evaporation.

Wheat

The farmers of this region also traditionally planted wheat on flatbeds. During the co-design activities under the ASSIB project, some farmers were interested to try cultivating different wheat varieties on ridges for comparison with the traditional flatbeds. Ridge sowing of wheat has the potential for water saving without compromising yields. Water saving is essential so more land can be cultivated to prevent salt accumulation.

As a result of the SERL workshop, the farmer groups suggested the following interventions for wheat in Rabi 2021-22: (1) assess the performance of wheat varieties in normal to saline soils; and (2) trial ridge versus flatbed wheat planting using different varieties. Gypsum intervention also received farmers' attention as a soil amendment during the SERL workshop, for which one farmer opted to initiate the assessment of gypsum application. The co-inquiry trials for Rabi 2021-22 are detailed below.

Trialing wheat varieties in Rabi 2021-22: Six farmers participated in co-inquiry investigations focusing on wheat varietal performance on soils with variable salinity status. The interventions included three wheat varieties (TD1, Kiran, and NIA-Zarkhez). The farmers cultivated one or two or all three varieties and compared them with their own seed variety. The quality seeds provided by MUET were designated with the prefix ‘M’ and the farmer seed with ‘F’.

Ridge v/s flatbed sowing of wheat: The Malwah farmers planted brassica on ridges to save water without compromising yield. However, wheat is almost invariably planted on flatbeds. Following the discussions held during the SERL workshop, two farmers, a man and a woman, opted to try the ridge method for wheat cultivation under a water shortage situation, using two varieties, TD1 and Kiran.

Use of gypsum as a soil amendment: One farmer initiated an exploratory trial with gypsum (0.75 tons/acre) applied before planting brassica (two acres with and without gypsum) and wheat (four acres with and without gypsum) to saline lands. Based on the beneficial effect of gypsum on crop yields and soil improvement, other farmers also felt motivated and planted wheat with and without the application of low rates of gypsum (0.2 to 0.4 tons/acre).

The farmers have continued varietal trials in Rabi 2023-24 for wheat and brassica. For wheat, five farmers participated using four varieties (TD1, Kiran, NIA-Zarkhez, and Imdad). In the case of brassica, four farmers planted three varieties, viz. Sindh Raya, Khanpur, and Noriaro.

Kitchen gardening

Kitchen gardening activities were also initiated at Malwah in Rabi 2021 following the participation of women in the SERL workshop. Prior to this, women had not shown interest in growing vegetables. The SERL process generated interest among women and served as an entry point for their participation in the kitchen gardening co-design process and plan. The discussions during the workshop helped the stakeholders and researchers understand the nature of problems encountered by women farmers, particularly inadequate training and orientation in planting different vegetables, availability of vegetable seeds at their level, planting methodology, variable soil salinity status, and limited or even non-availability of irrigation water.

In the first phase, five women farmers of village Mitha Khan Dharejo were identified based on their interest in vegetable cultivation and land and irrigation water availability. After a half-day training in vegetable cultivation given by Dr Noorunisa Memon, a Horticulturist from Sindh Agriculture University Tandojam, they grew vegetables of their choice (Figure 4). As first-timers, they encountered management problems, particularly regarding irrigation scheduling, seed germination, and planting methods under variable salinity status.

Besides expressing the need for further training, some women farmers expressed interest in having their soil analysed, particularly regarding its salinity and fertility status. Soil sampling (0-15 and 15-30 cm) and analysis of eight women's farm fields were done in Kharif 2022 with assistance from service provider Fauji Fertilizer Company (FFC). The analysis showed that: (a) soil pH is normal (7.6 to 8.3, and <8.0 for most soils); (b) soil salinity varied from one site to another, with EC (1:2.5) values 0.31 to 3.57 dS/m; (c) exchangeable sodium is normal in most soils (0.4 to 4.1 $mmol_c$/100 g); (d) organic matter and available phosphorus are both low (0.32 to 0.79% and 2-10 mg/kg respectively); and (e) exchangeable potassium is high (136 to 680 mg/kg), indicating no need to apply potash fertilisers.

Later, in October 2022, a one-day Training and Demonstration on the Multi-layer Cropping Model for Kitchen Gardening was organised. The resource persons included (1) Ghulam Mustafa Nangraj, Director Information & ICT Agriculture Extension Services and Deputy Program Coordinator Agriculture for Nutrition, Sindh, and

(2) Dr Tanveer Fatima Miano, Professor, Department of Horticulture, Sindh Agriculture University Tandojam. The training was meant to enhance women farmers' knowledge and understanding of kitchen gardening using this multi-layer cropping model on saline/non-saline soils, obtain their views and feedback, and demonstrate the methodology of growing vegetables with reference to the five-colour nutrition-sensitive vegetable plantation approach (Nangraj et al., 2024). The training helped orient women farmers' knowledge and they shared their views openly and individually regarding how to pursue these objectives in their kitchen gardens as per the details provided**.**

In the second phase, five women farmers cultivated different types of vegetables on beds following the multi-layer vegetable cultivation model (Table 2). They followed the five-colour vegetable plantation approach that aligned with the nutritional requirements. Three of these farmers used sugarcane mulch to determine its effect on yield and other associated benefits.

Figure 4. Malwah women farmers participating in the first kitchen gardening training workshop

Table 2. Multi-vegetables cultivated during the Rabi 2022-2023
(adapted from Kumbhar et al., under review)

Women farmer code	Vegetables grown	Mulch used
WF 1	spinach, coriander, peas, radish, carrot, fenugreek, onion, garlic, brinjal, tomato, bottle gourd, cabbage	sugarcane
WF 2	spinach, coriander, peas, radish, carrot, fenugreek, brinjal, tomato, cabbage	sugarcane
WF 3	spinach, fenugreek, coriander, peas, radish, carrot, onion, garlic, cabbage, tomato, brinjal	sugarcane
WF 4	spinach, coriander, peas, radish, carrot, fenugreek	no mulch
WF 5	spinach, coriander, peas, radish, carrot, fenugreek, tomato, cabbage, brinjal, beetroot	no mulch

To ensure the availability of quality seeds of desired varieties, a one-day training on "Vegetable Seed Production and Storage" was jointly organised by MUET and SOFT teams and conducted by Dr Tanveer Fatima Miano (Horticulturist, SAU, Tandojam) for female farmers at Village Mitha Khan Dharejo (Figure 5). The primary objective of the training was to enhance women farmers' knowledge related to vegetable seed production and storage and preservation for the next season.

Fruit tree plantation

Continuing discussions through the SERL process led the farmers to grow fruit trees alongside the vegetable cultivation area. The training was organised with practical on-field demonstrations to prepare pits and manuring requirements for planting different fruits, like mulberry, jaman, lemon, guava, grapefruit, jujube and mango. Later, fruit seedlings were procured and planted by different farmers.

Figure 5. Women farmers showing their interest in kitchen gardening to cultivate multiple vegetables at Malwah

2.4. Trial Data and Analysis

Soil Properties: During each season, representative soil samples were drawn before planting each crop and analysed for soil texture, EC, pH, and other parameters as necessary.

Crop Management and Data Collection: Crop management and yield data were recorded during each cropping season. Several discussion sessions were also held between participating farmers and other stakeholders to clarify concepts and ensure co-inquiry learning through all activities. Technical training programs from subject experts helped build farmer capacity to manage crops and salt-affected soils.

2.5. Farmer Capacity Building

Training for capacity building has been an ongoing activity meant to equip Malwah farmers with the necessary knowledge by engaging subject experts as resource persons. Ten training sessions were held with the support of resource persons sourced from different public and private sector organisations. A list of training and resource persons is provided in Appendix 4.

2.6. Scaling Out Research Outcomes

The process for scaling out ASSIB outcomes through farmer-to-farmer workshops started with the completion of two and half years of implementing Malwah co-inquiry research action plans. We then sought to develop an appropriate scaling out strategy, including the selection of farmer facilitators (FF), comprehension of successful interventions, preparation of training workshops and associated handouts, capacity enhancement of farmer facilitators for engagement with neighbouring farming communities and reinforcing their social contact with other farmers and relevant stakeholders, particularly the service providers of the area to improve service delivery and enhance closer connections with communities. Later, a farmer-to-farmer ‘scaling out workshop’ was conducted at the Malwah bright spot in February 2024 involving the Malwah farming community, other farmers from neighbouring communities, and MUET and SOFT teams.

3. Results

3.1. Trialling Brassica Varieties

The results showed that Khanpur, followed by Mehran New, outperformed Sindh Raya and the local farmer varieties grown by the four farmers under normal to saline soil conditions (Figure 6). The farmers experienced a yield increase of 5.89 to 39.9% with Khanpur variety compared to their varieties.

The soil test results showed that all soils were silty clay loam with alkaline pH (8.1 to 8.4) and EC (1:2.5 soil-water extract) ranging from 1.24 to 2.54 dS/m in surface soils (0-15 cm). The exchangeable sodium ranged from 2.2 to 2.6 mmolc/100g. The soils were low in organic matter (0.58 to 0.89%) and available phosphorus (4-7 mg/kg) and rich in available potassium (270-470 mg/kg).

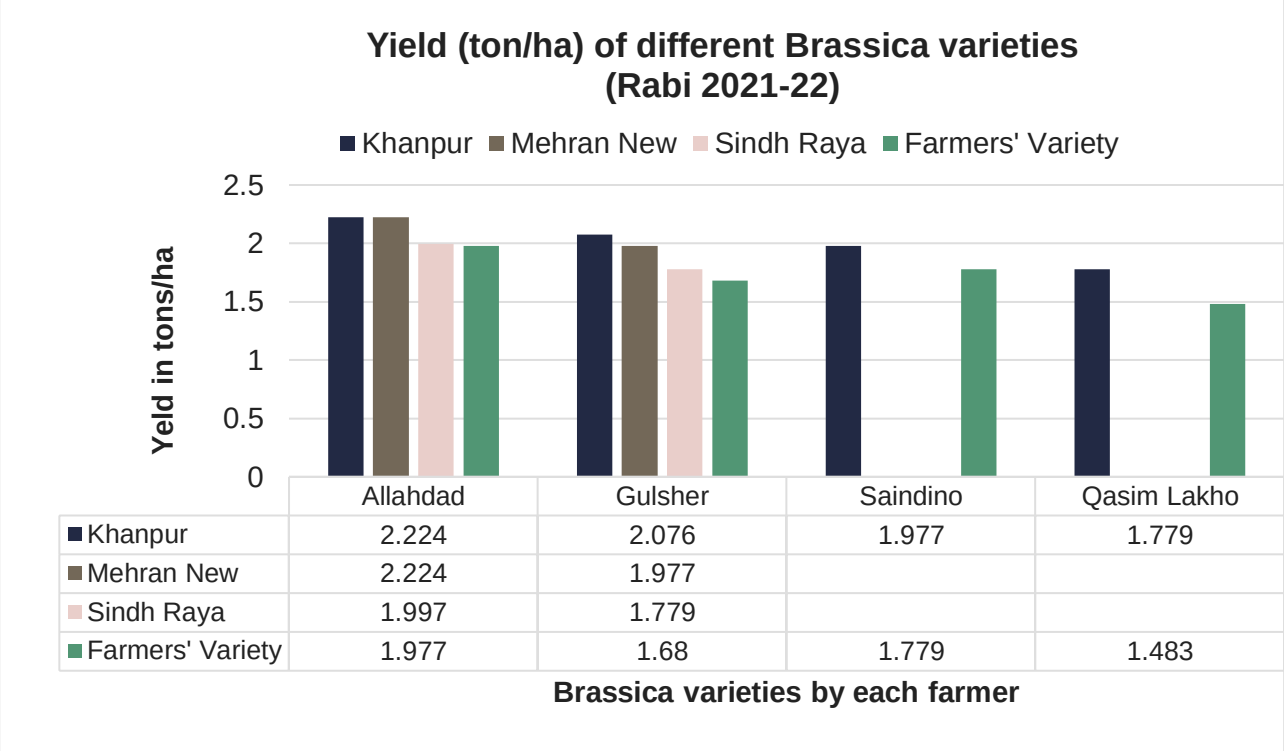

Figure 6. Yields of different brassica varieties (Rabi 2021-22) grown in soils with variable salinity

Prompted by the highest yield of the Khanpur variety, two farmers saved their seeds and planted them in 2022-23. They also shared their seed with other farmers, including one female farmer, Ms Mukhtiar Naz Dharejo, who cultivated brassica varieties. In 2023-24, four farmers replaced their seeds with a fresh supply of Khanpur and compared it with Sindh Raya and their own variety. Brassica germination and early growth were adversely affected due to unexpected and untimely heavy rainfall with a hailstorm. Consequently, two of the four farmers lost their crops. The yield obtained by the remaining two farmers (Figure 7) showed that Khanpur produced the highest yield, followed by Sindh Raya, while the farmer's variety had the lowest yields.

3.2. Wheat Investigations

3.2.1. Trialling wheat varieties

During Rabi 2021-22, six farmers participated in co-inquiry investigations focusing on wheat varietal performance on soils with variable salinity status. The yield data in Figure 8 indicated that TD1 outperformed other varieties while NIA Zarkhez (NIA-Z) performed better under saline soil conditions.

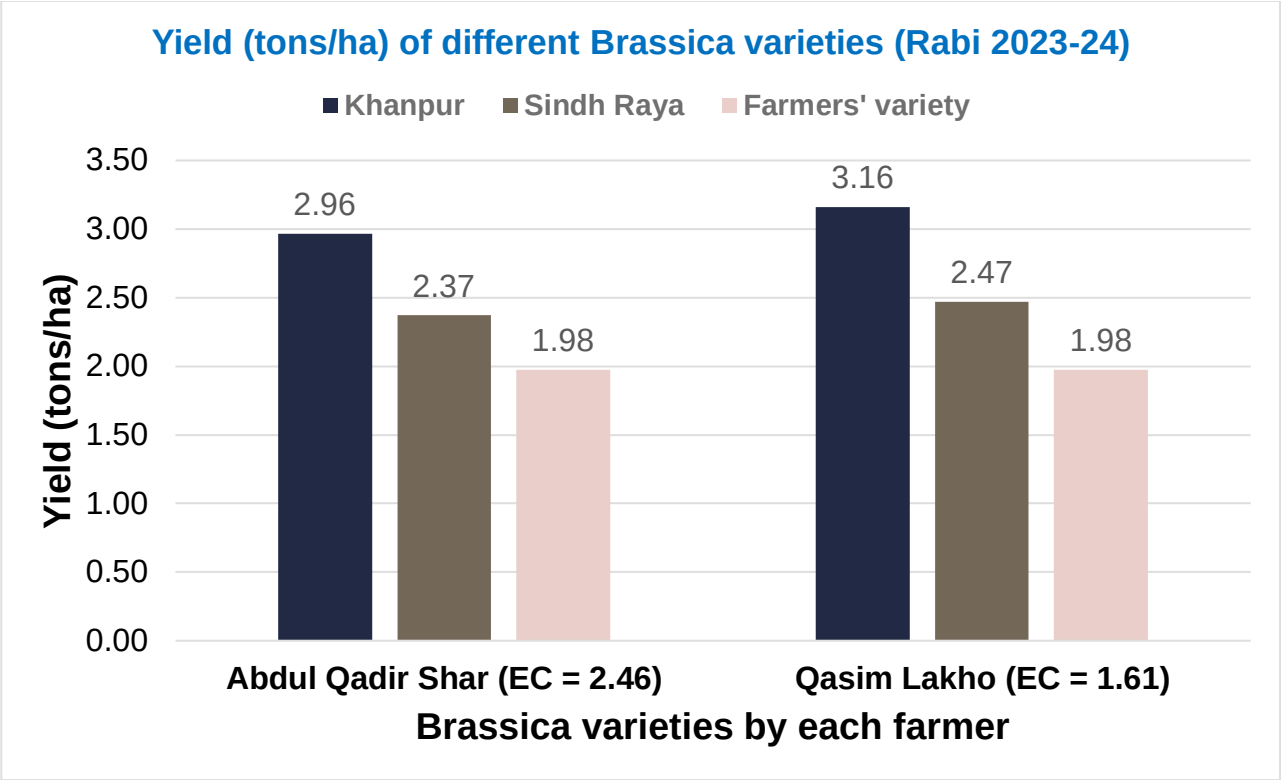

Figure 7. Yield performance of different brassica varieties (Rabi 2023-24) under variable soil salinity

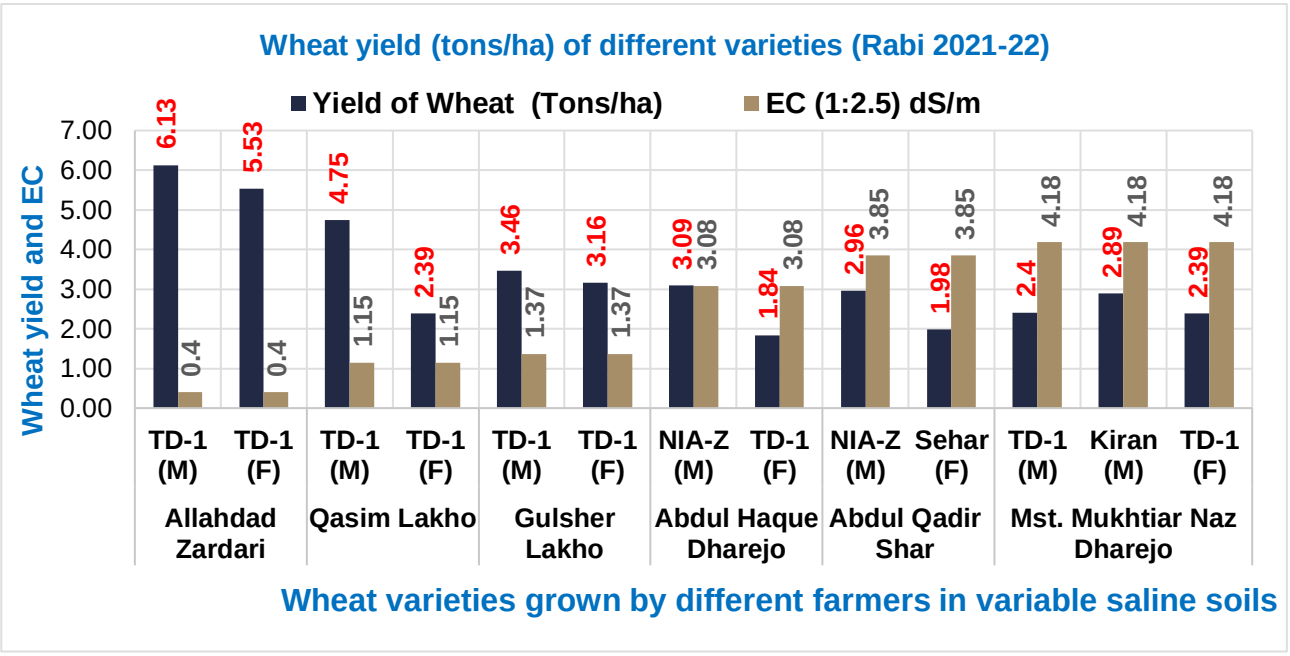

Figure 8. Yield performance of different wheat varieties grown on variable saline soils (Rabi 2021-22)

Given the continuing interest of the farming community in varietal testing and identification of high-yielding varieties suited to their soil conditions, four varieties were tested in Rabi 2023-24. Five farmers participated, and each trialled three wheat varieties of their own choice. It is pertinent to mention that unexpectedly heavy rain with hailstorms occurred at the onset of the Rabi season, which affected seed germination and growth of wheat and young brassica seedlings. The wheat yield data are presented in Figure 9.

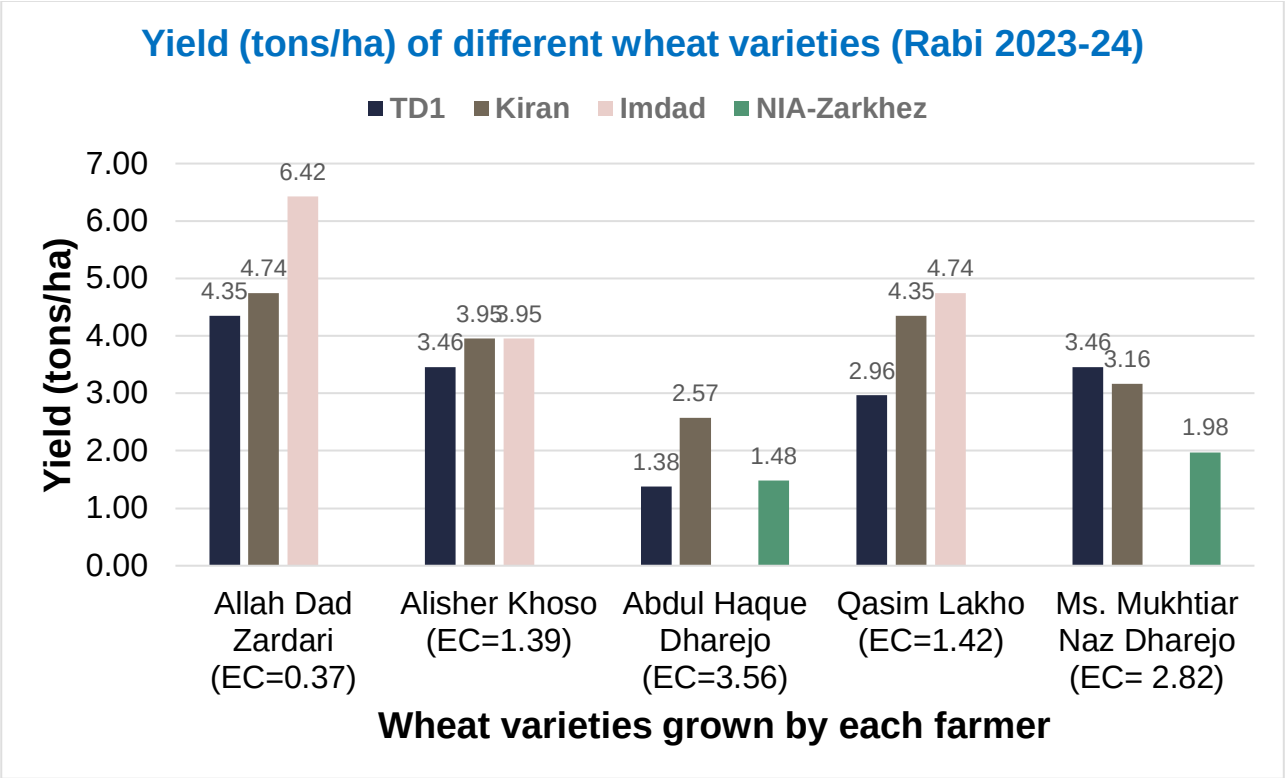

Figure 9. Yield performance of different wheat varieties grown in salt-affected soils (Rabi 2023-24)

Evidently, the new variety, Imdad, which was being tested by the Malwah farmers for the first time, showed the highest yields, followed by Kiran and TD1.

3.2.2. Ridge versus flatbed sowing of wheat

Two farmers planted wheat in Rabi 2021-22 using the ridge method; one used only one variety (TD1), and the other used two varieties (TD1 and Kiran). Irrespective of the farm field and variety used, when planted by the ridge method, wheat yields were higher by 13.1 to 15.2% (TD1) and 17.4% (Kiran) compared with the traditional flatbed method (Figure 10). Besides, growing wheat using the ridge method requires less water. Expressed by each variety, TD1 required 52.2 to 62.6% and Kiran 66.2% of the water used by the flatbed method.

3.2.3. Wheat cultivation using low doses of gypsum

The beneficial result experienced by one farmer in Rabi 2021-22 of applying a low dose of gypsum for a crop wheat received due attention in the discussions where learnigns were shared during the SERL process in 2022 and was included in the co-inquiry activity plan as a new intervention. Three farmers used gypsum in wheat (Rabi 2022-23) at different rates, as detailed below:

(a) Farmer 1 (Abdul Qadir Shar):
No gypsum compared with gypsum at six bags/acre (0.3 tons/acre or 0.741 tons/ha)

(b) Farmer 2 (Abdul Haq Dharejo):
No gypsum compared with gypsum at four bags/acre (0.2 tons/acre or 0.494 tons/ha)

(c) Farmer 3 (Muhammad Yaseen Lakho):
No gypsum compared with gypsum at:
(i) four bags/acre (0.2 tons/acre or 0.494 tons/ha): and
(ii) eight bags/acre (0.4 tons/acre or 0,988 tons/ha)

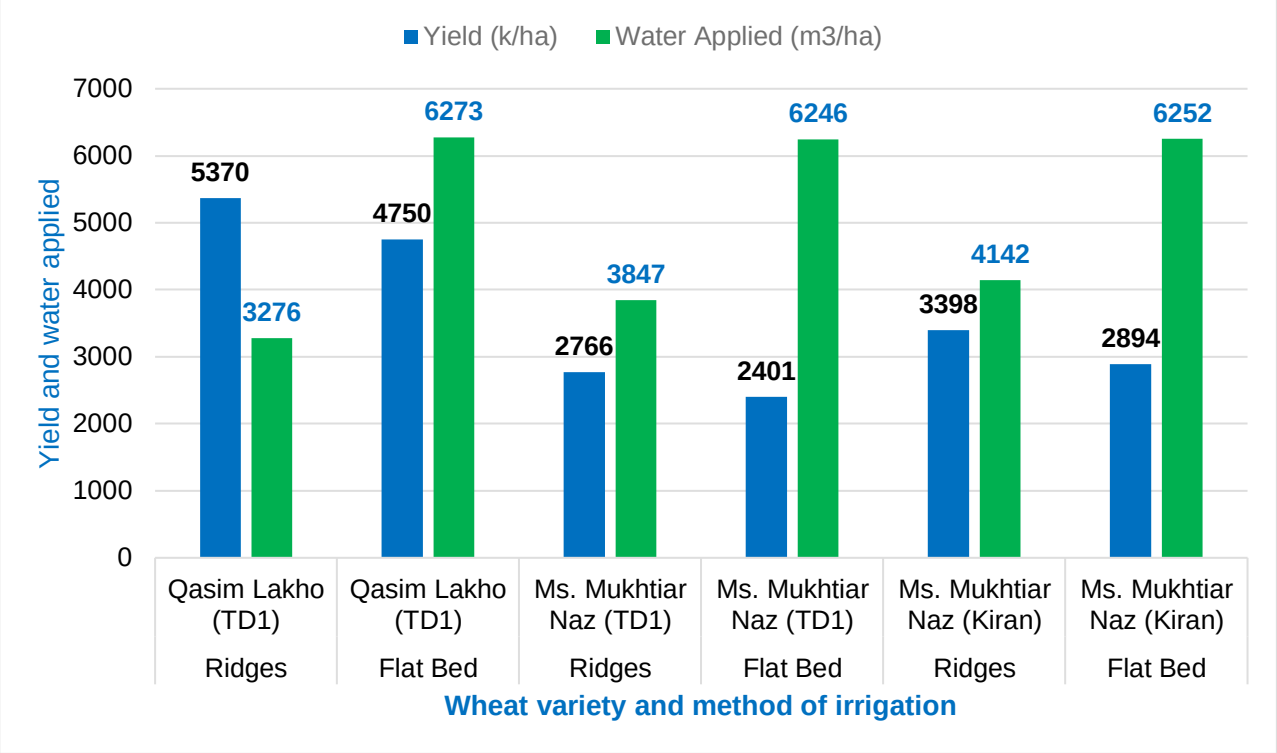

Figure 10. Comparison of yield and water applied under ridge and flatbed planting (Rabi 2021-22)

There was a clear benefit of applying low doses of gypsum, ranging from 0.2 to 0.4 tons/acre (0.494 to 0.988 tons/ha) (Figure 11). Yields increased by 16.7 to 23.1% with gypsum application compared with no gypsum at 0.2 tons/acre (0.494 tons/ha) and 33.3% with 0.4 tons/acre (0.988 tons/ha) (Farmers 2 and 3, respectively). In the case of Farmer 1, the yield increase with 0.3 tons/acre of gypsum was 66.6%, presumably because this field had already received 0.75 tons/acre (1.85 tons/ha) of gypsum in the previous season.

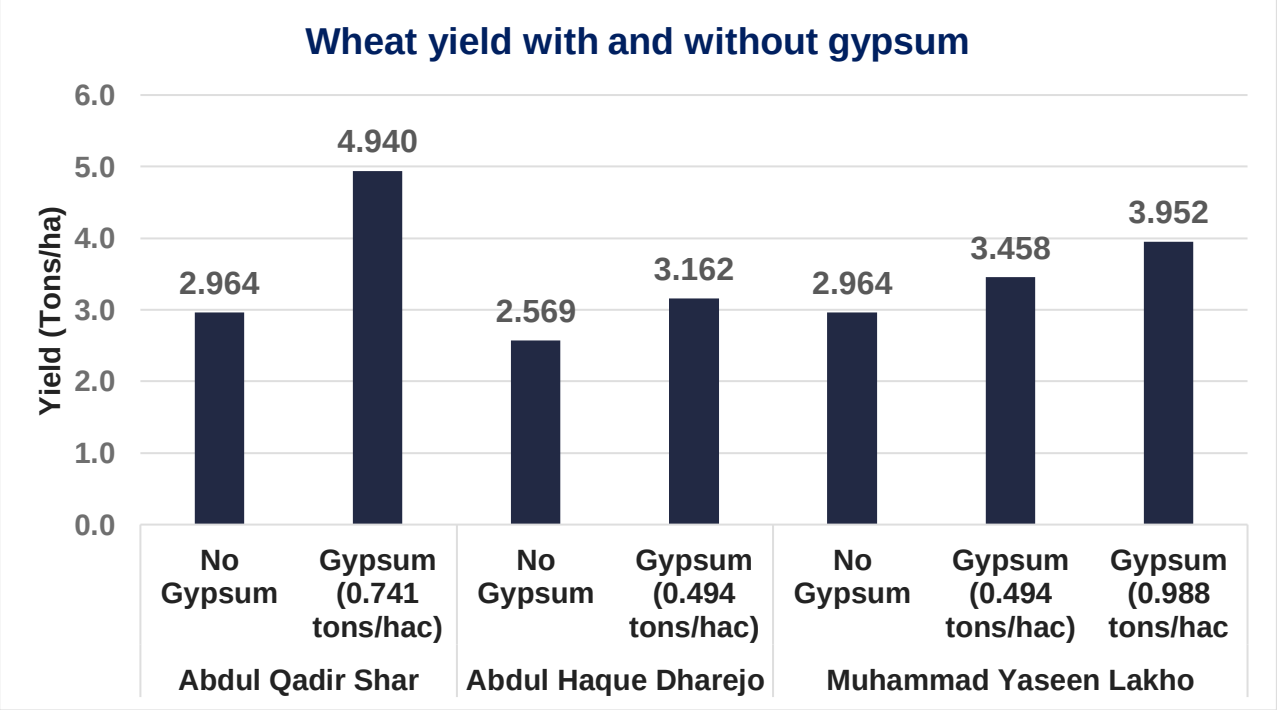

Figure 11. Comparison of wheat yields with and without gypsum application

3.3. Vegetable Cultivation Experiences of Women Farmers

The women farmers initiated co-inquiry investigations involving vegetable cultivation after they participated in the training session introducing the multi-layering method. The method recommended a bed size of approximately four feet in width, so that mulch could be easily applied. Three of the five women growing vegetables used sugarcane as mulch (see Table 2, Methods section). The average yield of vegetables in kilograms per week was computed for these three farmers, comparing mulched with non-mulched plots (Table 3). The data showed a yield increase for seven of the nine vegetables grown due to mulching, with only fenugreek and garlic revealing no demonstrable effect from the use of mulching. The tomato crop had a yield increase of 200%, while all remaining vegetables showed had a yield increase between 11% (carrots) and 92% (peas). Many factors contribute to these variations, notably soil salinity profile, vegetable type and crop management. The overall results clearly demonstrate that mulching is beneficial with better yields, soil moisture preserved and weeds easier to control.

More broadly, the practice of growing multiple vegetables has also delivered on the opportunity for women to ensure continual supply of healthy and fresh organic vegetables throughout the season – a direct outcome of the interest and active involvement of women farmers and their families in kitchen gardening activities. All family members, including youth (both boys and girls), have engaged in kitchen gardening. This includes uptake of seed saving, enabling the practice to continue across seasons indefinitely (see Figure 12).

Table 3. Yield comparison of vegetables grown with and without mulch by women farmers

	Yield (kg/ week)		
Vegetable	**No mulch**	**Mulch**	**Yield increases due to mulch**
Coriander	2	3	50%
Peas	6	11.5	92%
Radish	27.5	32.5	15%
Carrot	22.5	25	11%
Fenugreek	10	10	~
Onion	20	30	50%
Garlic	10	10	~
Tomatoes	5.33	16	200%
Cabbage	11.67	15	28%

3.4. Malwah Community Capacity Building

Capacity building of the farming community was a regular activity at the Malwah bright spot. Several training sessions were conducted by the MUET and SOFT teams for men and women farmers of the Malwah farming community (Figures 13 and 14), with three of the ten training programs specifically conducted for women farmers (Appendix 4). The resource persons/ experts were drawn from different organizations, including two horticulture experts from Sindh Agriculture University Tandojam (Figure 15). and one from Agriculture Extension Sindh. The farmers took a keen interest in these training sessions. In the words of one the resource persons who was interviewed for the project (see Allan et al., 2024):

> *"The women farmers produced and consumed vegetables at home, distributed them among neighbours, and even marketed part of it. Their happiness was expressed through their smiles and confidence."*

Figure 12. Malwah women farmer field investigations involving kitchen gardening and seed storage

Figure 13. Men and boys participating in training sessions

Figure 14. Women and girls participating in kitchen gardening training sessions

Figure 15. 'Story of Change' interview with a resource person who conducted training sessions with women farmers at Malwah

3.5. Malwah Farmers Disseminate ASSIB Learnings through TV Programs

Given the exposure through SERL workshops and training in different aspects of vegetable production, Malwah farmers felt confident to participate in having their experiences recorded for TV programs. Together with SOFT and MUET team members, these farmers (as listed in Table 4) shared their views and experiences regarding the five-colour cultivation of vegetables and fruits, which were later telecast as part of five TV programs in Sindhi language on five TV channels (KTN, Mehran, Sindh, Dharti and Awaz TV) during the evenings of June 2023 (see Figures 16 and 17).

A major focus of these programs was on promoting the five-colour approach for growing multiple vegetables and fruits for improved nutrition in the province of Sindh. The farmers felt confident and shared their experiences in cultivating vegetables in a multi-layer mode in variable saline soils along the Malwah Distributary. Some programs were also recorded and telecast on different radio channels focusing on organic farming and agriculture farming.

Table 4. Malwah co-inquiry team presenting their experiences for TV programs

Program no.	ASSIB researchers and facilitators	Malwah farmers
1	Prof. Dr. Abdul Latif Qureshi (MUET)	Mr. Zulfiqar Ali Dharejo
2	Prof. Dr. Tanveer Fatima Miyano (SAU)	Mr. Qasim Ali Lakho
3	Ms. Benazir Kumbhar (SOFT)	Ms. Pari
4	Mr. Babar Zaman (SOFT)	Mr. Mutahir Shah
5	Mr. Mohsin Channa (SOFT)	Mr. Habib Soomro

Figure 16. Malwah farmers and MUET and SOFT team members participate in local language TV programs promoting the five-colour vegetables approach

Figure 17. Malwah farmers and SOFT and MUET team members in the TV recording room at Hyderabad

4. Discussion

It is increasingly recognised that farmers' participation in decision-making processes is vital for the success of the programs dealing with farming communities associated with salt-affected landscapes (Ali et al., 2018; Ashraf et al., 2022; Ali, 2023). The ASSIB project's approach responds to this need by selecting and engaging farming communities associated with salt-affected landscapes in the co-design of research undertaken in co-inquiry mode with the participation of researchers and other stakeholders. The integral component of this approach is the SERL model (Heaney-Mustafa et al., 2023), which we followed in engaging the Malwah farming community to identify and research the adaptation options suited to their situations.

Three SERL workshops were held during the ASSIB project period (2021-2024) with the active involvement of the Malwah farming community (men, women and youth), researchers and other stakeholders to co-design interventions and participate in co-inquiry investigations. The seasonal interventions were designed to address priority issues identified through co-inquiry discussions. The process generated farmer interest and participation, especially because the farmers were given the responsibility to help identify the interventions and even the training needs for their capacity building. The sphere of activities went beyond the usual course of research investigations. The findings were jointly evaluated before initiating the next round of co-inquiry activities. Through all these activities, women farmers and youth were also engaged, contributing to enhanced livelihood sources and food security.

Given the above background, the results presented in this report are discussed below for each investigative component:

Brassica: Experimentation with four brassica varieties helped the Malwah farmers identify a promising variety, Khanpur, during the first cropping season, 2021-22. Further experimentation with different varieties screened a recently registered Sindh Raya as the highest-yielding variety. This experience has opened many avenues for the farmers to look for even better-performing varieties from public and private seed suppliers in Sindh and even from Punjab.

Wheat: Initially, seed quality was identified as the main issue because most farmers used the same TD1 variety. Using pure seed and trialling four wheat varieties, including TD1, they obtained the highest yields with TD1, additionally identifying another variety, NIA Zarkhez, which performed better under slightly saline soil conditions. The urge to identify even better-yielding varieties continued. In 2023-24, they included a new variety, Imdad, among the four varieties being tested. During this latest round, Imadad gave the highest yields. For moderately saline soils, NIA-Zarkhez performed better than other varieties, but yields are low, and farmers keep looking for even better varieties for saline soils.

Ridge sowing: Irrespective of the variety and farm field, yields from ridge-planted wheat outperformed flatbed wheat by 13 to 17%, with water-saving of 38 to 48 %. Due to their involvement in decision-making and trialling, the farmers became convinced that this is a preferred method for wheat cultivation, producing better yields for them and saving their water. This intervention has the potential to bring more land into cultivation and simultaneously avoid salt accumulation on the soil surface. On the other hand, the farmers faced some constraints as well: a proper ridger and a tractor were required to match irrigation water availability on the day of planting.

Gypsum: It is the first time that any Malwah farmer has used gypsum on their lands. It was during the first SERL workshop consultations that one farmer picked up on the idea and planted brassica and wheat with and without gypsum at 0.75 tons/acre. The farmer shared the beneficial effect of gypsum application with other farmers during the second SERL workshop, which adopted this intervention for trialling in Rabi 2022-23. The results were highly encouraging, which prompted one farmer to buy 100 bags of gypsum, which he applied to 13 acres of brassica/wheat.

Cultivation of Vegetables: Starting from day one, women farmers were equally a part of the ASSIB activities, with particular reference to kitchen gardening for vegetable cultivation and training for their capacity building. Along the way, they overcame the problems faced during the first cropping season and grasped the technique for successful five-colour vegetable cultivation in multi-layer mode with the added benefit of mulch application which improved yields and preserved precious soil moisture. They also started seed multiplication and storage for the next season.

5. Conclusions and Ways Forward

Following through the SERL process embedded as a part of the ASSIB Project approach, the Malwah farming community is better equipped to design and investigate future adaptation options to live with the salinity. The following points can be concluded based on their active participation in SERL and all the associated activities:

- A noticeable sense of ownership among the Malwah farming community, men and women, in that what they have already trialled, experienced and equipped themselves with.
- A continuing urge to exporing new ways and means to identify high-yielding crop varieties suited to their salt-affected landscape.
- Linkages established with service providers, fertiliser companies (Engro, FFC), public and private seed suppliers, soil testing and analysis facilities, local representatives of agriculture extension, research, and water management, and soil salinity experts.
- Capacity and confidence building of farmers apparent from how they organised and conducted a farmer-to-farmer workshop to share ASSIB learnings to the neighboring farming communities, including identifying and inviting farmers themselves and facilitating the entire activity with confidence.
- The farmers are now aware of the benefits of soil testing, actively seeking it and and associated interpretation of the data results – this includes the women farmers who are insisting on having their soils analysed.
- Kitchen gardening has provided organic vegetable throughout the season for participating farm families, and the number of women farmers opting to grow vegetables in increasing. Vegetables grown with mulched application were observed to offer much better produce and yields in most cases, besides many other associated benefits. The participating farmers were delighted with the outcomes, with constant access to fresh and healthy vegtables, pleasure of sharing their produce with neighbours and friends, and even selling the excess in the market for an added source of income.
- Fruit tree plantation, procurement of nursery and vegetable seeds from nearby markets is another added dimension to Malwah farming portfolio.
- The farming community is socially better connected and placed to appreciate the benefits of social networking.
- The individual and collective impact from the ASSIB project has been documented through interviews that capture multiple stories of change (see Allan et al. 2024).

A continuity of the ASSIB approach should receive due attention for sustaining the benefits beyond the bright spots. The farmer facilitators are enthusiastic to disseminate the ASSIB learnings to other farming communities. All future projects for adoption by the agriculture and irrigation departments should provide in-built mechanism for institutionalisation of this approach.

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Appendix 1. List of Malwah Bright Spot Stakeholder Forum Members

NB. Membership details have changed over time. We have done our best to reflect details of all those who have had a role on the Stakeholder Forum at some time during its three-year existence.

Name	Position	Qualifications/ Field of Expertise
Malwah male farmer representatives		
Zulfiqar Dharejo	Local progressive farmer; President, Benazirabad District Chamber of Agriculture	Leadership role in Groundwater Project SHF for Malwah
Abdul Razaque Arain	Local progressive farmer	
Malwah female farmer representative		
Mukhtiar Naz Dharejo	Local progressive farmer	Leadership role in Groundwater Project SHF for Malwah
Representatives from key stakeholder organisations		
Imran Dhamach	In charge, Soil and Water Testing Lab, Sakrand, District Benazirabad	Soil Scientist; Soil Fertility Management; General Agriculture
Nabi Bux Jamro	Director, Biosaline Agriculture Research and Development, Agriculture Research Sindh, Tandojam	Soil Scientist; Soil Salinity Management; General Agriculture
Nazar Gul Pathan	Deputy Director, Drainage and Reclamation Institute of Pakistan, Tandojam	M.E. Agricultural Engineering; Drainage Expert
Muhammad Ramzan Channa	Additional Director, Agri. Extension, district Benazirabad	Agronomist; Agri. Extension Specialist; was involved in the Groundwater Project SHF for Malwah
Badarul Hassan	Deputy Director OFWM, SIAPEP	B.E. (Agri.); Watercourse Specialist
Inayat Mirani	Deputy Director Livestock, Benazirabad	Doctor of Veterinary Medicine; Livestock Specialist
Tehmina Mangan	Chairperson, Department of Agri. Economics, Sindh Agriculture University, Tandojam Now: Vice Chancellor of the Begum Nusrat Bhutto Women University, Sukkur	Agricultural Economist; Environmental Economist; Rural Development; leadership role in Groundwater Project activities with Malwah
Mustafa Nagraj	Assistant Publicity Officer, Agri. Extension, Hyderabad Now: Director of Integrated Pest Management in Upper Sindh, Sukkur	Agronomist; ICT Agriculture Extension Services; Agriculture for Nutrition; leadership role in Groundwater Project activities with Malwah

Name	Position	Qualifications/ Field of Expertise
Community engagement team members from SOFT		
Yousif Channa	Project Coordination Officer SOFT	Agronomist; Extension Specialist
Babar Zaman	Community Engagement Officer SOFT	MSc in Entomology
Benazir Kumbhar	Community Engagement Officer SOFT	MSc in Agronomy
Mohsin Channa	Community Engagement Officer SOFT	MSc in Entomology
Tahira Sher Baloch	Community Engagement Officer SOFT	MA in Sociology
Hina Memon	Community Engagement Officer SOFT	MSc in Agriculture Extension
Fozia Memon	Community Engagement Officer SOFT	MSc (Agri.) Hons. In Soil Science
Umair Nahiyoon	Community Engagement Officer SOFT	MSc in Agriculture Economics
MUET representatives		
Abdul Latif Qureshi	Professor; ASSIB Team Member	Hydrologist; groundwater specialist; leadership role in Groundwater Project activities with Malwah
Kamran Ansari	Professor; ASSIB Team Member	Water Resources Management
Kazi Suleman Memon	Soil Scientist; ASSIB Team Member	Soil Scientist
Waqas Ahmed	Assistant Professor; ASSIB Team Member	Groundwater management; was involved in the Groundwater Project SHF for Malwah
Asmat Ullah	Assistant Professor; ASSIB Team Member	Natural Resources Management

Appendix 2. Table Showing Agenda of SERL Workshops

Asset-Based Community Development (ABCD) Introduction of farmers and stakeholders
Detailing other assets and capacities within the people and the location
Identification of problems
Prioritisation of problem (by voting) Sharing of ideas Brainstorming ideas for solutions to the selected problems – identify two ideas
SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis of the identified two ideas
Prioritization of the most promising idea (by voting) and developing a title for the research co-inquiry
Development of SMART (Specific, Measurable, Achievable, Realistic, Time-based) Action Plan ▪ What – is going to be done? ▪ When – is it going to be done? ▪ Where – is it going to be done? ▪ Who – is responsible for seeing it gets done?
Feedback Plan (to be determined by farmers, stakeholders, and facilitators) ▪ How – will we know if it worked/did not work? ▪ What – information will we need to know if it worked or not? ▪ When – will we monitor the plan? ▪ Who – will be responsible?

For more details and explanation – see Heaney-Mustafa et al. (2023).

Appendix 3. ASSIB Malwah Co-Inquiry Action Plan Research Questions

RQ1: What management options are available for the salt-affected landscape?

a) What are the types of soil salinity (saline or sodic soil), and what is the severity of the problem?

b) What factors contribute to the salinity problem and/or aggravation, and how can salinity intensification be avoided?

c) What are the available options to reduce/ manage soil salinity? e.g.

   i. Increase drainage for better flushing of salts from the crop root zone.

   ii. Plant salt-tolerant crops to manage economic risks and ensure land cover.

   iii. Restore salt balance via chemical amendments like gypsum.

d) Compared to traditional practices, what are the best land-forming options for growing crops on salt-affected landscapes (ridges, raised beds, the role of laser levelling, etc.)?

e) How can we maximize the agronomic, water-saving, and economic benefits of different crops/crop varieties in salt-affected soils?

f) What are the best mulching practices to enable the growing of salt-sensitive crops necessary for improved nutrition and/or source of income?

g) Given canal water shortage and sub-optimal groundwater quality, can conjunctive water use be safely adopted for agronomic and economic benefits?

RQ2: What crop species and varieties are suited to salt-affected landscapes, and what is the impact of soil salinity on crop yields and economic benefits?

a) In agronomic and socio-economic terms, which crops and crop varieties are suited to the level and type of salinity under a given water availability regime?

b) What is the relationship between soil salinity and total biomass and grain yield of crops?

Appendix 4. Training Sessions Conducted with the Malwah Farming Community

Training	Date	Objective	No. of Participants	Resource Persons	Facilitators	Output
1. Soil sampling and water testing	6 October 2021	Enhance farmer knowledge about soil and water sampling and aware about analyses process	10	Mr. Imran Dhamach Soil and Water Testing lab Sakrand	Dr. A. Latif Qureshi, Dr. Kazi Suleman Memon, Umair Nahiyoon, Fozia Memon	Farmers can conduct soil and water sampling and send for analysis
2. Kitchen gardening (for women farmers)	27 October 2021	Build women farmer capacity and promote kitchen gardening	12 women farmers	Dr. Noorunisa Memon Horticulturist SAU Tandojam	Dr. A. Latif Qureshi, Umair Nahiyoon, Fozia Memon	Women farmers start growing vegetables in their gardens
3. Management of salt-affected soil	4 December 2021	Enhance farmer knowledge about management of salt effected soil for better yield	20	Dr. Nizam uddin Depar Soil Scientist NIA Tando Jam	Dr. A. Latif Qureshi, Dr.Kazi Suleman Memon, Umair Nahiyoon, Fozia Memon	Farmers managing salt sffected soil with recommended methods
4. Seed production	26 January 2022	Enhance farmer knowledge about seed production and storage for the next planting season	18	Manzoor Khuhro	Dr. A. Latif Qureshi, Umair Nahiyoon, Fozia Memon	Farmers can store vegetable seeds for next season
5. Fertiliser use and management	31 March 2022	Build farmer capacity to increase crop production through more effective use of fertilisers	19 men farmers	Mr. Umair Islam (FFC) Dr. Kazi Suleman (MUET)	Dr. A. Latif Qureshi, Babar Zaman, Mohsin Channa, Hina Memon, Benazir Kumbhar	Farmers can use fertilisers and manage their lands properly

Training	Date	Objective	No. of Participants	Resource Persons	Facilitators	Output
6. Multi-layer cropping for kitchen gardening in saline soil (for women farmers)	15 October 2022	Introduce and build capacity for multiple vegetable kitchen gardening	14 women farmers	Mr. Ghulam Mustafa Nangraj (Agriculture Extension Sindh) Dr. Tanveer Fatima Miano (SAU Tandojam)	Dr. A. Latif Qureshi Babar Zaman, Mohsin Channa, Hina Memon and Benazir Kumbhar	Farmers grow multiple vegetables in their kitchen gardens
7. Vegetable seed production and storage (for women farmers)	15 February 2023	Enhance women farmer knowledge of vegetable seed production and storage for next season	17 women farmers	Dr. Tanveer Fatima Miano	Dr. A. Latif Qureshi Babar Zaman, Mohsin Channa, Hina Memon and Benazir Kumbhar	Women farmers can store vegetable seeds for next season
8. Sun satellite model training provided by PCRWR	12-13 July 2023	Introduce new farming technologies	15 men farmers	Mr. Hafiz Abdul Salam Eng. Nazar Gul PCRWR-DRIP Tandojam	Dr. A. Latif Qureshi Dr. Kazi Suleman Memon Muhammad Yousif Channa, Babar Zaman, Mohsin Channa, Hina Memon, Benazir Kumbhar	Malwah farmers interacted with progressive farmers and visited PCRWR's DRIP Centre at Tandojam to learn more about soil and water testing methods and its importance
9. Fruit plantation	8 April 2023	Guide farmers in tree plantation layout and land preparation	8 men farmers	Dr. Tanveer Fatima Miano (SAU Tandojam)	Dr. A. Latif Qureshi Mr. Muhammad Yousif Channa Babar Zaman, Mohsin Channa, Benazir Kumbhar	Farmers integrated fruit trees into their kitchen gardens
10. Fertiliser use and management by Fuji Fertilizer Company	12 December 2023	Build farmer capacity to increase crop production by more balanced use of fertilisers	28 men farmers	Mr. Ali Raza, Zonal Manager, Fauji Fertilizer Company (FFC)	Dr. A. Latif Qureshi Babar Zaman, Benazir Kumbhar	Farmers can use fertilisers and manage their lands properly

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