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Sun-Satellite Model - A Farmer-to-Farmer Learning Approach for Empowering Bright Spot Communities

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Pakistan Council of Research in Water Resources (PCRWR)

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Table of Contents

List of Figures

List of Annexures

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Executive Summary

The Indus Basin faces significant challenges in soil salinity due to its topography, aridity, and irrigation system. The soil salinity issue affects crop productivity and socio-economic conditions, particularly in the Lower Indus Basin, where nearly half of the land is affected by salinity. Traditional large scale engineering approaches have proven ineffective, necessitating a shift towards sustainable management strategies. An effective approach to enhance the expertise and know-how of farming households is to provide them with direct exposure to other farmers who have successfully adjusted to living in areas affected by salinity and waterlogging.

The Pakistan Council of Research in Water Resources (PCRWR) proposed the Sun-Satellite Model to facilitate knowledge exchange among farmers using a farmer-to-farmer learning approach. The learning framework, the Sun-Satellite Model, embodies a dynamic and collaborative method for exchanging knowledge and enhancing capacity within agricultural communities. This approach was applied to the communities involved in Adapting to Salinity in the Southern Indus Basin (ASSIB) project.

Nawazabad Farm exemplifies successful salinity management as a ‘sun’ site promoted by PCRWR, where ‘sun’ farmers have been implementing the best salinity management practices for over three decades. ‘Satellite’ farmers from bright spot sites of Malwah, Tippun Dublo, and Jalalpur were exposed to the best salinity management practices at this farm. Farmers from the bright spot communities were provided with insights and skills regarding salinity management practices to enhance their ability to tackle salinity-related challenges. This model fostered reciprocal learning, strengthened social bonds, and empowered bright spot communities through collective decision-making, paving the way for best salinity management practices.

1. Background

Soil salinity is inherent in the Indus Basin due to its flat topography, aridity, and natural river course diversion that expands due to the irrigation system (Tarar, 2002). It further increases with depth (Iqbal et al., 2020). A recent analysis of the salt balance by PCRWR reported that the Indus River and its tributaries bring about 31.56 million tonnes (Mt) of salt annually to the basin. Out of the total salts, about 19.95 Mt are deposited in the canal commands at the rate of 1.25 tonnes per hectare. About 8.81 Mt of salts are drained below the Kotri Barrage. The remaining 2.80 Mt of salts are retained in wetlands or join the underlying aquifer through seepage (Saiqa et al., 2022).

As irrigation is widespread in the Indus Basin, soil salinity is prevalent, which affects crop productivity. In addition to saline soils, waterlogged soils also occur in the Southern Indus Basin due to a lack of drainage systems, posing a significant impediment to optimal use of agricultural production systems. Salt-affected soils adversely affect the socio-economic conditions of the people living in these areas. Currently, about 4.5 Mha are affected by various levels of salinity (WAPDA, 2007). The salinity concentration is high in the Lower Indus, where nearly half of the land is affected by soil salinity. Without adequate water management and agricultural practices, salt-affected soils may adversely affect crop productivity, restricting the agricultural livelihood of farming families and communities.

Salinity is not static but instead dynamic and varies over space and time. It is a long-term complex issue that cannot be removed from the system entirely. However, it may be managed. Various engineering approaches, such as vertical and horizontal drainage systems, have been adopted to address salinity issues. However, these approaches have not proved effective or sustainable (Ashraf et al, 2022; Ali, 2023). Therefore, living with different salinity levels must be managed through various physical, biological, and chemical approaches.

In Pakistan and around the world, several techniques and practices have been developed to address salinity issues. However, these have not been adopted by farmers and the communities on a broader scale due to (i) the salinity management techniques and practices were developed at research stations, with little or no efforts made to transfer this knowledge to farmers, (ii) communication gaps between professionals and farmers, (iii) farmer training is lacking in all policies, strategies and projects (iv) lack of farmer participation in decision-making processes (Ashraf et al., 2022).

A useful strategy for improving farming families' skills and knowledge involves other farmers sharing their first-hand experience and demonstrations of how they have adapted to living with salinity and waterlogged soils. Farmers can more easily learn from each other as they share knowledge and skills in their cultural norms to solve the

issues. In recent years, a number of farmer-focused approaches have been developed in contrast to traditional ‘top down’ driven by extension, researchers and professional experts. For example, ‘lead’ farmer concept has been adopted as part of a pilot farmer-to-farmer extension study in Kerala, India through the Lead Farmer Centered Extension Advisory and Delivery Services (LEAD) (2010-11) (Paul et al., 2019; Sreekanth & Bindu, 2023). The study found that ‘lead’ farmers possess many innovations and skills, and with satellite farmers given the opportunity to revolve around the lead farmers and adopt the technologies ‘lead’ farmers recommended. The approach created cooperation among farmers and was deemed a cost-effective and potentially sustainable service delivery mechanism for rural farmers (Paul et al., 2018).

Pakistan Council of Research in Water Resources (PCRWR) introduced a similar concept known as the ‘Sun-Satellite Model,’ used to facilitate and promote knowledge exchange among the farmers. Under the project "Adapting to Salinity in the Southern Indus Basin (ASSIB)", funded by the Australian Government through the Australian Centre for International Agricultural Research (ACIAR), a platform was provided to document and explore the experience of applying the Sun-Satellite Model for farmer-to-farmer learning. The ASSIB project team had adopted a similar metaphor for its farmer-to-farmer learning approach through the identification of 'bright spot' communities in salinity-affected areas. These ‘bright spot’ communities were identified according to criteria that included the potential for adaptive capacity. Three of these communities were selected for involvement in the Sun-Satellite Model examination because they demonstrated their capacities to adapt to living productively and sustainably with salinity and their knowledge had been enhanced through their own practice changes.

2. Objective

The main objective of this report is to examine the Sun-Satellite Model in relation to farmer-to-farmer learning under the ASSIB project.

3. Sun-Satellite Model

The Sun-Satellite Model represents a dynamic and collaborative approach to knowledge exchange and capacity building within agricultural communities. In this Model, the ‘sun’ farmer embodies a wealth of experience, expertise and traditional knowledge in farming practices often as a mentor or guide to the ‘satellite’ farmer. Importantly, the Sun-Satellite Model emphasises a reciprocal exchange of knowledge with the intention that both ‘sun’ and ‘satellite’ farmers actively learn from each other. After seeking guidance and insights from the 'sun' farmer, the 'satellite' farmer may have fresh perspectives, innovative ideas, and alternative approaches from which the 'sun' farmer can also learn. This bi-directional flow of information fosters a dynamic learning environment where sun and satellite farmers benefit from each other's experiences and perspectives.

The Sun-Satellite Model represents a powerful paradigm for farmer-to-farmer learning, offering flexibility for clusters of farmers to glean wisdom and experiences from progressive farmers through its bright spot sites.

As detailed in Figure 1, researchers, farmers, agricultural service providers (ASPs), the private sector, and extension services all play crucial roles in comprehensively understanding agricultural issues. To address these challenges effectively, a technical support platform like the Sun-Satellite Model is essential for bright spot communities, offering them socially acceptable solutions. This collaborative approach fosters knowledge exchange and innovation by linking bright spots with ongoing research and experiences of progressive farmers. This interconnected network enhances understanding and facilitates the implementation of sustainable practices, ensuring the success of agricultural communities.

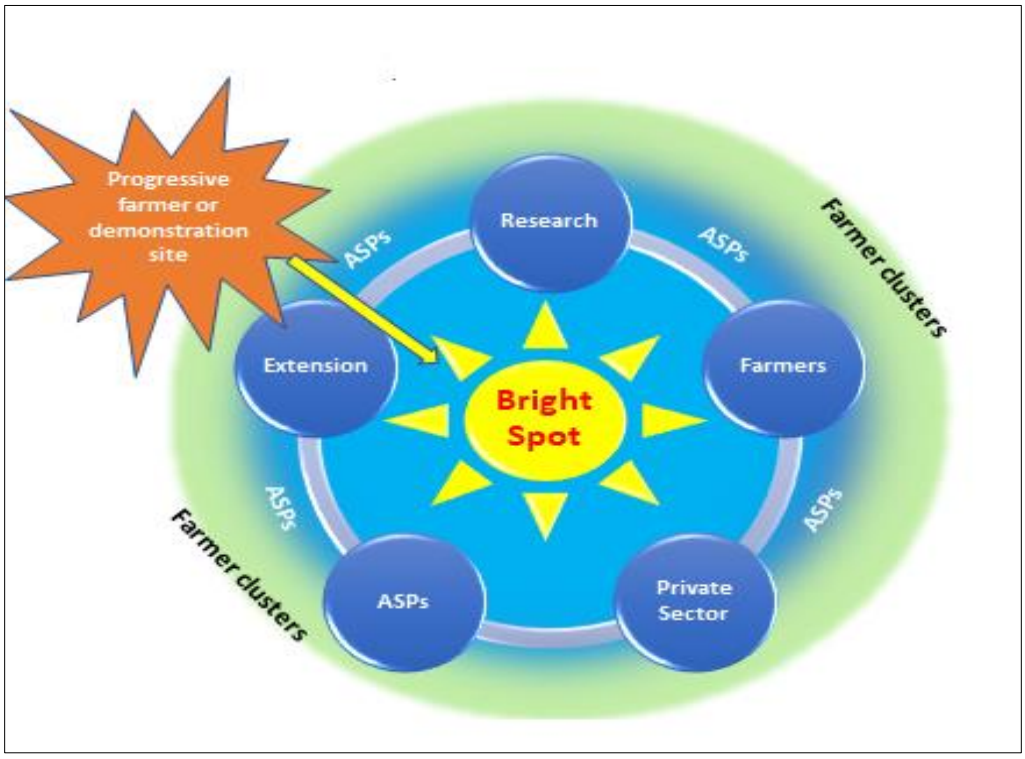

Figure 1: A Sun-Satellite Approach for Farmer-to-Farmer Learning

This Sun-Satellite Model has immense potential to bring positive change and transformation in agricultural landscapes worldwide. Furthermore, the Sun-Satellite Model promotes community cohesion, harmony, and self-reliance by harnessing local knowledge and resources. By empowering farmers to learn from each other, the model enhances agricultural productivity and resilience and strengthens social networks and collective decision-making processes within rural communities. Details of the ‘sun’ site led by the sun farmer and the satellite farmers are provided next.

3.1 Sun Site - Nawazabad Farm

Nawazabad Farm is a privately managed farm located in District Tando Allahyar, Sindh province, comprising approximately 810 ha (Figure 2). Around 100 ha of this area were affected by waterlogging and salinity. The farm owner approached PCRWR in 1989 to resolve the issue where the depth of the water table was about 0.15 m from the soil surface.

Figure 2: Nawazabad Farm (Sun Site)

Figure 3: Tile Drainage System installed at Nawazabad

PCRWR installed tile drainage on a waterlogged area (40 ha) to lower the water table (Figure 3). The tile drainage system successfully kept the water table to a depth of 1.5 m and provided the opportunity for saline agriculture on the reclaimed land. PCRWR now refers to Nawazabad Farm as a 'sun' site, where best salinity management practices are being carried out under the supervision of the farm manager and his team, who are thus identified as 'sun' farmers.

Different salt tolerant crops and orchards (Figure 4) are cultivated at the farm with jujube (*ziziphus mauritiana)*, lemon (c*itrus limon)*, eucalyptus *(eucalyptus globulus*), sapodilla (*manilkara* z*apota)* babul (*acacia)*, Jantar (*sesbania*), rice (*oryza sativa*), wheat (*triticum*), flax (*linum usitatissimum*) and mustard (*brassica*).

Figure 4: Salinity Management at Nawazabad

The Nawazabad sun site has continued to serve as a field research and demonstration site used by PCRWR, which has conducted a series of research experiments to understand the best salinity management strategies. The research studies have broadly covered physical, biological and chemical reclamation techniques.

3.2 Satellite Farmers

The ASSIB project team, in consultation with PCRWR, proposed three groups, each comprising ten satellite farmers from three bright spot sites: (i) Malwah distributary, Shaheed Benazirabad, (ii) Tippun Dublo, Keti Bandar, Thatta, and (iii) Jalalpur Peerwala, Multan. The satellite farmers of the above sites have been actively engaged with the ASSIB project team for the past two and a half years. Therefore, they were more experienced and had the potential to learn and adapt to salinity according to their local conditions. PCRWR provided a platform for farmer-to-farmer learning through the Sun-Satellite Model to these farmers. The involvement of women farmers as part of the delegations did not occur due to constraints of cultural norms inhibiting women from travelling outside their communities if not accompanied by their husband or father.

4. Use of the Sun-Satellite Model for Knowledge Transfer

Before experiencing the Sun-Satellite Model as an approach to farmer-to-farmer learning for bright spot communities, PCRWR started the coordination process (Figure 5) with the stakeholders of the ASSIB project: (i) Mehran University of Engineering and Technology (MUET), (ii) Muhammad Nawaz Shareef University of Agriculture, Multan (MNSUAM), (iii) Society of Facilitators and Trainers (SOFT), (iv) International Union for Conservation of Nature (IUCN), and (v) representatives of the three bright spot communities involved.

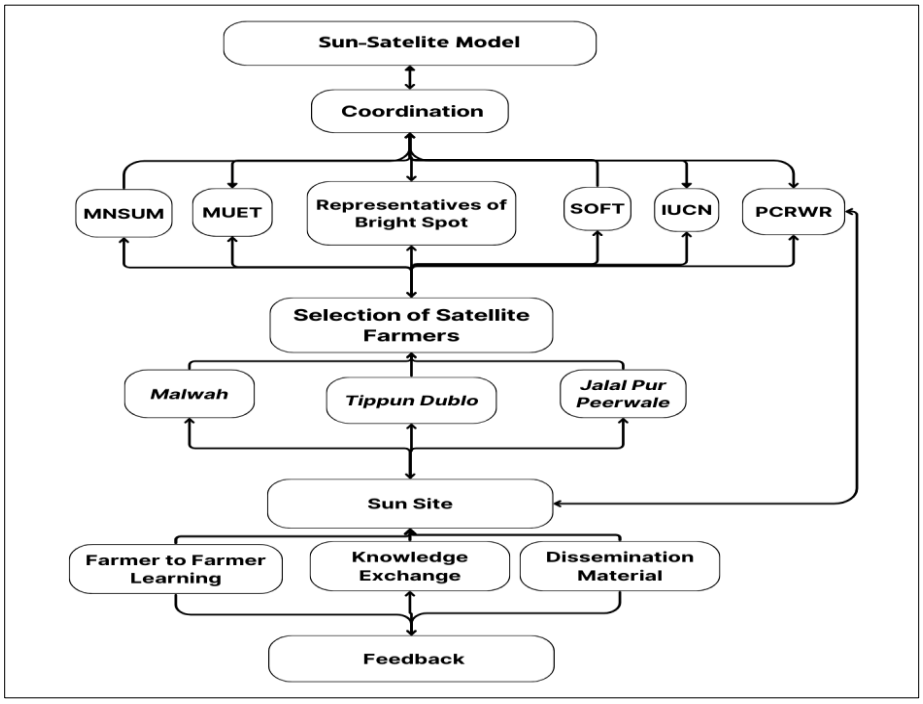

Figure 5: Sun-Satellite Model in Action

In this context, several meetings with follow-up discussions were arranged at the US-Pakistan Center for Advanced Studies in Water (USPCAS-W) and the Drainage and Reclamation Institute of Pakistan (DRIP). As a result, a group of 10 satellite farmers from each bright spot site visited the sun site. The ‘satellite’ farmers observed the best salinity management practices at Nawazabad Farm (‘sun’ site) and interacted with the ‘sun’ farmers. The ‘sun’ site farmers and PCRWR team shared their experiences and practices related to salinity and waterlogging management with the ‘satellite’ farmers. Dissemination materials (brochures) were developed in both Urdu and English languages regarding salinity management, saline agriculture, and aquaculture and are available on the PCRWR website as part of the activity. The brochures (attached as Annexures III to V) were made available to the ASSIB project team and distributed among stakeholders for broader dissemination. Feedback sessions were arranged at Malwah, Tippun Dublo, and the DRIP office (for the delegation from Jalalpur) to monitor and evaluate the impact of the Sun-Satellite Model approach.

5. Farmer-to-farmer Learning

The Sun-Satellite Model effectively brainstorms and builds farmers' confidence in selecting and adapting strategies to live with salinity. It involves farmer-to-farmer learning as a two-way learning process where sun and satellite farmers share their experiences. The satellite farmers of the Malwah bright spot site (Figure 6) visited the sun site (Nawazabad Farm) and observed several agricultural crops and fruit plants grown on saline and waterlogged soils. The satellite farmers showed interest and asked questions from sun farmers regarding sowing practices, fertiliser application, irrigation systems, harvesting and marketing procedures.

The satellite farmers observed the plantation of sapodilla and jujube on a new pattern where one row was dedicated to sapodilla and the other to jujube with a plant-to-plant distance of 6 m. They were told by the sun farmer that initially, the plantation of jujube and sapodilla was carried out on saline soil on a trial basis. Amazing results were found; the orchards fully matured and generated substantial net income.

Responses by the satellite farmers were documented by the ASSIB project’s communication engagement team, and two of these documents are attached as Annexures I and II. With regards the planting of sapodilla and jujube together, the satellite farmers appreciated the efforts, noting that planting these two crops together would benefit farmers. One satellite farmer said, "I have been working with landlords for 40 years and have never before seen the practice of planting two different orchards together. Therefore, my knowledge has significantly increased" (Annexure - I).

Figure 6: Farmer-to-Farmer Learning (Malwah Bright Spot)

The satellite farmers appreciated the high-density rice (*oryza sativa*) and jantar (*sesbania*) crops (Figure 7). They also observed a high plant population, which was lower in their area. They added that their farming community used fewer nurseries during rice transplantation, resulting in lower yields. The sun farmer mentioned that they prefer to sow the IRI-6 variety of rice in their waterlogged and saline lands because it was more successful in such conditions. Furthermore, he mentioned that they cultivated sesbania and harvested it once or twice. Afterwards, they mulched the remaining sesbania into the same soil through a rotavator, which provided green manure to the soil and improved the fertility of saline soil.

Figure 7: High-density Oryza Sativa and Sesbania Crops

The satellite farmers representing the Malwah site shared their experiences with the sun farmers about ASSIB project activities. One of them explained that the training provided to the female farmers enabled them to cultivate vegetables during the Rabi and Kharif seasons. The grown vegetables fulfilled their needs, eliminated the time and cost used to purchase the same from the market. He thanked the ASSIB team for providing seeds and capacity building in multi-vegetable cultivation. Another farmer from the same site mentioned that five females have been cultivating multiple vegetables for two years with the support of the ASSIB team, while others urged for seed provision from the ASSIB team. The sun farmer highly appreciated the success stories of multi-vegetable farming. The model demonstrates the potential for genuine two-way exchange and learning.

The satellite farmers representing Tippun Dublo, in Keti Bandar, Thatta, (Figure 8) stated that they achieved a high yield of rice (10-12 tons/ha) as compared to the sun farmers (8-9 tons/ha) in the salt-affected soils. The difference in yield may be attributed to variations in sowing dates, climatic conditions, crop variety, and the addition of farmyard manure.

Figure 8: Peer-to-Peer Knowledge Exchange (Tippun Dublo Bright Spot)

They further shared that Tippun Dublo's soils were more saline than the Nawazabad Farm. According to their opinion, saline land can be made cultivable by applying deep ploughing followed by cultivating rice, sesbania, and berseem, a viable option for reclaiming salt-affected lands. The rotation of rice and berseem crops also helps reclaim highly saline-sodic soils. The sun farmer sharing his experience suggested that in the coastal belt, oilseed crops such as mustard, sunflower and vegetables like tomato, chilli,

onion, bottle gourd (kaddu/loki) and ridge gourd (toori) could be grown successfully. He added that sapodilla (chiku) had a high tolerance to waterlogging and salinity, making it suitable for the climatic conditions of the coastal belt. The sun site farmer interacted with satellite farmers of Jalalpur (Figure 9) and showcased the block plantation of acacia, jujube, lemon, eucalyptus and sapodilla on the salt-affected soil at Nawazabad Farm.

Figure 9: Farmer-Led Education (Jalalpur Bright Spot)

The sun farmer said, "We are adapting the saline-agro forestry on our saline soils, getting substantial yields and generating income as well". The satellite farmers from Jalalpur were amazed to see the management and pruning techniques for jujube trees. They asked the sun farmer why their trees did not yield well. Upon further discussion, it became evident that they were not familiar with this pruning technique. He also mentioned that they were practising intercropping berseem and cotton in the jujube orchards and getting more benefits from the same piece of land. The satellite farmers also shared the experience of intercropping high-density onion, okra and sugarcane on raised beds with mulch application. The sun farmer shared his experience of getting substantial income on waterlogged soils through the block plantation of acacia and eucalyptus trees (Figure 10). He suggested using gypsum, followed by ample good-quality water, was very beneficial for reclaiming saline lands.

Figure 10: Farmer Discussion in Front of Acacia and Eucalyptus Block Plantation

The sun farmer also mentioned using farmyard manure in his banana field. He said using decomposed farmyard manure in banana and mango orchards resulted in excellent yields. The satellite farmers from Jalalpur were amazed to see gooseberry (*phyllanthus emblica*), locally called aamla, and myrobalan (*terminalia chebula*), locally called hareer trees, phalsa (*grewia asiatica*), date palm (*phoenix dactylifera*), banana *(musa paradisiaca*), mango (*mangifera indica*) and rose (*rosa*) growing so well in salinity-affected soils. He added that he sold the fruit from only five hareer trees, which yielded Rs. 120,000 this year. The satellite farmers were eager to introduce saline-tolerant fruit trees observed in Sindh, such as sapodilla, aamla, and hareer, as they are highly profitable fruit-bearing trees. However, they expressed concerns about their small landholdings and how they would acquire these plants, given that these trees are uncommon in their area. One satellite farmer stated that at the age of 75, he had never seen such trees before and expressed his willingness to introduce these trees to his community. Another satellite farmer of Jalalpur shared his experience of growing moringa plantation. The sun farmers of the Nawazabad Farm were surprised to hear about the high value of moringa seeds and leaves in the local market, and that satellite farmers were earning Rs. 5,000/- per tree annually from their saline lands. In contrast, despite the considerable transplantation of moringa trees at the sun site, no market has been established to purchase and promote the moringa seeds or its leaves in Sindh province. The above discussion shows how the sun-satellite farmers interacted with each other, sharing their experiences and communicating freely without any hesitation with each other. Therefore, the Sun-Satellite Model helps match the chemistry of different farming communities and groups.

6. Feedback from the farmers

During the feedback sessions (Figure 11), a recap of all activities observed at the sun site was conducted, with open discussion promoted for all farmers of bright spots Malwah, Tippun Dublo and Jalalpur. The satellite farmers deliberated on various adaptation options with the DRIP, PCRWR, MUET, IUCN and SOFT teams. One of the satellite farmers said, "There were many things to learn. The orchards were well-

maintained, and they took great care of them. Everything was organised according to the system, especially the tile drainage system for improving waterlogged lands, which was particularly impressive. It was something I had never seen before". The satellite farmers responded that they were keen to adopt and implement the new techniques they had seen at the sun site. According to the Jalalpur bright spot farmers, the salinity conditions and underlying reasons differ significantly at their farms in Punjab when compared to the sun farm in Sindh. They highlighted that their primary challenges were lack of access to canal water and the low quality of groundwater, which were the main contributing factors to salinity in their fields.

One of the critical comments was that only large landlords with vast land holdings and resources can implement advanced water and salinity management techniques and those smallholder landowners cannot afford to make such big investments. The purpose of showing this model is not to apply the gained knowledge exactly on the same scale. Many interventions were applied at different scales. Every satellite farmer had the opportunity to learn something from the sun farmers and apply any intervention or technique according to his own needs. Even a small intervention of pruning the trees at the appropriate time and in the appropriate way may lead to significant yield improvement.

Figure 11: Feedback Sessions

Therefore, any adaptable, understandable, and feasible technique can be replicated even on a small piece of land. The essential factor is knowledge, which is acquired through farmer-to-farmer learning. It is not important who is conveying the message; what is being communicated is more important. Furthermore, the satellite farmers feel that one visit may not be enough. Their desire for more visits suggests a genuine interest in learning and improving their knowledge and understanding. Overall, the positive impression left by the visit and the recognition of the farming practices showcased suggest that the farmers value the knowledge and learning at the sun sites, indicating the potential for future adoption of these techniques.

Taking advantage of the visit, the farmers visited the Drainage and Reclamation Institute of Pakistan (DRIP), the regional office of PCRWR at Tando Jam. During the visit, the farmers learned about the physical, biological and chemical reclamation of saline and sodic soils. The physical reclamation includes deep ploughing, surface scraping, laser levelling and salt leaching. The biological factors include growing salt-tolerant crops, shrubs, grasses and agroforestry. The chemical approach involves improving the saline-sodic soil by applying gypsum, press mud, and farmyard manure. Farmers observed sugarcane sowing on ring pits, ridges and raised beds. They also showed interest in bananas grown on beds and cotton planted on ridges. The Jalalpur farmers mentioned that they had already adopted some chemical and mechanical interventions observed in Sindh, which were also suitable for their lands. For example, they have used gypsum and farmyard manure as chemical amendments, ridges, and raised bed sowing methods. The farmers visited the meteorological station, soil and water analysis laboratory, and lysimeter station (Figure 12) to learn about crop water requirements and irrigation scheduling. The farmers learned that if they knew about the irrigation scheduling (when and how much to apply?) for major crops like wheat, cotton, sugarcane, banana, and rice, the same yield could be achieved with much less water applied. The farmers were interested in growing salt-tolerant varieties of sugarcane "NIA-2012", wheat "NIA-Zarkhaiz", and canola "NIA-Surhan" on their salinity-affected soils.

Figure 12: Demonstrations at Lysimeter, Meteorological Observatory and Soil & Water Analysis Laboratory, DRIP, Tando Jam

The farmers were convinced that soil and water samples should be analysed before crop sowing. The farmers were pleased to observe the climate parameters, especially minimum and maximum temperatures, rainfall, humidity, and wind speed.

7. Conclusions

The Sun-Satellite Model provided a platform for farmer-to-farmer learning as a two-way learning process. The satellite farmers observed the best salinity management practices at the sun site. This experience helped them learn and potentially replicate the promising practices on their farms. Sharing knowledge and expertise on salinity management practices with bright spot communities helps build their capacity to

address salinity challenges. The bright spot communities can sustainably manage the salinity on their fields over time by increasing awareness through these types of farmer-to-farmer learning opportunities and by implementing best practices relevant to the salinity conditions they face on their lands.

Furthermore, this model links experienced professionals from various departments such as MUET, IUCN, SOFT, PCRWR, MNSUAM, and the farmers. The model offered several advantages, most notably addressing the issues faced by the farmers and sorting out solutions. Collaborative efforts from various stakeholders, coupled with the willingness of satellite farmers to adopt the best salinity management practices, can assist them in coping with salinity. In turn, it will result in increased crop yields in saline conditions, conservation of water resources, and protection of the environment. However, concentrated efforts to continue and expand farmer-to-farmer learning, build capacity and awareness of the salt-affected farming communities, fostering collaboration among stakeholders, promote best practices, and implementing robust monitoring and evaluation mechanisms are essential. These actions can effectively tackle salinity-related challenges, resulting in enhanced agricultural productivity and sustainable environment management.

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Annexure-I

Bright Spot Malwah Farmers' Feedback on their Sun-Satellite Model Experience

Society of Facilitators and Trainers (SOFT)

The following table documents responses by farmers from the Malwah bright spot who had participated in the Sun-Satellite Model inspired exchange provided by PCRWR in July 2024. These were responses to a set of questions put to them by the SOFT team at a workshop held at Malwah in December 2024.

Sr.	Farmer	What did he learn?	What impacts did the experience have on them?	Have they adopted any of the practices they observed?	If Yes, why	If No, why
1	A	There were many things to learn, the orchards were very good, they took care of them very well, everything was according to the system, the system of improving the waterlogged lands was very good. It was something I hadn't seen before.	Many things were new and some we are already doing. A lot can be achieved with hard work and support. We can work hard but we do not have enough resources.	I do not own the land and I do not have enough resources to properly plant gardens or systems. I am a sharecropper and do as the landlord says. I probably told you earlier that we cannot do this level of work because it costs a lot of money.	No new practices adopted	I do not own the land, and I do not have enough capital amount
2	B	Planting two crops together will benefit farmers. I have not seen such innovative methods before. I have been working with landlord for 40 years, my knowledge has increased a lot.	My knowledge has increased a lot, which will help me in future	I do not own any land nor am I a sharecropper. I am a servant; I do as the landlord tells me.	No new practices adopted	I do not own land and am not a sharecropper.

Sr.	Farmer	What did he learn?	What impacts did the experience have on them?	Have they adopted any of the practices they observed?	If Yes, why	If No, why
3	C	It was a good tour for me. Let me tell you my 80 acre land of which 90% is waterlogged 10% has some farming. This is the situation of all lands in my area, there is no drainage system. Our lands are destroyed	My greatest concern there was the waterlogged lands. The best tile drainage system was implemented. The sun farmer was telling that our land was also prone to waterlogging, but the land has been reclaimed with this system and it was visible. That means such lands can also be reclaimed.	We cannot install tile drainage system, it requires a lot of resources and money. But there they also planted eucalyptus trees to address the waterlogging issue. After this visit, I planted 400 trees on my land but only 30 plants survived because of high waterlogging issue.	Because I want to reclaim my land from waterlogging, and want to cultivate crops	
4	D	I learned that we could get more yield from the land through proper technical methods and through multiple agriculture practices.	Not much because I have been farming for a long time. I was very much impressed by the fruit orchards there. We have the same kind of orchards but only mangos and Jujube, but there were different types of fruit orchards.	Not yet. But for the future I am thinking about cultivation of fruit trees.	There is not much expenditure in gardens etc. and the income is also good.	Less resources and not having such capital investment.
5	E	We learned that the crop planting method is good, they were working with latest techniques	After this visit, one thing that impacted me more was the fruit tree plantation.	Yes, I planted fruit trees on my land such as lemon, orange and jujube trees.	Plantation of fruit trees is my passion. I like fruit trees.	

Sr.	Farmer	What did he learn?	What impacts did the experience have on them?	Have they adopted any of the practices they observed?	If Yes, why	If No, why
6	F	I learned the sugarcane ring pit method. Multiple fruit tree plantation was a good and new thing for me	The rice crop was planted which was very good. I want to cultivate rice with this method.	Not yet. But for the future I am thinking about cultivation of rice.		I do not have my own land and I am a sharecropper and have less resource as well.
7	G	A farm we visited was quite big but we are small farmers. Their work is out of reach. There is no comparison with this type of big farm. But I saw some new experiences that we could do with our limited resources such as rice cultivation was very good at farm, and sugar cane cultivation at ring pit method was new for me.	With these latest techniques we can improve our yield and improve our land as well.	I have planted 10 gum arabic tree (*Vachellia nilotica*) around my land and planning for more different species of tree.	There will be shade from the tree and if needed, you can sell it and get good money.	
8	H	I learned that everything is possible. If you have resources, you can improve your yield and soil also. You can plant everything like trees, fruit trees.	New experiences were good	No new practices adopted	No new practices adopted	Unavailability of resources and money
9	I	Rice and other crops like sesbania are beneficial for saline soils.	Learn new things, will apply in future	Yes, I planted sesbania at my land.	I learned that It can survive in salinity affected land, and the land will be improved.	

Sr.	Farmer	What did he learn?	What impacts did the experience have on them?	Have they adopted any of the practices they observed?	If Yes, why	If No, why
10	J	I saw how the big landowners managed their lands. I loved their orchards and learnt how to manage them.	It has a great effect on me, and if I ever get the chance, I shall definitely plant orchards in the same way	Not yet		Because I am not holding any land, my father takes care of our land and crops.

SOFT facilitator observations

1. Most farmers think the practices demonstrated at sun sites are beyond their reach and that they would need a lot of money and resources to follow them.
2. Malwah farmers have been facing water shortages for a long time, so they cannot do such cultivation as they observed during the visit.
3. These people are small landowners; most do not even have their own land and work as sharecroppers.
4. Their understanding is not developed enough from one visit; they want more such visits.
5. They seem to have been most influenced by the fruit orchards they saw there, but they have been unable to implement it at Malwah.
6. Overall, all the farmers seemed impressed by the visit and recognised the farming practices there.

Annexure - II

Summary of Bright Spot Jalalpur Experience of Sun-Satellite Model Visit

This draft includes notes taken at the time, summarizing the activities, responses, and reflections about the PCRWR Sun-Satellite experience.

Promote support and advance the living skills for sustainable livelihood

Society of Facilitators & Trainers (SOFT)

Summary: Sun-Satellite Model (Jalalpur Peerwala)

Date: 20-22 September 2023

Satellite(s): Jalalpur Peerwala Community (Multan, Punjab)

Sun site(s): Nawazabad Farm (Tando Allahyar, Sindh)

Drainage & Reclamation Institute of Pakistan (DRIP) (Tando Jam, Sindh)

Introduction

This report documents the key takeaways from the visit to Tando Jam, Sindh on September 20-22, 2023, focusing on insights into salinity management and the Sun-Satellite Model. The team consisted of SOFT Multan male facilitators and community farmers from Jalalpur Peerwala, Multan.

The visit covered a variety of activities, including:

- Demonstration of field activities at Nawazabad farm (sun site, PCRWR)
- Demonstration of saline agroforestry at Nawazabad farm
- Demonstration of tile drainage system at Nawazabad farm
- Demonstration of high-value salt tolerant crops at Nawazabad farm
- Demonstration of ridge, bed & ring pit sowing techniques at DRIP
- Visit of farm, soil & water analysis lab & Lysimeter at DRIP
- Q & A by the farmers & recap of activities

Day 1 (September 20, 2023)

Here the journey begins…

- The SOFT-Multan team departed from Multan to head towards Jalalpur Peerwala to pick up the community farmers who will be joining for the Sindh visit.
- The team arrived at Jalalpur Peerwala, gathered all the participating farmers, and left Jalalpur after enjoying morning tea with the farmers.

Enjoyed the hospitality of Sindhies…

- Upon entering the Sindh province, the farmers from Jalalpur, emphasized to the SOFT team members their eagerness to visit the field of an ASSIB farmer in the Malwah community.
- The Multan farmers engaged in a fruitful discussion with ASSIB farmer covering the interventions they are implementing to tackle salinity and the positive impact of the ASSIB project on their communities.
- After tea, the ASSIB farmer led the team on a visit to his sugarcane fields, illustrating the comparison of various sugarcane sowing techniques.
- He also showcased different fruiting trees on his farm and discussed varying salinity levels in his fields.

- Both Punjab and Sindh farmers engaged in discussions about the differences in their cultures and norms.
- Farmers from Multan were deeply impressed by the hospitality of ASSIB Farmer and departed happily towards Tando Jam after this short break.

Farmers visiting the sugarcane field at Malwah

Finally…

- The Multan team arrived at Sindh Agriculture University (SAU), Tando Jam for a night stay after a long & tiring journey.

Day 2 (September 21, 2023)

- **Time to visit Sun…**
- A representative from DRIP (PCRWR) joined the team at the SAU guest house to lead the team to the Sun site (Nawazabad farm).
- The team departed from the SAU guest house and reached Nawazabad farm.
- The DRIP (PCRWR) team & farm representatives welcomed the team at the farm.

Discussions & Insights…

- Following recitation and introductions, a representative from DRIP (PCRWR) provided a comprehensive overview of the Sun-Satellite model.
- After a brief introduction of the model, he discussed about the collaboration of PCRWR with the Nawazabad farm and highlighted their major interventions.
- He further highlighted the "Tile Drainage System" established in 1989 at Nawazabad farm in collaboration with PCRWR to address the farms' waterlogging & salinity issues.

Farmers overviewing the printed material on salinity given by DRIP (PCRWR)

- He also discussed different biological, chemical & mechanical reclamation techniques that are being used at Nawazabad farm to address the salinity issues.
- Another representative of PCRWR elaborated more about different salinity conditions, highlighting the regional variations of Punjab & Sindh provinces. He emphasized the Multan farmers that you cannot adopt or practice each and everything that you'll see

here at your land in Punjab due to different situations. He emphasized assessing the soil texture, soil properties, groundwater levels and properties, crop selection and other related factors before adopting any intervention.

- All the Multan farmers really praised the importance of assessing intervention suitability before adoption.
- Multan farmers discussed and ensured that they must check the suitability of any specificintervention first before practicing or adopting it.
- He also discussed the mixing of less available canal water with poor-quality groundwater and then using it for irrigation.
- Afterwards the farm manager of Nawazabad farm, was invited to talk with the guest farmers.
- He explained the activities and interventions they are practising at their farm to deal with the waterlogging and salinity issues.
- He highlighted that waterlogging is the major issue at Nawazabad farm that ultimately causes the salinity.
- Then, the representative of SOFT-Sindh shared insights with farmers, explaining the purpose of the sun-satellite model and this visit.
- While discussing with farmers, he shared a thought-provoking statement. He said "Lands don't deteriorate, we do").
- Multan farmers expressed their concerns about the deterioration of their lands, attributing it to the unavailability of canal water and poor-quality groundwater.
- The Multan farmers identified the continuous use of poor-quality groundwater as the main reason for their saline lands.

A field visit of Sun…

- After a productive discussion and a working tea session, the farm manager guided a field visit to illustrate salinity and its mitigation measures at Nawazabad farm.
- The sun farmer also invited smallholder farmers adjacent to his farm for this session, providingan opportunity for them to meet fellow farmers from Punjab.
- The Multan team visited the "Tile Drainage System" at the farm and received a briefing on how it works, its efficiency, and importance from both the PCRWR team and the farm team.

- The farm manager mentioned that the groundwater level is 1.5 m here at the farm, causing severe waterlogging and ultimately resulting in salinity. However, with this tile drainage system, we were able to lower the water levels of our land and make the land cultivable.

Farm Manager briefing the guest farmers in the field

- The farm manager also demonstrated saline agroforestry, including babool (keekar or acacia), ber (*jujube or ziziphus*), chikoo (*Sapodilla*), jamun (*Java plum*), aamla (*Gooseberry*), hareer (*Terminalia*), phalsa, dates, banana, citrus, and mango orchards.
- The Multan farmers were genuinely amazed to see the management and pruning of ber, as it was new to them, and they were not accustomed to managing ber trees in the way this farm does.
- The sun farmer also informed the Multan farmers that they are practising intercropping of berseem and botton in the ber orchards and getting more benefits from the same pieceof land.
- He highlighted the importance of keekar cultivation in waterlogged lands. He mentioned that they cultivated keekar 10 years ago in waterlogged land, and keekar significantly lowered their groundwater level. He shared that, according to their estimation, in addition to reclaiming their land, keekar plantation yielded them 2.5 lacs/ha in 10 years.
- At this point, the satellite farmer questioned the sun farmer, asking why they didn't consider planting Moringa instead of keekar.
- The sun farmer responded that while moringa is suitable for saline lands, it is not ideal for waterlogged lands.
- The satellite farmer raised arguments on this point, but PCRWR experts supported the sun farmer’s answer, explaining that moringa doesn't have deep roots. Here at Nawazabad, the primary concern is to lower the water table of waterlogged lands, which is why Moringa is not preferred as a replacement for keekar.
- Multan farmers expressed dissatisfaction with the management and health of the mango orchards they visited at Nawazabad farm. According to them, mango trees appeared unhealthy, with fewer leaves, suggesting poor future yields.
- In discussions among themselves, they concluded that waterlogging might be the major reason for the unsatisfactory health of the mango orchards. They independently reached the conclusion that mango plantation is not suitable for waterlogged lands, as excess water negatively impacts their health. Satellite farmers also shared their thoughts with sun farmer about the mango orchards at this farm.
- Satellite farmers also visited the Jantar and rice fields of the farm. They were briefed that both of these crops are suitable for waterlogged saline lands.

- The sun farmer mentioned that they prefer to sow the IRI-6 variety of rice in their waterlogged saline lands because they have found this variety to be more successful in their conditions.
- A young farmer from Jalalpur, shared his experience of cultivating rice for the first time on 0.40 ha of his farm. He mentioned that they have limited availability of good-quality water, but he still preferred cultivating rice because he wants to produce his own mulch for use in other crops.

Satellite farmer observing the rice field at Nawazabad farm.

- He also mentioned that the SOFT-Multan team suggested he experiment with "Alternate Wetting & Drying (AWD)" technique in half of his rice, as this irrigation method is water-saving. He stated that he has noticed a significant difference in water consumption, saving multiple irrigations with this AWD technique compared to their traditional irrigation method.
- Farmers from Nawazabad farm expressed their reservations about this technique, stating that while it is good for water-saving, it is not suitable for them. Their purpose is not to save water but to use it and lower down their groundwater levels.
- The young farmer also shared his experiment of intercropping high-density onion, okra, and sugarcane at raised beds with mulch application.
- The sun farmer highly praised this experiment and jokingly said to the SOFT-Multan team,"You people brought the selectively wisest people".

Discussion after field visit…

- After the field visit, all the participants gathered at the Nawazabad farm for a post-visit discussion session.
- The sun farmer informed the farmers that he has used powdered gypsum in his farm with plenty of good-quality water to reclaim theirwaterlogged saline lands. The satellite informed that Jalalpur have higher levels of sodicity, while Nawazabad farms don't have sodic soils.
- The sun farmer also shared his experience of using farmyard manure in his banana fields. He mentioned that using fermented farmyard manure in banana and mango results in excellent yield for the following two years.

On-farm feedback session…

- Before wrapping up from the Nawazabad farm, the SOFT-Multan team requested rapid feedback from the farm manager and the Jalalpur farmers.
- Farm manager: He took the lead and praised the Jalalpur farmers, mentioning that these farmers are more knowledgeable than the Sindh farmers who visited before. He also commended the ability of these farmers to achieve high yields on small pieces of land while managing salinity solely through their interestand efforts.

All participants clapped the Jalalpur farmers, boosting their morale.

- Satellite farmer 1: He said that “If you work hard, you can do everything”.
- Satellite farmer 2: He was impressed by the proper pruning & management of fruit trees (especially Ber) and expressed his willingness to adopt these practices.
- Satellite farmer 3: He was amazed by the production of Amla in saline lands and expressed his willingness to grow Amla on his farm. He believes that this tree can grow well in the conditions available on his farm.
- Satellite farmer 4: He was quite amazed by the Amla and Hareer trees. He mentioned that he was born in 1947 and is 75 years old now but has seen both of these trees for the first time. He expressed his willingness to introduce these trees to his community.

  The sun farmer mentioned that he sold the fruit from only 5 hareer trees, which yielded Rs.120,000 this year.
- Satellite farmer 5: He highlighted that he is also impressed by the proper pruning of Ber, as they didn’t used to prune the Ber and have very dense trees, which he now found is wrong. He mentioned Amla and Hareer in his list as well.
- Satellite farmer 6: He was impressed with the Hareer, Amla & Chikoo production in saline lands.
- Satellite farmer 7: He was impressed with the production of rose and banana plantation at this farm.

After this quick feedback session, the Multan team and DRIP team moved to the DRIP-PCRWR office in Tando Jam for lunch and the afternoon session.

Afternoon session at DRIP-PCRWR…

- On arrival at DRIP (Tando Jam), the team had a formal lunch and prayer break.
- After lunch, the DRIP team led a visit to the soil and water testing laboratories. Farmers were briefed on the testing procedures and the parameters that are being measured during the testing.
- SOFT-Multan facilitators briefed the farmers on how to collect the soil and water samples and label them properly. Farmers were briefly guided on the importance of taking samples and labelling them correctly to obtain accurate results.
- Moving forward, the farmers were

demonstrated the ridges, raised beds, and ring pit method of sowing sugarcane. Farmers were also guided on how to prepare their lands for these sowing methods.

- The DRIP team also demonstrated their meteorological setup and explained the working of each apparatus. Farmers were truly amazed to visit this meteorological setup, and they got to know for the first time how this meteorological data is being recorded.
- Farmers questioned the DRIP team about how they disseminate this meteorological data to the farmers. The DRIP team answered that this data is regularly published in "Ibrat Newspaper," which is the second-biggest newspaper in Sindh.
- The DRIP team demonstrated the Lysimeter to the Multan team and explained its procedure and working briefly. Farmers were quite amazed to visit the Lysimeter because its total setup was underground, almost 5 m below the surface level. Farmers raised different questions, which were satisfactorily answered by the DRIP team.

Recap of the activities…

- In this evening session at DRIP, a recap of all the activities seen at Nawazabad farm and DRIP was performed. The room was opened for discussion for everyone. Multan farmers discussed different adaptation options with the DRIP and SOFT team and asked related questions from representatives of PCRWR, and SOFT.
- According to the Multan farmers, the salinity conditions and reasons are entirely different at their farms in Punjab compared with Nawazabad farm in Sindh.
- They mentioned that their major issue is the unavailability of canal water and poor-quality groundwater, which is the primary reason for salinity in their fields in Punjab. While in Sindh, the scenario is entirely different. The lands are waterlogged and have an excess of water availability, which is the main reason for salinity there.
- Therefore, Punjab farmers cannot adopt most of the interventions they have seen in Sindh to mitigate their salinity issues.
- Multan farmers mentioned that they have already adopted some chemical and mechanical interventions seen in Sindh, which are suitable for their lands as well.
- For example, the proper use of gypsum and farmyard manure as chemical interventions, and ridges and raised beds sowing methods.
- They also mentioned that using mulch in raised beds or ridges multiplies the effectiveness of controlling salts in their lands.
- Multan farmers also expressed reservations, citing their small landholdings and limited resources, which make it challenging for them to afford expensive interventions.
- The SOFT-Multan team appreciated the farmers for raising their concerns and expressed confidence that they are doing their best to improve their conditions with salinity within the available resources.

Overall…

- The farmers remained very confident, energetic, and willing to learn something new throughout the visit.
- Multan farmers were eager to introduce saline-tolerant fruit trees seen in Sindh, including chikoo, aamla, and hareer, as they are highly profitable fruiting trees. However, they expressed concern about their small landholdings and how they will obtain these plants since these trees are not common in their area.
- Multan farmers were also impressed by the proper pruning of fruiting trees, especially Ber, and expressed confidence that they will adopt this management strategy for pruning fruit trees.
- Overall, all the farmers were quite happy that their time paid off and were overwhelmed by the hospitality of Sindhis.

Annexure-III

Australian Centre for International Agricultural Research | Australian Aid

PAKISTAN COUNCIL OF RESEARCH IN WATER RESOURCES
PCRWR

Living with Salinity – An Effective Strategy

- Salinity is a major threat to crops in arid and semi-arid regions worldwide. In Pakistan, the area affected by salinity is more than 4.5 Mha. Sindh province is most vulnerable to the salinity where about 3 Mha of area is affected.
- The issues of soil salinity are more serious in the lower parts of the Indus Basin where about 54% area is saline.
- Soil salinity reduces the plant growth, affects crop yields, and also results in crop failure. Soil salinity has emerged as a serious threat to food security.

Types of Salinity

Soil salinization occurs when soluble salts are retained in the soil profile. Traditionally, there are three types of salt-affected soils: saline, sodic, and saline-sodic.

Saline Soil

Sodic Soil

Saline - Sodic Soil

Table: Categories of Soil Salinity

Description	ECe (dS/m)
Non Saline	0 - 2
Slightly Saline	2 - 4
Moderately Saline	4 - 8
Strongly Saline	8 – 16
Extremely Saline	>16

Source: Handbook 60 (U.S. Salinity Laboratory Staff, 1954)

Table: Type of Salt Affected Soils

Types	ECe (dS/m)	pH	ESP	SAR
Saline	> 4.0	< 8.5	< 15	< 13.0
Sodic	< 4.0	> 8.5	> 15	> 13.0
Saline - Sodic	> 4.0	< 8.5	>15.0	>13.0

Source: Handbook 60 (U.S. Salinity Laboratory Staff, 1954)

Living with Salinity

- Salinity is a complex issue which cannot be removed from the system entirely, rather it can be managed. In past different engineering approaches (vertical and horizontal drainage systems) have been adapted to deal with the salinity, but these were neither effective nor sustainable.
- Therefore it is imperative to live with different levels of salinity by managing it through physical, biological, and chemical approaches. Farm and field scale interventions are more suitable for these methods.
- The physical approach is deep ploughing, surface scraping, laser leveling and intensive water leaching. The biological approach includes growing of salt tolerant crops, saline agro forestry, shrubs and grasses etc. The chemical approach consists of use of gypsum, press mud and farm yard manure etc.
- PCRWR and other relevant departments has a body of work on salinity management. This brochure highlights the physical, biological and chemical interventions carried out to manage the salinity.
- This brochure is the knowledge product of PCRWR under Adapting to Salinity in the Southern Indus Basin (ASSIB) project funded by the Australian Government through Australian Centre for International Agriculture Research (ACIAR).

Physical Reclamation

- Deep ploughing (50 cm) coupled with laser leveling is more effective for reclaiming the soils.

Deep ploughing with laser leveling

- This process of deep ploughing with intensive water leaching should be repeated five to seven times continuously.
- If it is found that the salts present in the soil have leached down; then slowly start planting crops.
- About 35% increase in wheat production and 40% increase in cotton yield has been recorded by driving a deep plough in the ground up to 50 cm depth.
- The Rice - Egyptian clover (Berseem) rotation results in about 82% reduction of EC_e, in the upper soil layer.

Biological Reclamation

- The crops Egyptian clover (Berseem) – Sorghum (Jowar) rotation provides 33% reduction in soil salinity (EC_e).

Egyptian clover – Sorghum Rotation

- The Barley (Jau) – Sesbania (Jantar) crop rotation results in decreasing the soil salinity (EC_e) up to 41%, particularly at the upper layer of soil (0-15 cm).

Barley - Sesbania Rotation

- In order to improve the sodic soil through biological reclamation, Laptochloa Fusca (Kallar grass), Acacia, and Eucalyptus should be planted.

Rice - Egyptian clover Rotation

- Maize and Sudan grass also reduce the EC_e up to 39% and 40%, respectively for saline soils. Sesbania (Jantar) – Egyptian clover (Berseem) rotation reduces the EC_e at lower depth (60 - 90 cm).

Maize and Sudan Grass Rotation

- Cultivation of Alfa Alfa (Loosan), Sorghum (Jowar) and Sesbania (Jantar) as green manure is recorded to reduce the soil salinity by 40%.

Alfa Alfa (Loosan)

- After cultivation of Alfa Alfa (Loosan), Sorghum (Jowar) and Sesbania (Jantar); 25 maunds per hectare for barley and 72 maunds per hectare for millet grass can be achieved.
- After growing such grasses, one can get cash crops like cotton, wheat and sugarcane.

- Four year old Acacia Nilotica tree can consume 1,400 to 2,000 mm of brackish groundwater annually, thereby acting as a biological pump. Whereas, Eucalyptus can use 1,000 to 1,200 mm saline groundwater per year.

Eucalyptus planted in blocks

Acacia planted in rows

- Banana crop residues can also be used as an effective green manure.

Banana Residues

Salt tolerant trees can be used for timber, pulp, firewood, fodder, cut-flowers, honey and other products (e.g. leaf oils), shelter and shade, wind, water and water table erosion control, wildlife corridors and aesthetic.

Acacia Nilotica (Babul)

- Some types of trees and shrubs such as Prosopis cineraria (Jand/Kandi/kikar), Tamarix aphylla (Farash), Atriplex (salt bush), Suaeda fruticose (Lana - shrub) and Maireana aphylla (salt bush) occur naturally on salt-affected soil, near to coastal or where, soils or ground water are saline.

Prosopis cineraria & Tamarix aphylla

- Farmers have known that saline soil can be improved and substantial revenue can also be generated by planting saline agro forestry, like Zizyphus jujube (Ber), Sapodial (Chiku), Citrus (Lemon), Pridium guajava (Amrood), Eugenia jamolana (Jaman), Phoenix dactylifera (khajoor), Azadirachta indica (Neem), Salix Balulonica (Baid), Pogamia pinnata (Sukhchain), Capparis aphylla (Karir), Cocos nucifera) (coconut palm), and Grevia asiatica (Falsa).
- The farmers also plant the salt tolerant vegetables on saline soil like tomatoes, broccoli, kale, chili, bell peppers, and spinach for their income generation purpose.

Chemical Reclamation of Saline Sodic Soil

- For reclamation of sodic or saline - sodic soils, gypsum (calcium sulfate). It contains 24% calcium and can be used as it is easily soluble in water.
- Application of chemical amendments such as gypsum, calcium chloride dehydrates, sulfuric acid, sulfur, aluminum sulfate, hydrochloric acid, and farmyard manure can reclaim sodic soils.
- Chemically, when gypsum is mixed into the soil, the calcium replaces the sodium in the soil through a chemical process and dissolves the salt into the subsoil, making the topsoil usable for crops. It also increases fertility of soil.

Gypsum in powder form

- Gypsum dose of 35 tons/hectare is quite effective against salinity and after its application it is possible to increase the production of rice and berseem by 30%.
- The use of press mud and farmyard manure has proved to be very effective in salinity affected land.

Press mud and farmyard manure

- A maximum increase of 60% in berseem production and 65% in rice production is recorded with the use of press mud of 50 tons per hectare.

Annexure-IV

Living with Salinity - Success Stories – (Sun Sites)

- Salinity cannot be removed from the system but can be managed.
- The farming community is managing the salinity on their own by experimenting various land conservation and saline soil reclamation practices.
- Farmer's understanding of salinity as a problem helped them to plan a strategy for salinity management.

Nawazabad Farm - Sun Site

- Nawazabad farm is situated in District Tando Allahyar, Sindh province.

Nawazabad Farm – Sun Site

- The farm was facing the issue of waterlogging and salinity. The farm management approached PCRWR in 1989 to resolve the issue of waterlogging, where water table was about 0.15 m from the surface.

Waterlogged Area

- PCRWR installed tile drainage on waterlogged area (40 hectares) to lower down the water table.
- The system was installed at Nawazabad farm through participatory approach.
- The operation and maintenance of the tile drainage system and practicing saline agriculture on the reclaimed land were the responsibility of the farmers.

Functional Tile Drainage System

- According to the farmer, the system works only if farmer takes the ownership.
- There are 10 sumps from where the drainage water is collected through gravity and pumped out to reclaim the land.
- The quality of pumped water is marginal (EC 1.5 - 2.5 dS/m), but the management of farm dispose of the pumped water to the nearby Jamrao distributary which offtakes from Nara canal.
- The tile drainage system successfully controlled the water table at 1.5 m depth and provided the opportunity for saline agriculture.

- The owner of the farm believes that salinity management is the only option to improve the land productivity.
- Mr. Saleem Ahmed Choudhry, Manager of the Farm said “We are adopting the saline agro forestry like Cheeku Jujube, and Lemon on our saline soil and getting substantial income generation”.

Cheeku planted in blocks

- In his opinion, chemical applications are less adaptable and have been shown to be less cost-effective than growing the salt-tolerant crops.

Jujube block plantation

- According to the manager, farmers are thriving because they have figured out "how to live with salinity" despite the fact that soil salinity exists in the system.

Acacia & **Eucalyptus on Saline Sodic Soil**

- Plantation of Acacia and Eucalyptus offers a cost-effective land management strategy to improve the farm income.
- The Acacia (Babul/Kikar) tree matures in 5 years and its forage provides shelter and grazing place for livestock.
- The Acacia wood is sold easily in the market as fuel wood or as raw material for local furniture industry.

Lemon planted on saline soil

- “We produce a sizable profit from saline soil because we did not leave the soil fallow for even one season, as salts would have accumulated on the surface and made the land unusable”. The Farm Manager Says.

Cheema Farm - Sun Site

- Cheema farm is situated in District Mirpurkhas, Sindh province.
- The farm comprises of 142 hectares and facing the water logging and salinity issue over patches.
- The owner of the farm, Mr. Muhammad Waseem Cheema said that salinity management through chemical and biological was only option to survive on saline soil.

Cheema Farm - Sun Site

- Further he added that they use cropping pattern i.e. Jantar in Kharif and wheat, mustard and fennel in Rabi Season.
- Regarding chemical amendments, he informed that they use gypsum to overcome the salinity and increase the yield.
- They also use sulphuric acid @ 12 liters/hectare for 3 to 4 irrigations to reduce the salinity.
- They also apply farm yard manure @ 50 tons/hectare and press mud of sugar mills as organic matter to increase the yield.

Jujubi planted in rows on saline soil

Lemon block plantation

Cheeku planted on saline soil

The farmers are making innumerable efforts to cope with the salinity but Government should focus on providing salt tolerant crop varieties to support the farmers to earn their livelihoods. Farmers should be informed on how to manage soil quality. The capacity building / training should be provided to the farmers regarding management of soil salinity with salt tolerant crops.

Saline Agro Forestry and Salt Tolerant Crops – Bright Spot Sites

PCRWR Sun Site "Nawazabad Farm", Tando Allahyar

Saline Agro Foretry

- Jujube (34 hectares)
- Lemon (20 hectares)
- Euclaptus (3.25 hectares)
- Sapodilla (3.2 hectares)
- Acacia (2 hectares)

Salt tolerant crops

- Jantar, Rice Wheat, Flax and Mustard

Functional Tile Drainage System on 40 Hectares

PCRWR Sun Site "Cheema Farm" - Mirpurkhas

Saline Agro Forestry

- Jujube (10.5 hectares)
- Lemon (0.4 hectares)
- Sapodilla (0.6 hectares)

Salt tolerant crops

- Jantar, Fennel, Wheat and Mustard

Glimpses of Sun Sites

Block Plantation of Acacia – Cheema Farm

Block Plantation of Lemon – Nawazabad Farm

Cheeku on Saline Soil at Cheema Farm

Cheeku planted in block at Nawazabad Farm

Annexure-V

Saline Aquaculture in Salinity Affected Areas of Southern Indus Basin for Local Food Security

- Global warming and climate change have badly affected marginal communities of the rural areas in Southern Indus Basin.
- In this region, the parent material of the soil is saline, and the depth of the groundwater is shallow. A recent investigation of the soil profile (0 - 5 m) by PCRWR shows that 28% of the area is saline and 20% is saline-sodic.
- In order to generate resilience among the local community against poorly drained soils and saline groundwater in this region, there is a need of high nutritional and value added alternative of field crops.
- Furthermore, there is a pressing need for exploring ways to use saline soil and brackish groundwater lenses and identifying alternative sources of livelihood under the prevailing conditions.
- The saline aquaculture is one of the potential options, which has been found viable worldwide. The main purpose of saline aquaculture is to utilize the land and water resources effectively and promote food security options.

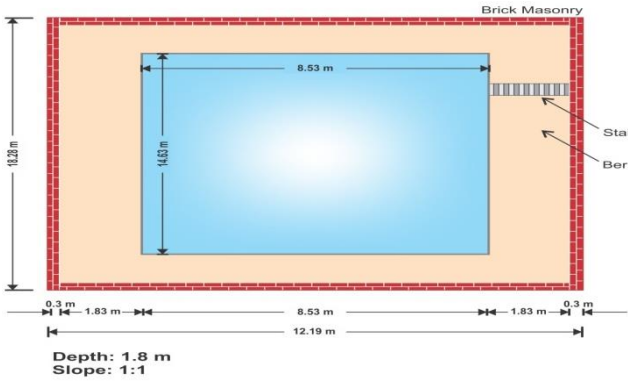
Background

- Saline aquaculture offers enormous potential to expand the blue economy and provide sustainable lives in the salinity-affected areas of Southern Indus Basin.
- It has a lot of potential as a means of alternative subsistence for farmers who must deal with rising salinity levels as well as a means of addressing food security and hunger in the nation.
- It is a relatively new activity in Pakistan, but it has great potential for development and growth.
- Saline aquaculture involves the farming of fish, shrimp, and other aquatic species in controlled environments, such as ponds, tanks, and cages.
- It has been identified as an alternative livelihood source for many rural farming households living in areas with brackish groundwater. However, there is still limited research and understanding of the constraints and development opportunities for small-holder saline aquaculture farmers in marginalized saline areas.
- In Pakistan, the annual consumption of fish is very low i.e. 1.7 kg per capita. Only 26% of total production of fish is consumed domestically, 19% being exported and 55% used for fishmeal.
- Pakistan's population is protein-deficient to the tune of 66%. The development of fish aquaculture is crucial for addressing protein deficit.
- The fisheries sector as a whole contributes to about 1% to the country's GDP and provides jobs for about 1% of the country's labour force.

- It is necessary to utilize all the available resources to develop fish industry through simple saline aquaculture practice.
- Among the new trends in fish culture, integrated semi-intensive system is more acceptable because, livestock dung can be utilized as a cost-effective source of fish feed.
- The small land holder having saline or poorly drained soil can develop the cost effective fish pond to stock the reasonable fingerlings for income generation purpose.

Development of a cost - effective fish pond

- A fish pond can be developed in saline or poorly drained soil, ideally near to saline groundwater (tube well water). The minimum dimensions of a fish pond can be 18 m x 12 m x 1.8 m.



Schematic diagram of fishpond

- The water level inside the fish pond should be maintained.

View of fishpond filled with water

- In case of sandy soil lining of fish pond with cement concrete is good option, whereas in case of hard clayey soil, lining of the pond may not be required.
- Fresh water of tube well in the pond needs to be added daily to maintain the Dissolved Oxygen level of the pond to fulfill the oxygen needs of ponded water.

Salt Tolerant Fish Varieties

- Mrigal Carp (*Cirrhinus cirrhosus*) locally called as *Morakhi* is one of the most important commercial carps in Sindh, Pakistan. It has high salinity tolerance even at 8 ppt, show no mortality.

Mrigal carp fish

- Silver Carp (*Hypophthalmichthys Molitrix*) also has high tolerance against the salinity as can tolerate salinities up to 12 ppt.

Silver carp fish

- Rahu Labeo (*Labeo rohita*) commonly known as *Kurh'rho* in the Sindh province is much liked in the food fish. It is rich in vitamin A, B, C and D. It can tolerate salinity up to 10 ppt in inland saline water, but it is expected to perform well in salinities ≤ 6 ppt.

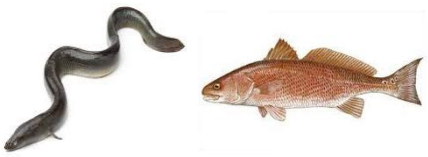
Rahu or Rohu Labeo fish

- Grass Carp (*Ctenopharyngodon Idella*) could survive at the salinity level of ≤8 ppt, however, it shows good adaptability to low salinity equivalent to 2 ppt. It is good tolerant of the high temperature and spawn at 20^{o}C to 30^{o}C temperature.

Grass carp fish

- The term "euryhaline species" refers to fish that, at some point in their life cycle, can tolerate a wide range of salinity. Salmon, eels, red drums, striped bass, flounder, and other fish may all live or thrive in waters with salinities ranging from fresh to brackish to marine.

Salmon



Eels *Red Drum*

Striped bass *Flounder*

- Tilapia zilli and Tilapia mossambica are among the most salinity-tolerant species. A tolerance for high salinity has been demonstrated in red hybrid tilapia. The red hybrid may become a preferred culture fish in brackish and seawater systems as well as in fresh water.

Tilapia

- International Water Management Institute (IWMI) Pakistan in partnership with WorldFish is implementing opportunities for saline aquaculture in Pakistan project, with funding from the Australian Centre for International Agricultural Research (ACIAR).
- IWMI in collaboration with Pakistan Council of Research in Water Resources (PCRWR) conducted a comprehensive survey of saline fish farmers across four districts, two from Sindh (Thatta and Badin) and two from Punjab (Muzaffargarh and Rahim Yar Khan). These Districts were selected in consultation with stakeholders to identify marginalized saline areas where aquaculture could be improved.
- The results of the project will feed into the policy and scenario analysis of the salinity in Pakistan, as well as inform policy directions for enhancing the production of saline aquaculture in Pakistan.
- PCRWR conducted a research study on saline aquaculture at its R&D Centre Mithi, Tharparkar. With the financial

assistance of The Asia Foundation (TAF), PCRWR developed the earthen fish pond (18 m x 12 m x 1.8 m) under the project "Piloting Climate Smart Aquaculture in Tharparkar for Local Food Security" at Field Research Station, Mithi. The main purpose of the project was to promote food security options in Mithi, Tharparkar through aquaculture and effective use of land and water resources. Twenty fish fingerlings of the varieties namely Rahu Labeo, Silver carp, Mrigal Carp and Grass carp were stocked into fish pond. Saline groundwater having EC between 8.5 – 9.0 dS/m was used to fill the pond.

- The farm yard manure and dry meal was supplied to the fish fingerlings. The cumulative per month application of feeds such as farm yard manure was 7.4 kg/month and dry meal 2.25 kg/month.
- The overall yield of Silver carp was the highest (1275 g/fish) followed by Grass (1093 g/fish), Mrigal Carp (965 g/fish) and Rahu labeo (610 g/fish). However, meal yield of Grass variety was highest (1093 g/fish) followed by Mrigal Carp (965 g/fish), Silver (945 g/fish) and lowest of Rahu labeo (610 g/fish). Silver carp variety had 330 g/fish of egg in his body.
- Hence, for the massive fingerling development, silver carp is recommended for saline aquaculture. However, for meal production and high economic return, grass carp should be selected for saline aquaculture. Fish meal may be procured from the market at the cost of Rs.450/kg. The lesson learnt from the research study is as under:

Lessons Learnt

- Water quality, stocking rate and the quality and quantity of food are most important factors that influence fish growth rate and production.
- All fish species stocked in the fish pond can comfortable live in 8.5 -9.0 dS/m salinity waters.
- To get highest yield along with egg production, silver carp is a good choice. It has good potential to produce the eggs and fingerlings.
- Silver carp is the most suitable fish variety for saline aquaculture.
- Grass carp is suitable for unit weight productivity; it gains more weight and brings higher economic return.
- The saline groundwater needs to be replaced in the pond on daily basis to maintain its DO level.
- After harvesting, the soil settled in the pond bottom may serve as rich source of fertilizer for crops.
- Saline aquaculture is feasible for poorly drained soil as well as in the desert environment.