SALINE AGRICULTURE FARMER PARTICIPATORY DEVELOPMENT PROJECT IN PAKISTAN
Punjab Component

Terminal Report, 2002 - 2008

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PAKISTAN ATOMIC ENERGY COMMISSION
Faisalabad, Pakistan

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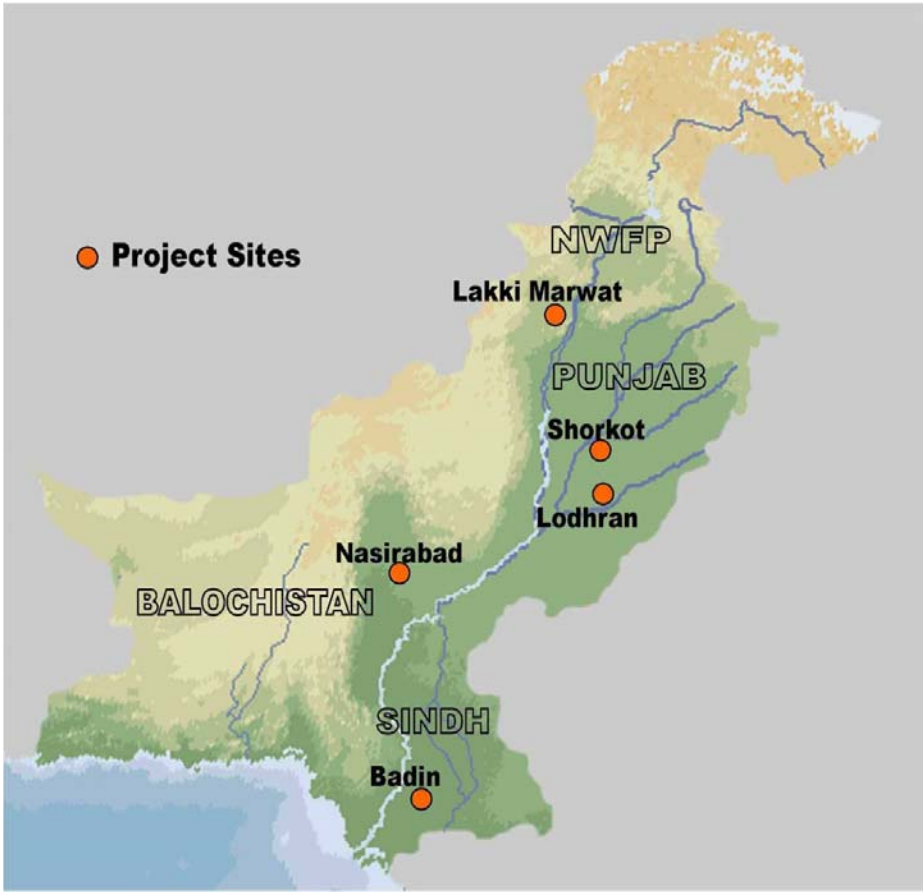

The Saline Agriculture Farmer Participatory Development Project in Pakistan (SAFPDP), sponsored by Government of Pakistan through Ministry of Food and Agriculture, was coordinated and executed by Pakistan Atomic Energy Commission at five sites in four provinces of the country as shown in the map above. The work at the two sites, Shorkot and Lodhran, in Punjab province was coordinated by Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad. This report presents the work undertaken by NIAB under Punjab Component of the SAFPD Project.

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Cover Photo: A view of agro-forestry system (Barley intercropped with *Eucalyptus camaldulensis*) on saline marginal land. In the far background is a compact plantation of an *Acacia* sp. Inset is a view of severely salt-affected wasteland.

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Table of Contents

Foreword

Since its inception, Pakistan Atomic Energy Commission (PAEC) has been committed to the peaceful uses of nuclear and other advanced techniques for economic development and prosperity of the nation. Along with defense and energy sectors, PAEC has also made significant contributions in the areas of agriculture, environment and healthcare. The R&D programs of PAEC Agriculture Institutes are focused on crop improvement, crop protection, fertilizer and water management for major crops, sustainable use of salt-affected wastelands and saline water, food preservation and value-addition, and improving animal health, nutrition and reproduction.

The twin problem of soil salinity and water-logging is one of the major constraints to agricultural productivity in Pakistan. About 6.8 million hectares of land are reported to be affected by varying degrees of salinity and/or sodicity; the groundwater in most of the affected areas is brackish and thus unfit for irrigation of most field crops and forest plants. As reclamation of all saline lands is impractical because of several economic and climatic constraints, PAEC's Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad has been pursuing research to select salt-tolerant plants for cultivation to profitably utilize the otherwise wasted resources: salt-affected lands and saline groundwater. The biomass so produced can be used directly as forage, timber, fuel-wood, and food/feed or even as raw material for agro-based industrial processing. NIAB has convincingly demonstrated various options on its Biosaline Research Stations near Lahore and Faisalabad. However, benefits of the technology can be realized only if it reaches the end-users and is applied on large scale.

With this perspective, the national project funded by Government of Pakistan through Ministry of Food and Agriculture, and executed by PAEC - `Saline Agriculture Farmer Participatory Development Project in Pakistan (SAFPDP)' - has successfully demonstrated NIAB-developed `Saline Agriculture Technology' on farmers' fields through coordinated development activities. This report covers the progress made and experiences gained on site-specific management of salt-affected land and water resources. It is pleasing to note that not only crop yields and farmers' income from salt-affected lands was increased, the land quality also got improved with `Saline Agriculture' interventions. A wide-spread adoption of the technology will certainly help improve socio-economic conditions of the affected rural communities.

Dr. Ansar Parvez
Chairman
Pakistan Atomic Energy Commission

Acknowledgements

The Terminal Report of `Saline Agriculture Farmer Participatory Development Project in Pakistan (SAFPDP)' - Punjab Component is the result of combined efforts of the project staff. Several colleagues from NIAB contributed in successful implementation of the project; colleagues from Soil Science Division deserve special appreciation. The continued support from successive Directors of NIAB over the project period remained the main driving force during project execution.

We are grateful to Government of Pakistan for providing funds and to Ministry of Food and Agriculture for sponsoring this project. Special thanks are extended to Dr. S. Javaid Khurshid, Chief Coordinator SAFPDP (PAEC HQ) for his efforts in facilitating the project activities. The overall support and supervision by PAEC authorities has always been a source of encouragement.

The project activities were dependent on community participation; we acknowledge the cooperation of community leaders, farmers, line departments and local government officials for their cooperation and support during the project execution.

Definitions, Acronyms and Abbreviations

- ***Desertification*** is defined as the diminution or the destruction of the biological potential of the land that can lead ultimately to desert like conditions.
- ***Participatory approach*** may be defined as people taking the initiatives in research and development activities and it is they who decide what is to be done, how, and carry out their decisions.
- ***Poverty*** is pronounced deprivation of well-being related to lack of material income or consumption, low levels of education and health, vulnerability and exposure to risk, viocelessness and powerlessness.
- ***Saline Agriculture*** in essence means, profitably utilizing saline environments by salt-tolerant macro- and micro-organisms for material and environmental gains. For example:
    1. It is the profitable and integrated use of genetic resources (plants, animals, fish, insects and micro-organisms) and improved agricultural practices to obtain better gains from saline land and saline water on a sustained basis.
    2. It is economic utilization of saline environments by developing sustainable and integrated agriculture production systems with salt-tolerant plants (trees, shrubs, grasses and crops), aquaculture, livestock, insects and micro-organisms using appropriate agronomic/irrigation practices. Land reclamation is not a primary objective but may be a fringe benefit in Saline Agriculture.
- ***Saline Agriculture Farmers (SAF)*** are local farmers who have been identified by the social mobilization teams for the project development work.
- ***Saline Agriculture Farmers Association (SAFA)*** is the community organization of Saline Agriculture Farmers in a particular village or site.
- ***Salt-affected land*** is defined as soils having total salt concentration and/or exchange-able sodium sufficient to interfere with the growth of most of the crop plants.
- ***Saline marginal land*** is defined here as partially degraded salinized land that, by using conventional agro-technologies, produces far less biomass (crops, grasses, trees, shrubs, etc.) than is possible from the same land if not salinized.
- ***Saline wasteland*** is defined here as degraded land abandoned by farmers due to acute salinity problem.
- ***Training*** is a deliberately planned learning process for improving people's job performance.
- ***CCB*****:** Citizen Community Board
- ***CBO*****:** Community-Based Organization
- ***EDO*****:** Executive District Officer
- ***SAR*** is sodium adsorption ratio – measure of soil sodicity.
- ***RSC*** is residual sodium carbonate – a parameter for quality of irrigation water.
- ***EC*** means electrical conductivity (dS m^{-1}) used as an indirect measure of salinity level***.***
- ***PCRET*****:** Pakistan Council for Renewable Energy Technologies
- ***GDP:*** Gross domestic production

Saline Agriculture Farmer Participatory Development Project in Pakistan

Punjab Component

Terminal Report, 2002 - 2008

1. Executive Summary

Moderate to severe, primary or secondary, salinity of various kinds adversely affects about 6.8 million hectares of land in Pakistan. Salt-affected soils have been either abandoned (saline wasteland) or provide a patchy and stunted growth of crops (saline marginal land). Annual economic loss due to salinity and water-logging problems has been estimated at more than Rs. 20 billion. Therefore, the problem of salinity and water-logging directly affects living standard of people. In this context, Government of Pakistan (GoP) has spent billions of rupees on hydro-engineering approach for combating salinity and water-logging but the results were not encouraging and sustainable.

Pakistani scientists have done pioneering research to develop alternative approaches to live with salinity for economically utilizing salt-affected lands which led to the development of the concept of **Saline Agriculture**. Saline Agriculture is defined as a profitable and integrated use of genetic resources (plants, animals, fish, insects and micro-organisms) and improved agricultural practices to obtain better production from saline land and saline irrigation water on a sustainable basis without employing costly reclamation measures.

Realizing the need to educate the end-users, i.e., farmers, to popularize Saline Agriculture Technology, GoP sponsored a country-wide outreach project, namely **Saline Agriculture Farmer Participatory Development Project in Pakistan (SAFPDP)**, in 2002 as a pilot activity for the purpose. Pakistan Atomic Energy Commission executed this project in all four provinces of Pakistan. Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad, implemented the Punjab Component of the project in Shorkot and Lodhran.

Before commencement of the project, a base line survey was conducted to assess the salinity, sodicity and drainage status at the project sites. It was observed that majority of the soils were salt-affected having moderate to severe problems of salinity, sodicity and pH. Almost all soils had low permeability because of high clay and sodicity levels. Canal irrigation water was in short supply; the canals were either non-perennial or did not receive water share of the system design. Groundwater was brackish and unfit for conventional agriculture.

Situation Analysis for socio-economic conditions, done in collaboration with National Rural Support Program (NRSP), revealed that, in general, the project areas had immense socio-economic problems. Crop production levels were very low, and livestock was underfed and malnourished. At places, soil salinity had badly affected civil infrastructure; many buildings and roads had crumbled prematurely. The farmers had a little access to farm machinery and improved agro-technologies. Majority of the people did not have access to education, basic health facilities, clean drinking water and other basic amenities of life. Sanitation system was non-existent or was sub-standard. As a result, incidence of diseases was high in both humans and livestock. With these sorts of scenarios, SAFPDP development activities were geared towards education of farming communities and problem-solving interventions through integration of knowledge and site-specific fine tuning of agro-technologies to create more

productive farming systems including crop-livestock and agro-forestry systems in the saline environments.

The project staff was catered a comprehensive orientation-training on Saline Agriculture which was, in fact, a train-the-trainers exercise, so that the staff could subsequently train the project farmers. SAFPDP developed Social Infrastructure by organizing farmers into village-level and site-level Saline Agriculture Farmers Associations (SAFAs). The farmers were provided farm machinery, seeds/saplings of salt-tolerant plants, fish seed, feed blocks and animal vaccines and other agricultural inputs either free of cost or on highly subsidized rates.

SAFPDP staff organized awareness seminars, vocational training courses, skill development programs and farmer field schools to educate the farming communities on all aspects of Saline Agriculture Technology. Training/skill development programs included participatory nursery raising, planting techniques on salt-affected soils, appropriate agronomic and irrigation practices for economic utilization of salt-affected soils and brackish groundwater, use of amendments like gypsum and mineral acids for the improvement of salt-affected land and brackish waters, grafting techniques and plant production technologies, use of salt-tolerant plants, animal healthcare, vaccination against animal diseases and preparation of urea molasses feed blocks, honeybee keeping and saline aquaculture. Farmer field schools were basically meant to educate farmers on production technologies of different crops and use of friendly insects for pest control to save on pesticide application. Knowledge sharing was also done with farmers, extension workers and interested persons elsewhere, through brochures, newsletters, print and electric media and a website, www.sem.org.pk.

With active participation of farming communities, Saline Agriculture Technology was demonstrated on 5560 acres at Shorkot and 5070 acres at Lodhran. SAFPDP also had a very good fallout effect in areas adjacent to the project sites. As SAFPDP was mandated to work on 5000 acres at each site, the actual progress exceeded its targets in the Punjab province.

Saline wasteland was planted with trees, shrubs and/or grasses for the production of food, forage, fuel and a range of industrial products on commercial basis i.e., livestock products, fish, honey and paper pulp, etc. Most importantly, livestock number and aquaculture enterprises rose sharply, promoting high-value agriculture. For example, maximum income (up to Rs. 40,000 per one-acre fish pond) by farmers was obtained by adopting Saline Aquaculture. Cropping systems on saline marginal land were improved with the use of salt-tolerant crop varieties, judicious use of soil and water amendments and improved agronomic/irrigation practices. As a result, yield of field crops rose sharply: wheat yield from 1.0-1.2 to 2.2-2.5, rice from 1.6-1.8 to 2.5-2.75, cotton from 1.2-1.5 to 2.5-3.0, and sugarcane from 35-40 to 48-55 tons per ha. The forage production systems were diversified and yields increased in case of all forage crops. SAFPDP also acted as a conduit for relevant departments in introducing biogas technology and improving water channels and streets/roads in the project areas.

With Saline Agriculture interventions, plant production and, thus, farmer income increased substantially, contributing towards food security and poverty alleviation at the project sites. Chemical properties of soils also improved with Saline Agriculture interventions, i.e., reductions in ECe, pH and SAR. Thus, quality of land and hence its capability and capital value were improved greatly. It is emphasized that because of re-vegetation efforts, Saline Agriculture could also be a potential strategy for reducing CO_2 in the atmosphere in degraded salt-affected areas, and thus tackling in one go, the human-induced climate change and land degradation.

SAFPDP was instrumental in socio-economic uplift and prosperity of rural communities in the project area. Total and crop-wise cultivated area in each village, farm machinery, lining of water courses and quality of life of farmers, as implied by social indicators like income of farmers, on- and off-farm livelihood, overall poverty ranking, and education status, etc. were improved appreciably. A large number of farmers from outside the project areas, scientists and other relevant persons of national and international origin also visited the project areas, with a take home message that Saline Agriculture Technology can help in tackling saline environments on a profitable and sustainable basis. Thus, SAFPDP effectively demonstrated that Saline Agriculture can improve the lives of rural communities within a short span of time.

2. Introduction

On the outset, a few lines from an open letter by head of United Nations Development Program, Islamabad to President of Pakistan appear appropriate to set the stage for this community development-oriented result-based endeavor, i.e., “Development is much more than economic growth, rather it is first and foremost about people, their choices in life and full realization of their potential. A focus on people is essential for the design and execution of development programs. Only prosperity for its people can ensure Pakistan’s future”. In our understanding, the message of this letter is especially applicable to salt-affected and other degraded environments in Pakistan (please see Section 3), where farmers are extremely resource-poor, voiceless and ignorant of advances on modern agricultural practices.

Government of Pakistan has spent billions of rupees on hydro-engineering approach (Salinity Control and Reclamation Projects, SCARPs and National Drainage Program, NDP) for combating salinity and water-logging but the impact remained discouraging and non-sustainable. `Saline Agriculture Technology’ (detail given in Section 3) is an interim, alternative cost-effective solution to salinity and may be profitably applied for economic utilization of our saline environments, till an engineering solution of the problem becomes achievable. Dissemination of Saline Agriculture Technology to the farmers appeared difficult through traditional agriculture extension system in the country. (Various problems of agriculture extension in Pakistan are explained in Annexure - 1). Therefore, there was a clear need to undertake a program for demonstrating Saline Agriculture development/ extension work.

The letter quoted at the outset also implied the need for establishment of agricultural outreach institutions with the required organizational and technical adjustments and the need for training activities to the extensionists and farmers. Thus, it was important to establish a network of field teams to educate and re-educate farmers at the farm/village level about the importance of the soil, water and crop management practices and animal husbandry. This prompted the Government of Pakistan to undertake an outreach project, namely `Saline Agriculture Farmer Participatory Development Project in Pakistan (SAFPDP)’. Pakistan Atomic Energy Commission (PAEC) executed this model project, simultaneously in all four provinces of Pakistan on 25000 acres of land, from July 2002 to June 2008.

With an overall objective of popularizing Saline Agriculture Technology by educating and helping farmers in developing Saline Agriculture production systems, SAFPDP aimed at rehabilitation of wastelands in saline environments and, thus, improving farming communities through the profitable integrated use of genetic resources (plants, animals, fish and insects) and improved agricultural practices. The project was implemented with the active involvement of farmers in decision-making and by sharing relevant technologies with them, thus ensuring utilization of salt-affected soils and brackish groundwater on a sustained basis. This report describes the activities, achievements, socio-economic impact of Saline Agriculture on farming communities.

3. Salinity Problem and Saline Agriculture Technology

Agriculture in Pakistan suffers from several problems including moderate to severe land degradation. Common forms of land degradation are salinity and/or sodicity, water-logging, soil structure deterioration, soil fertility depletion, surface sedimentation/burial, soil erosion, surface scraping/excavation and soil contamination. Therefore, in general, crop and animal productivity per unit land area is low, particularly on small land holdings.

3.1. Salinity Problem

The salinity problem in Pakistan has been ranked highest among the factors badly affecting agricultural production in Indus Plain − the prime agricultural land in the country. Moderate (saline marginal land with generally poor crop yields; Fig. 1) to severe (saline wasteland with no or scanty growth of plants; Fig. 2) primary or secondary salinity problem affects about 6.8 million hectares of land in Pakistan. The crux of the problem is salt-affected and/or water-logged farmland resulting from faulty irrigation system/practices. Crop and animal productivity is low in these areas. The economic loss, so incurred, has been estimated around Rs. 20 billion per annum.

Salinity is an inherent problem of arid and semi-arid areas all over the world. Salts occur naturally in soils. Rains may dissolve these salts and sweep through streams and rivers to the sea. Where rainfall is sparse or there is no quick route to the sea, some of this water evaporates and dissolved salts become more concentrated. In arid areas, this can result in the formation of salt lakes or in brackish groundwater, salt-affected land, or salt deposits,

Fig. 1. Patchy growth of cotton (left) and rice (right) on saline marginal lands.

Fig. 2. Saline wasteland with patchy growth of rough grasses (left) and *Suaeda fruticosa* (right).

creating the worst environmental problems. Moreover, irrigation employed to bring land in arid areas into production, has often led to water-logging and salinization of productive land. The ill effects of salinity problem include low plant productivity and in some cases death of plants, either due to salt toxicity or reduced uptake of water by plants or indirectly due to deterioration of soil structure.

Salinity and water-logging problem is implicated in decline of several ancient civilizations. At present, it is threatening the agricultural production system of developing countries in arid and semi-arid areas; 25% of the Indus Basin, 40% of Nile Delta, almost 50% of the irrigated areas of some countries in central Asia, most of the Mesopotamian plain and substantial areas in North Africa are affected by moderate to severe salinity problem. Not to mention many of the poor and undernourished live in these areas. Populations are growing so quickly that the land and water resources are unable to sustain them; prime farmland and fresh water are already fully utilized. There is a clear need to bring salt-affected land and water resources into production.

3.2. Saline Agriculture Technology

Traditional efforts focus on modifying the environment to suit the plants for combating salinity and/or water-logging. Therefore, a successful, complete and durable solution of salinity and water-logging problem is considered in developing a comprehensive system of leaching and drainage of excess salts and water from the soil. Successful reclamation of the affected land is, indeed, preferable in terms of resource conservation. However, such a solution of salinity problem is expensive, energy intensive, time consuming and beyond the socio-economic and technical resources of the developing countries like Pakistan. Moreover, reclamation of salt-affected land requires large amounts of water (which is not available) to leach away salts before conventional crops can be grown.

An alternative to the traditional leaching and drainage solution could be in developing and adopting methods to live with salinity. In this context, PAEC and some other organizations have significantly contributed towards the development of a low input Saline Agriculture Technology. This technology provides a cheap alternative on interim basis for utilizing salt-affected and/or water-logged land and brackish groundwater too saline for irrigating conventional crops, without employing costly reclamation measurers. Since Saline Agriculture is a low input technology, it is very appropriate under socio-economic conditions of the developing countries for the utilization of brackish groundwater and salt-affected soils, for developing farming systems involving Agro-forestry and Animal Agriculture on a sustained basis.

Saline Agriculture Technology places prime emphasis on the selection and introduction of multipurpose salt-tolerant plants with desirable characteristics, salt-tolerant crop varieties which can match the saline environments, can utilize land and water resources too saline for conventional crops and can withstand other adverse conditions like drought. In most cases, salt tolerance in plants enables them to produce yields under saline conditions that are comparable to those obtained from salt-sensitive crops grown under non-saline conditions. Emphasis is also placed on use of suitable soil and water amendments, environment friendly fertilizers and suitable agronomic/irrigation practices that can help utilize salt-affected soils and brackish groundwater successfully.

Maximum amount and kind of salts that can be tolerated by salt-tolerant plants vary among species and even varieties of a species. While salinity reduces the growth of most plants, many salt-tolerant plants have a special and distinguishing feature; low levels of salt improve their growth and their products may have a better quality. Higher yields of cotton, better quality tomatoes for the canning industry, and quality melons in slightly saline environments, are a case in point. Salt-tolerant plants may also require special care. Each species has its own peculiarities of germination, growth, harvest, and processing. Some salt-tolerant plants require fresh water for germination and early growth but can tolerate higher salt levels during later vegetative and reproductive stages. Some can germinate at high salinities but require lower salinity for maximal growth. Salt-tolerant plants are core component of Saline Agriculture Technology; therefore, some information on selection method and salt tolerance in plants is given in Annexure - 2.

It is emphasized that introducing new crops is always risky. Undomesticated salt-tolerant plants usually have poor agronomic qualities such as wide variations in germination and maturation. The foliage of salt-tolerant plants may not be suitable for fodder because of its high salt content. Some salt-tolerant plants have alkaloids, resins, essential oils, pharmaceutical feedstock and other unusual compounds. Nutritional characteristics or even potential toxicities have not been established for many edible salt-tolerant plants. But given their promise to help meet the needs of developing countries, attention on salt-tolerant plants seems increasingly justifiable. Exploration for new species for the selection of desired genotypes, from a wide range of natural variability in individual salt-tolerant plants should continue. Recent advances in plant biotechnology include work on salinity tolerance and productivity and may assist to identify suitable plants.

Growth of a plant is subject to numerous agricultural and environmental effects. Interactions between salinity and various soil, water, and climatic conditions all affect the plants' ability to tolerate salt. When unfamiliar plants are introduced where land, water, and climate are hostile, difficulties are compounded. Most particularly, when saline irrigation water is used for crop production, careful control is necessary to avoid salt buildup in the soil and to prevent possible contamination of fresh water aquifers. Therefore, interdisciplinary communication is important in further research on sharpening Saline Agriculture Technology. Cooperation among plant ecologists, plant physiologists, plant breeders, soil scientists, and agricultural engineers could accelerate further developments in the technology.

Despite above apprehensions, it may be argued that the agricultural use of saline water or soils can benefit many developing countries for the economic production of food, forage, fuel, fiber, and other commercial products. The introduction of Saline Agriculture Technology may not necessarily restore the soil to the point that conventional crops can be grown, soil is often improved and erosion is reduced. Salt-affected farmland can thus be used without costly remedial measures.

The agricultural development strategy of Pakistan at present includes:

- Obtain higher production growth rate to ensure food security, self sufficiency and export surpluses.
- Increase productivity of crops, livestock, fisheries and forest sectors.
- Evolve an export-oriented strategy to exploit export potential.
- Conserve and develop natural resources.

Rehabilitation of salt-affected soils with Saline Agriculture Technology can contribute towards achieving all these objectives.

4. Saline Agriculture Farmer Participatory Development Project in Pakistan (SAPFDP)

4.1. Objectives

The main objectives were to:

1. Disseminate and optimize Saline Agriculture Technology with active participation of farmers, line departments, community-based organizations (CBOs) and local students.
2. Maximize economic returns from salt-affected soils by diversification and value-addition to farm products.
3. Mitigate salinity-associated poverty and food insecurity in rural areas.
4. Improve quality of national development programs through nuclear techniques.
5. Reverse environmental degradation and enhance aesthetic value of wastelands.
6. Training and capacity building in the communities ensuring gender equity for the realization of the above objectives.

4.2. Progress

SAFPDP had both social and physical dimensions. The Punjab Component of the project focused on education of farming communities and problem solving through integration of knowledge and site-specific fine-tuning of agro-technologies to create more productive farming systems including crop-livestock and agro-forestry in saline environments. SAFPDP helped farmers develop Saline Agriculture enterprises on a substantial area. In addition, it also acted as a forum for discussion meetings of multidisciplinary researchers, extensionists, NGOs, educationists and farmers. They helped identify the constraints and search for potential solutions, evaluate different options and suggest strategies for improving the agricultural production, with emphasis on catering the needs of farmers. A brief description of SAFPDP activities and progress made on social and technical sides at project sites, Shorkot and Lodhran, in Punjab is given below.

4.2.1. Surveys

4.2.1.1. Selection of Sites for SAFPDP in Punjab

The selection of sites in Punjab was done in consultation of Ministry of Food and Agriculture and National Rural Support Program (NRSP). For this purpose, visits were made in rural areas of Toba Tek Singh, Shorkot, Bahawalnagar, Bahawalpur, Fort Abbas, Multan, Lodhran, Rahim Yar Khan and Dingarh in Cholistan. Later, three sites in Punjab, one each in Shorkot, Lodhran and Rahim Yar Khan were short listed for detailed salinity and drainage survey. Following the socio-economic surveys conducted in consultation of NRSP, Shorkot and Lodhran sites were selected for development work under SAFPDP. Shorkot site is located near Shorkot Cantonment and is irrigated by the tail of Jhang Branch of Lower Chenab canal. Lodhran site is located midway between Lodhran and Dunyapur and is irrigated by Basantpur Distributary of Mailsi canal.

4.2.1.2. Salinity and Drainage Survey

The salinity and drainage survey of more than 5000 acres of land at each site in Shorkot, Lodhran and Rahim Yar Khan was completed before the commencement of development work. The salinity/sodicity problem was widespread with visible efflorescence of salts on the surface or uneven crop growth in cultivated fields. High/moderate salinity/sodicity and pH levels were later confirmed with laboratory analyses of collected soil samples. Generally speaking, substantial part of the surveyed area at the above-mentioned sites was highly salt-affected and barren (saline wasteland) with no or scanty growth of low nutrition halophytic species. Some moderately salt-affected area was under crops, mainly cotton-wheat and rice-wheat cropping systems (saline marginal land), with generally poor crop yield.

Soils, in general, were clayey, belonging to the moderately fine and fine textural groups and, therefore, likely to be slowly permeable, having a severe drainage problem and thus prone to water-logging, when irrigated. These soils would also be problematic for seed-bed preparation. It is emphasized that the project areas were served either by a non-perennial irrigation system and/or did not get due share of water of the system design. Water deficit was a chronic problem. The groundwater was of very poor quality and farmers were in compulsion to irrigate their crops with brackish groundwater, enhancing land degradation and damage to crops.

4.2.1.3. Socio-Economic Survey

The farmers at Shorkot and Lodhran sites have small land holdings. The survey conducted in collaboration with NRSP revealed that these areas had immense socio-economic problems. The farmers had a little access to farm machinery and improved agro-technologies. Crop production level was very low, and livestock was underfed and malnourished. Majority of the people did not have access to education, basic health facilities, clean drinking water and other basic amenities of life. Sanitation system was non-existent or was sub-standard. As a result, incidence of diseases was high in both humans and livestock. Soil salinity had badly affected civil infrastructure. Many buildings and roads had crumbled prematurely.

4.2.2. Action Plan

The 'Action Plan' of SAFPDP was formulated upon the conclusion of a 'Situation Analysis' involving farmers, comprising a socio-economic and a salinity and drainage survey. So it was participatory and consensus-based and incorporated most current issues confronting farming communities in saline environments, and the required actions for their resolution. Working closely with farming communities, technology transfer chains (CCBs, extensionists and NGOs) were the hallmark of SAFPDP. Therefore, the project execution was in line with the policy of GoP for a participatory NGO-based strategy for rural development and development agenda of international agreements and conventions that provide for the involvement of civil society, the private sector and government agencies in the development process. Some more detail on SAFPDP and how SAFPDP worked is given in Annexure - 3.

4.2.3. Human Resource Development

Agricultural development is a function of farming communities. The more farmers are educated (men, women and youth), more the development becomes dynamic and evolutionary. For introduction and transfer of Saline Agriculture Technology to end-users, communication was ordered at different levels ranging from awareness seminars, training and skill development programs and knowledge sharing on latest researches with the line departments and farming communities and finally through a participatory development process designed to bring about a behavioral change. SAFPDP organized miscellaneous awareness seminars, vocational training courses, skill development programs and farmer field schools to educate the farming communities on all aspects of Saline Agriculture.

4.2.3.1. Orientation/Training of Field Officers

On outset of project activities, a comprehensive multidisciplinary orientation/training course on Saline Agriculture and related technologies was organized at NIAB Faisalabad in 2002, for SAFPDP field officers from all four provinces. It was, in fact, a train-the-trainers exercise as these officers were subsequently to train the farmers on their turn. The contents of the training course are presented in Annexure - 4. At the end of the training, the participants were given a test; the successful candidates were awarded the certificates (Fig. 3).

Fig. 3. A Field Officer receiving training certificate from the Chief Guest.

4.2.3.2. Organization of Farming Communities

The fundamental importance of farmers' participation in managing agriculture problems can never be over emphasized. Since SAFPDP advocated a bottom-up approach, it was needed to involve farming communities, in the decision making and to be empowered in the long run. It was a transformational change in thinking based on new practices and new forms of community engagement, through investment in human and social capital. For this purpose, SAFPDP developed social infrastructure by organizing project farmers as Saline Agriculture Farmers Associations (SAFAs). SAFAs periodically conducted business meetings with project staff to catalyze the development work and to provide feedback to them (Fig. 4). SAFAs were organized at two levels: Lower SAFA and Upper SAFA. Lower SAFA was a group in a village with familial ties and dealt with farm-level problems of Saline Agriculture Farmers (SAF). Upper SAFA was a type of federation of lower SAFAs, and dealt with strategies and policies being pursued by SAFPDP. SAFAs were elected bodies, having their community chosen office bearers such as Chairmen, Secretaries and Treasurers.

The project staff trained these SAFA members, on almost all relevant aspects of community development and Saline Agriculture related technologies. With time, some of these community leaders became reasonably experienced to further the project objectives more fully. In due course of time, SAFAs might be acting like civil societies, capable of designing their agendas, with some support form technical persons, in planning and executing programs to solve their problems, and seek independent funding on their own. Towards this end, SAFAs were got registered as Citizen Community Boards (CCBs) and some, in deed, started applying for funding for development in their areas. Advantages of involving communities in development work in more detail are discussed in Annexure - 5.

Fig. 4. View of community meetings organized by SAFAs in the project areas.

4.2.3.3. Awareness, Skill and Vocational Training

Farmers' knowledge and constraints are key factors in the success of any management option. Therefore, it was needed to educate farmers on optimal land and water use, and to be convinced of the economic benefits of adopting required management practices. For this purpose, SAFPDP conducted awareness seminars on Saline Agriculture Technology and vocational training courses, for a wide range of participants at Shorkot and Lodhran and in adjacent towns in association with local governments and NGOs.

Also conducted were a series of practical training courses (Figs. 5 & 6; Table 1), for imparting training to the farmers, on participatory nursery raising, planting techniques on salt-affected soils, use of amendments like gypsum and mineral acids for the improvement of salt-affected land and brackish waters, grafting techniques and plant production technologies, animal healthcare, vaccination against livestock diseases and preparation of urea-molasses feed blocks, honeybee keeping and saline aquaculture. Special training courses conducted by SAFPDP for lady SAFAs were on kitchen gardening, tailoring/ embroidery, smoke-less stoves and food processing.

Fig. 5. A training course for farmers.

Fig. 6. A view of training course for females, on smoke-less stoves.

4.2.4. Supply of Inputs

4.2.4.1. Tree Saplings/Seeds and Other Material Support

NIAB has a modest inventory of selected salt tolerant plants. Tree saplings (Fig. 7), planting material of grasses, and seeds of salt tolerant crop varieties and some other inputs like urea-molasses feed blocks and vaccines and labor for planting trees were provided to the farmers. Moreover, some support with tractors and farm implements including costly equipment such as laser land leveler, either free or on token rates was also provided to the farmers.

Fig. 7. Tree saplings in a project nursery.

Table 1. Summary of Awareness, Skill Development and Other Training Programs conducted in Shorkot and Lodhran project areas.

Sr. No.	Nature of Trainings
1	Awareness seminars on Saline Agriculture (Two at each site)
2	Hands-on training on nursery raising
3	Training on planting techniques in Agro-forestry
4	Training on Budding and Grafting in Fruit Plants to Field Assistants of the project
5	Vaccination techniques and preparation of Urea Molasses Feed Blocks for livestock
6	Training course on Aquaculture by Fisheries Research Institute, Lahore
7	Demonstration and hands-on training on Laser Land Leveling by Water Management Department, Toba Tek Singh
8	A training course for farmers and staff on Livestock Production, Feed and Disease Management
9	Exposure visit for farmers of the Shorkot site area to SAFPDP site in Lodhran
10	Participation in Seminar on Drip Irrigation System at NIAB, Faisalabad
11	A training course for farmers on Blue revolution in Saline areas and an exposure visit to BSRS, Pakka Anna
12	A training course on Honey Bee Keeping
13	A training course on Nursery Raising
14	A training course on livestock production and planting techniques
15	A training course on Saline Aquaculture
16*	Training courses on Food Processing: Squash, Jam and Ketchup preparation (Five)
17*	Training courses on kitchen gardening and tailoring (Two)
18*	Training course on preparation of smoke-less stoves (Three)
19*	A training course on livestock diseases

*The courses/trainings exclusively for female farmers.

SAFPDP also sponsored for its farmers detailed training courses on livestock husbandry at Animal Research Station, Bahadarnagar (Okara) and on Aquaculture at Fisheries Research Institute, Lahore. Farmer field schools were held for imparting training to the farmers from time to time on production technologies for major crops and integrated pest management (IPM) to replace or reduce the use of chemicals in pest control and maintain soil fertility with judicious use of environment friendly chemical fertilizers. With these activities, the capacity of farmers in handling salt-affected soils and use of some supplementary technologies was substantially increased.

4.2.4.2. Friendly Insects for Pest Control

Studies done on farmers' fields on use of friendly insects to reduce pest attack and by implication pesticides clearly showed that application of pesticides could be substantially reduced and thus money was saved by the farmers. If these techniques can be applied on a large scale on contiguous tracts, worth of the program can be observed more fully. Pakistan is importing pesticides annually worth Rs. 800 billion, polluting environment; more than 80% pesticide is used on cotton crop. Use of friendly insects by SAFPDP has been, therefore, mainly on cotton followed by sugarcane crop.

4.2.4.3. Installation of Tube-wells

SAFPDP installed 22 tube-wells at project sites in Shorkot and Lodhran. While SAFPDP provided the material, SAFAs collectively bore the expenditure on installation of tube-wells. These tube-wells were propelled by diesel engines. Farmers using the tube-wells arranged POL. A success in collective use of tube-wells, their repair and maintenance, POL arrangement and security of tube-wells by farmers is a noteworthy achievement.

4.2.4.4. Lining of Water Channels

The water channels at the commencement of SAFPDP in Shorkot and Lodhran were not in a good shape. These were not straight, too deep at certain places and shallow and wide at other places. Large amount of irrigation water was wasted in these channels. SAFPDP helped bring these channels in proper shape (Fig. 8), and got them brick lined with kind cooperation of Water Management Department, Government of Punjab. Overall nine water channels were corrected at Shorkot and Lodhran. With this improvement, availability of irrigation water for agriculture at the project sites was increased substantially.

Fig. 8. An improved water channel in a project area.

4.2.5. Physical Progress

SAFPDP made an excellent progress by helping farmers in developing Saline Agriculture production systems on 5563 acres at Shorkot and 5067 acres at Lodhran, with a range of interventions suited to the site-specific conditions. Salt-tolerant plants, trees and miscellaneous forages were introduced. Existing cropping systems were diversified. Trees can be grown as mono-culture (compact plantation of trees or shrubs or single crops), bi-culture (e.g., silvipastoral and agro-forestry) or poly-culture (combination of several types of plants). Progress made with tree planting and improvement/diversification of cropping systems and other related interventions is summarized in Table 2. SAFPDP also had a very good fallout effect in areas adjacent to project sites. SAFPDP was mandated to work on 5000 acres at each site. Therefore, with the above mentioned progress, SAFPDP (Punjab Component) exceeded its targets. The following sections briefly describe the extent and nature of various Saline Agriculture interventions along with their impact and problems faced.

4.2.5.1. Compact Plantations

A tractor mounted post-hole digger was used to establish compact plantations of salt-tolerant, multipurpose trees. (Different types of benefits of trees (economic, environmental and aesthetic) are described in Annexure - 6.) Suffice here to say that like most of the developing countries, rural people in Pakistan rely on wood for cooking and heating and spend increasing amount of time and money to acquire fuel. Some trees also provide forage to rural communities.

Acacia and *Casuarina* species are among the most salt-tolerant trees studied for salt tolerance at NIAB. *Acacia nilotica* and *Acacia ampliceps* have shown potential for forage and fuel production on salt-affected soils. Therefore, these species were tried on large scale on farmers' fields (Fig. 9). There were some disappointments in the early stages due to failures in case of compact plantations. However, success rate substantially improved later. The reasons observed for earlier failures were:

1. In general, farmers showed a pathetic attitude towards trees. Farmers showed very little interest in providing irrigation water and protection from animals and weeds to trees planted by SAFPDP.

2. The farmers provided most problem land for tree plantations and failures occurred in most cases on soils, very clayey or having dense sub-surface layers, extending to greater depths. Some soils were so hard that the tractor with 85 HP engine could not easily push a post-hole digger, into the soil. There was only a brief period suitable for planting. Special preparation such as furrowing, ridging and mulching was required in addition to application of gypsum and some nutrients as a starter dose, to facilitate early growth. Unfortunately, gypsum and fertilizers could not be purchased and applied in some cases at the time of planting of tree saplings. Therefore, establishment of tree saplings became difficult on some dense salt-affected soils.

Table 2. Area covered (Acres) by different Saline Agriculture interventions in Shorkot and Lodhran.

Nature of intervention	**Area covered (Acres)**	
	Shorkot	**Lodhran**
Trees (compact plantations)	363	333
Agro-forestry	613	123
Kallar grass	178	201
Other forages	618	652
Crops	101	315
Wheat	2306	1768
Rice	516	205
Cotton	245	517
Sugarcane	145	–
Cropping system diversification	15	12
Fish ponds	86	12
Biopower	5	5
Plowing/Deep Tillage	122	201
Leveling/Laser land leveling	720	1121
SAG/Gypsum application	1250	1208
Zero tillage sowing	133	334
Bed and corrugation sowing	40	157
Total area	***5563***	***5067***

Fig. 9. Compact plantations of *Acacia ampliceps* (left) and *Acacia nilotica* established on saline land.

3. In most cases, death of plants was observed after 12-15 months of growth. Exact cause of death of plants was not known. The leaves of dying plants turned yellow and roots were found confined in the holes in bunch form. Probably the roots could not penetrate into dense/compact soil and died due to suffocation. This hypothesis is supported with observations of good growth when *Acacia ampliceps* plants were planted on raised beds.

4. Choice of wrong tree species, because of farmers' insistence in some cases, led to failure of plantations, e.g. *Zizyphus* sp. (*BERI*) on saline wasteland and *Acacia ampliceps* on hard and laminated clayey soils.

5. Being water deficit areas, termite attack in some cases was severe that killed the plants.

Notwithstanding these difficulties, the survival rate for tree growth later improved, because:

1. With prolonged social mobilization and education by SAFPDP, farmers better appreciated the value of trees.

2. With experience gained in the last few years, choice of species by farmers improved.

3. Method of planting was improved with bed planting on dense clayey soils.

It is to be emphasized that chemical properties of soil, reasonably improved with compact plantation of trees, because of reductions in ECe, pH and SAR (Fig. 10).

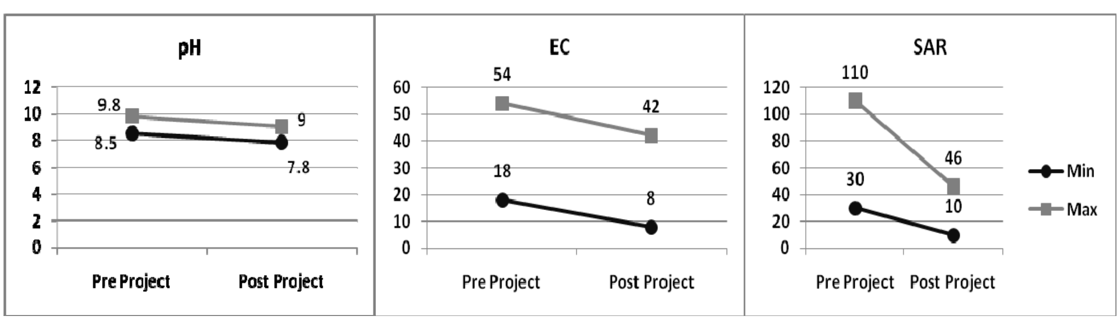

Fig 10. Pre- and post-planting ranges of soil properties of a field with *Acacia ampliceps* plantation.

4.2.5.2. Agro-forestry

Attempts were also made to develop agro-forestry systems for combining the benefits from salt-tolerant trees (long-term and environmental benefits) and crops (short-term economic benefits). Trees and shrubs can also serve purposes other than only to provide fuel or forage or any other economic goods. They can reduce wind erosion, protect in between crops, and serve as a first step in land restoration. Saplings of trees can also be planted as living fences.

Trees planted, as agro-forestry systems in the beginning also met with a pathetic attitude from farmers like that observed in case of compact plantations. However, awareness increased among farmers on the wisdom of growing trees with crops. Near the conclusion of the project, more and more farmers were demanding that trees be planted on their saline marginal land along with crops. It is emphasized that reductions in ECe, pH and SAR of soil were greater in agro-forestry systems than in the compact plantations (Figs. 10 & 12).

Fig. 11. Agro-forestry: *Eucalyptus* and Barley.

This may be due to the reason that farmers cared more for their crops in agro-forestry systems with better irrigations, use of amendments and fertilizers, which effected a greater soil improvement compared with planting of only trees.

During the project period planted trees were not yet ready for harvesting, hence their commercial value is not known. However, theoretical calculations shown in Tables 3-6 suggest that tree plantation on salt-affected land as compact plantations or in agro-forestry systems may be quite cost-effective.

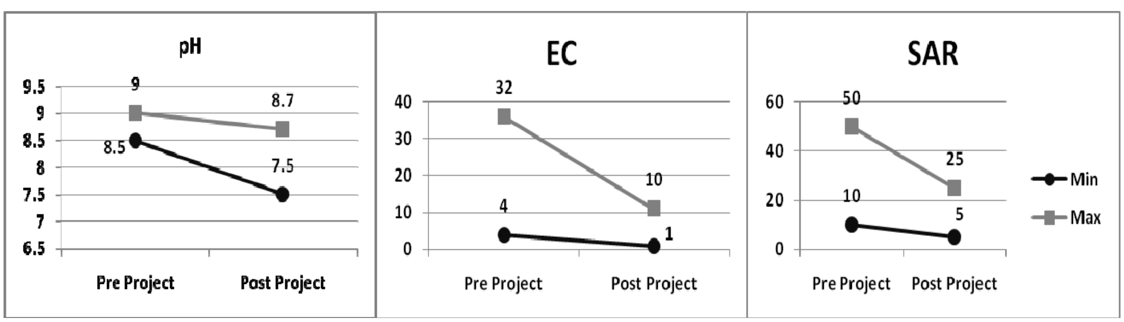

Fig. 12. Pre- and post-planting ranges of soil properties of a field with an agro-forestry system involving *Acacia nilotica* and wheat.

4.2.5.3. Forages

Salt tolerant grasses are a potential source of forage. A good progress was made to expand a badly needed forage base in the project areas. This was made possible by promoting Kallar grass (*Leptochloa fusca*) cultivation (Fig. 13) and some other forage plants. Kallar grass is an ideal plant as a primary colonizer for economic utilization of salt-affected soils, irrigated with brackish ground water. More than any other forage grass, it tolerates salinity, water-logging and high pH, etc. and recovers well from cutting and grazing.

The economic value of Kallar grass as a forage for buffaloes and goats has been well demonstrated by NIAB. It also needs to mention that Kallar grass, not only provides forage for animals, land under this grass rapidly improves, within 2-3 years (Fig. 14) and farmers can start growing lesser salt tolerant crops on land vacated by Kallar grass.

Successful campaigns were also made to increase the cultivation of some other forage crops (e.g., *Sorghum* and *Sesbania*) on saline cultivated land for increasing the number of livestock in the project areas.

Fig. 13. Kallar grass is a good source of forage on salt-affected soils.

It is emphasized that the project areas were forage-deficit areas and at the commencement of SAFPDP some farmers were importing forage from other areas to feed their animals. When SAFPDP was terminated, a very good forage base with salt tolerant plants at the project sites was almost developed. Chemical properties of soil under other forages also improved but the effect was not as great as in case of Kallar grass.

Some trees and shrubs are salt-tolerant and can also provide forage. Therefore, trees and shrubs could be valuable components of grazing lands and can serve as complimentary forage sources to grasses in saline environments. Some success was achieved with trees to provide forage to compliment forage crops.

Table 3. Cost estimate of compact plantation with 726 plants of *Acacia nilotica* per acre (Spacing: 6 feet x 10 feet).

Item/Activity	Input required	Unit cost	Cost per acre (Rs.)
First year charges			
Field leveling	4 Tractor-hours	Rs. 400/- per hour	1600
Plowing	Twice	Rs. 350/- per acre	700
Layout	2 Man-days	Rs.250/- per person	500
Ditching	5 Tractor-hour	Rs. 400/- per hour	2000
Holing	–	Rs. 1000/- per acre	1000
Gypsum	8 bags 0.5 kg per plant	Rs. 65/- per bag	500
Farm yard manure	Half trolley	Rs. 2000/- per trolley	1000
Saplings	800 Nos.	Rs. 3/-	2400
Labor Charges	4 Man-days	Rs. 250/- per person	1000
Irrigations	24 Nos. *each fortnight	Rs. 500/- per irrigation	12000
Weeding	4 Man-days	Rs. 250/- per person	1000
Unforeseen	–	–	1000
Second year charges			
Irrigations	12 * monthly	Rs. 500/- per irrigation	6000
Restocking	–	–	800
Unforeseen	–	–	1000
Total charges of two years			32,500

Table 4. Estimated sale price of *Acacia nilotica* trees after 10 years of growth.

Tree category	No. of trees	Sale price per tree (Rs.)	Total Price/Income (Rs.)
Good trees 10th year	200	700	140,000
Medium trees 6th year	300	500	150,000
Small trees 4th year	200	300	60,000
Total income (anticipated value after 10 years)			350,000
Total expenditure (brought forward from Table 3)			32,500
Total profit (after 10 years)			317,500
Profit per year (excluding land rent)			317,50

Table 5. Cost estimate (in Rs.) of planting trees in agro-forestry systems with 200 plants of *Acacia nilotica* per acre (Spacing: 15 feet x 15 feet).

Activity	Input required	Unit cost	Total cost per acre
First year charges			
Field leveling	4 Tractor-hours	Rs. 400/- per hour	1000
Plowing	Twice	Rs. 350/- per acre	700
Layout	2 Man-days	Rs. 250/- per person	500
Ditching	One Tractor-hour	Rs. 400/ - per hour	400
Holing	–	Rs. 400/- per acre	400
Gypsum	2 bags @ 0.5 kg per plant	Rs. 65 /- per bag	130
Farm yard manure	Quarter trolley	Rs. 2000/- per trolley	500
Saplings	200 Nos.	Rs. 3/-	600
Labor charges	2 Man-days	Rs. 250/- per person	500
Irrigations	not included as trees get irrigation with crops		–
Weeding	2 Man-days	Rs. 250/- per person	500
Unforeseen			500
Second year charges			
Restocking	–	–	300
Unforeseen	–	–	1000
Total charges of two years			7,030

Table 6. Estimated sale price (in Rs.) of *Acacia nilotica* trees after 10 years of growth.

Tree category	No. of Trees	Sale price per tree	Total price
Good trees	60	700	42,000
Medium trees	80	500	40,000
Small trees	60	300	18,000
Total income after 10 years			100,000
Expenditure in 2 years ((brought forward from Table 7)			7,030
Total profit			92,970
Profit per year (excluding land rent or additional income from crops)			9,297

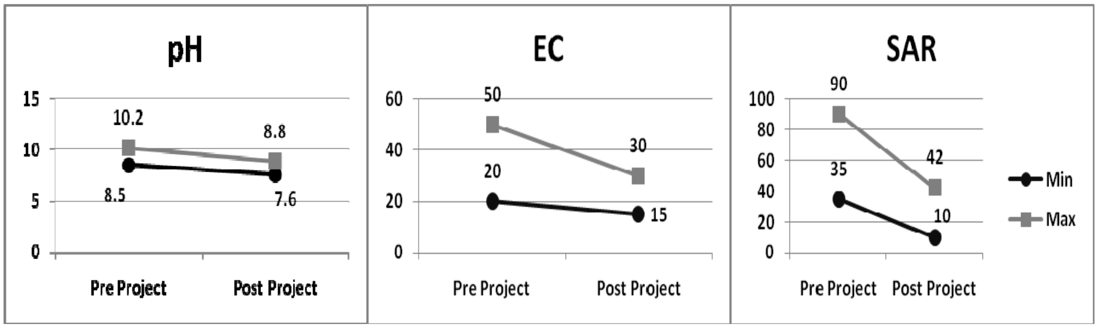

Fig. 14. Pre- and post-planting range of soil properties of a Kallar grass field.

4.2.5.4 Crop Improvement

Most farmers prefer growing crops, even on their saline land in the hope of short-term gains. They do so despite the fact that trees, shrubs and grasses are generally more salt-tolerant than crops. Moreover, in saline environments, economic and environmental value of growing grasses, shrubs and trees could be much more. The usual result is no or patchy and stunted growth of crops sown on salt-affected soils. Farmers complain that they do not get proper crop yield from saline environments. Therefore, SAFPDP helped farmers improve the productivity and sustainability of existing cropping systems. The major cropping systems in Pakistan are cotton-wheat and rice-wheat. In addition to major conventional crops, farmers also grow forages, oil seeds and sugarcane in some cases. SAFPDP was successful in helping farmers increase yield of all these crops. For example, the difference in growth of wheat on left or right side of the field (Fig. 15) is due to Saline Agriculture interventions.

Fig. 15. Acid application (left) and its effect on wheat growth (right); see the dramatic difference between wheat in the control and acid-treated plots - An example of Saline Agriculture interventions.

Various strategies followed to optimize crop production in the project areas are mentioned in Table 2. Overall speaking, they can be grouped under, use of improved/salt-tolerant crop varieties, soil and water amendments (particularly acids for a sustainable use of brackish groundwater), better agronomic and irrigation management practices (Fig. 16) and environment friendly fertilizers. Agronomic practices like deep tillage of soil and zero tillage of wheat were particularly found most useful.

Fig. 16. Bed-and-corrugation technique for water saving.

Fig. 17. Zero tillage sown wheat, after rice harvest.

Normally used fertilizers like Urea and DAP are not good for our saline-sodic soils. Application of these fertilizers may increase pH on a short-term basis resulting in increased nutrient loss and/or reduced nutrient uptake by plants. Therefore, SAFPDP promoted the use of environment friendly fertilizers like nitrophos and SSP to overcome this problem. Water management campaigns were vigorously organized at the sites to introduce bed planting, bed-and-corrugation technique, and laser land leveling. As a result, average yields of various crops increased substantially at the project sites. The need for water management in agriculture is briefly explained in Annexure - 7.

Increase in crop yield on saline marginal land because of Saline Agriculture interventions is summarized in Table 7. Data show that the yield of field crops rose sharply. For example, wheat yield rose from 1.0-1.2 to 2.2-2.5, rice from 1.6-1.8 to 2.5-2.75, cotton from 1.2-1.5 to 2.5-3.0, and sugarcane from 35-40 to 48-55 tons per ha. The data collected from several farmers suggest that zero tillage sowing of wheat helped reduce cost of wheat production (sowing charges by > 60%), in addition to increased yield of wheat grain by 120 to 160 Kg because of timely sowing.

Table 7. Average yields (Tons/ha) of crops on normal, saline marginal and saline waste land with and without Saline Agriculture interventions at SAFPDP sites in Punjab.

Crops	**Lodhran**			**Shorkot**				
	Normal land	**Saline marginal land**		**Normal land**	**Saline marginal land**		**Saline waste land**	
		Pre-project	**Post-project**		**Pre-project**	**Post-project**	**Pre-project**	**Post-project**
Wheat	3-3.5	1-1.2	2.2-2.5	3.0-4.0	1.2-1.8	2.2-2.75	0	2.2
Rice	3.3-3.8	1.6-1.8	2.5-2.75	3.5-4.0	1.5-2.0	2.5-3.0	0	2.5
Cotton	4.0-4.5	1.2-1.5	2.5-3.0	1.2-1.5	0.6-0.8	1.0-1.2	-	-
Sugar-cane	-	-	-	60-70	35-40	48-55	-	-

It needs to be mentioned that at present, not only, farmers do not get enough economic returns to account for money spent on land preparation, irrigation, seed and other agricultural inputs, but also, low yields badly affect national averages. It is emphasized that within irrigated areas, about 3 million hectare of land is salt-affected and is cultivated to crops with a severe reduction in crop yield, with an annual economic loss of Rs. 20 billion. Therefore, there is a clear case for a nation-wide adoption of Saline Agriculture interventions.

Saline Agriculture interventions also resulted in improvement in soil properties in the upper one-foot of soil. The following diagrams present the data on pre- and post- project soil conditions in case of each intervention (Figs. 18 to 21). It is readily apparent that the positive impact of various SAFPDP interventions on soil properties was substantial.

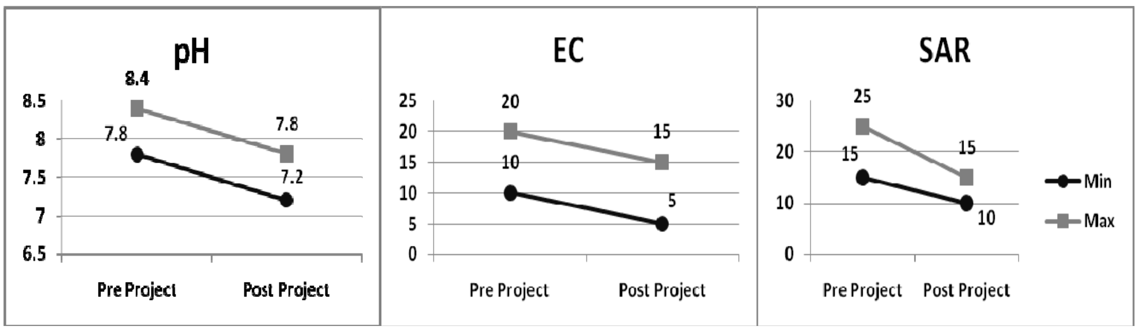

Fig. 18. Pre- and post- crop ranges of soil properties of a wheat field planted after deep tillage.

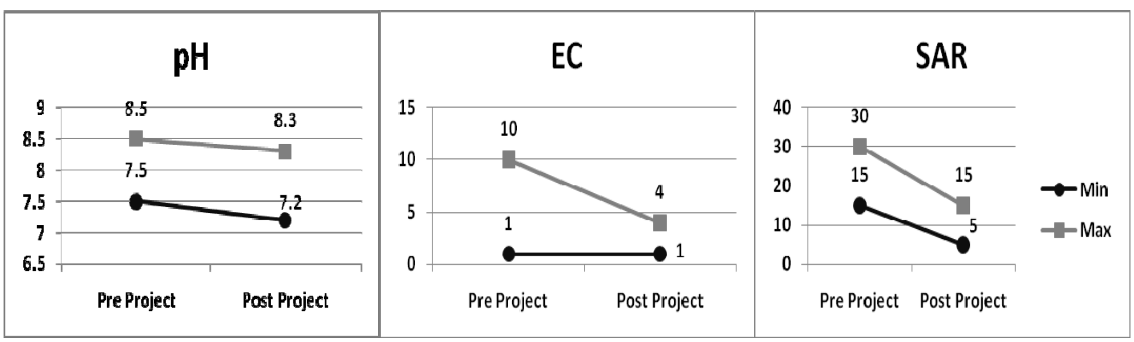

Fig. 19. Pre- and post- crop ranges of soil properties of a wheat field planted after laser land leveling.

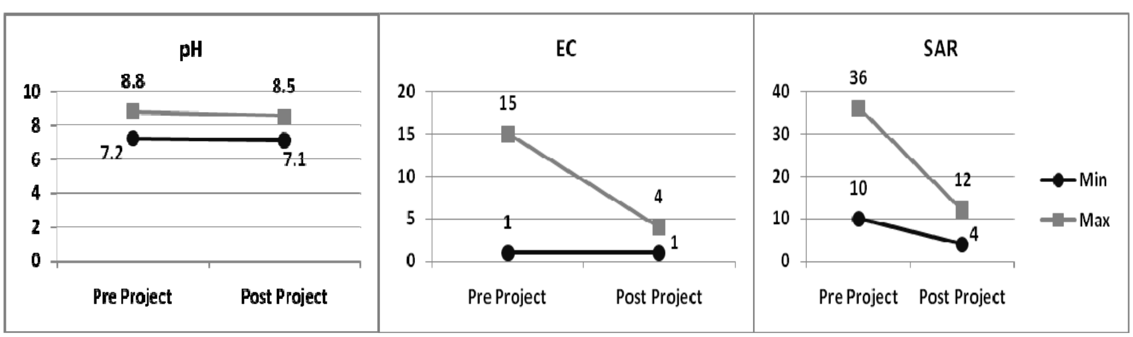

Fig. 20. Pre- and post- crop ranges of soil properties of a wheat field irrigated with acid treated brackish tube well water.

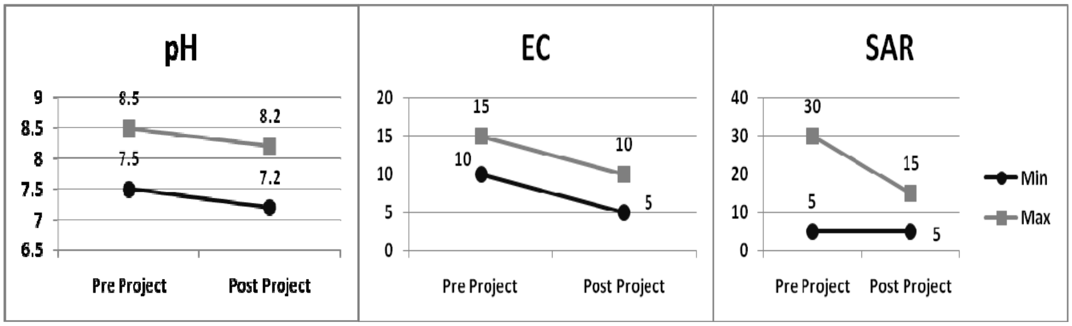

Fig. 21. Pre- and post- crop ranges of soil properties of a rice-wheat system field where wheat was grown with zero tillage.

4.2.5.5. Crop Diversification

A modest activity was initiated for diversification of cropping systems for increased total yield and increased efficiency of water and nutrient use. A short duration cowpea variety was introduced in the rice-wheat cropping system during fallow period and was also intercropped with cotton crop, with good results. Acceptance of this intervention by farmers on a substantial area has yet to be seen.

In the beginning of winter, when Kallar grass becomes dormant, Kallar grass fields were sown with wheat with the help of zero tillage technology. Wheat crop grew reasonably well, providing around 1.5 ton per ha of wheat grain (Figs. 22 & 23). Farmers also used wheat crop as forage when it was green. This exercise was helpful in providing one more crop from salt-affected soils where grass was grown. The soil properties also got improved (Fig. 24).

Fig. 22. Wheat intercropped with Kallar grass, during winter.

Fig. 23. Harvesting of wheat intercropped in a Kallar grass field.

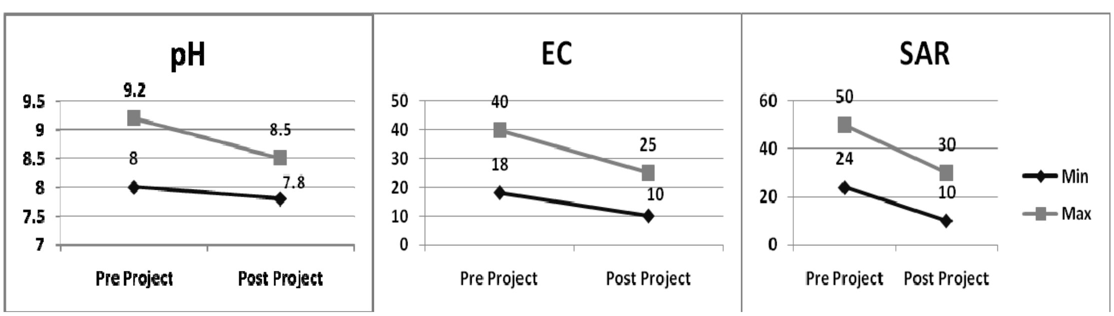

Fig. 24. Pre- and post- crop ranges of soil properties of a field under Kallar grass-Wheat intercrop.

4.2.6. High-Value Agriculture

SAFPDP particularly emphasized high-value agriculture in its program by promoting enterprises on livestock, aquaculture and honeybee keeping because of better economic returns and increased livelihood opportunities in the rural areas. The following sections suggest that, compared with existing land use, all alternative choices of `Saline Agribusiness' involving livestock and aquaculture utilizing on-farm salt-tolerant vegetation are more economical. Further, the gainful employment for livestock/aquaculture is far more than their crop counterparts, irrespective of location and size of livestock holding. Moreover, while crops favored predominant absorption of the male labor, these enterprises have even distribution of employment between males and females.

SAFPDP emphasized high-value agriculture also because the dietary pattern of consumers in Pakistan and regional countries are rapidly shifting from cereal-based to high-value food commodities. A sustained rise in per capita income at least in some segments of society, urbanization, and globalization are the drivers of this shift. As recently reported, substantial import of meat by China from US is a case in point. This transformation of the agricultural sector will have profound effects on overall direction of agriculture development, nature of the agricultural supply chain, opportunities for small holders, and the role of public policy and investment. More detail on rationale, needs, possibilities and benefits of high-value agriculture are explained in Annexure- 7.

The options for high-value agriculture in saline environments are:

4.2.6.1. Livestock

In general, livestock is a part of rural landscape in Pakistan and provides almost 50% share of national GDP contributed by agriculture sector. Almost all types of livestock can be raised in saline environments. Kallar grass is particularly attractive for this purpose because it can be fed to all types of livestock (Fig. 25). *Acacia ampliceps* is even more salt tolerant and grows very well on saline waste land (Fig. 26) but is not attractive for all types of livestock.

Environmental conditions on salt-affected arid lands in Pakistan are too harsh. Small ruminants (sheep and goats) indigenous to arid areas have a competitive edge on other animals. They are very well adapted to salt tolerant vegetation, have ability to utilize poor quality fibrous feeds and can tolerate vagaries of physical environment in degraded areas.

Fig. 25. Kallar grass - a good forage for all types of livestock.

Fig. 26. *Acacia ampliceps* grown on a highly salt-affected field.

Acacia species, Kallar grass along with some other forage crops, e.g., lucerne, berseem, *Sorghum* and *Sesbania* were mainly promoted to support livestock at SAFPDP sites. With increased forage base, the number of animals has been substantially increased. For example, a farmer at Sorkot kept 100 goats on 10 acres of *Acacia ampliceps* and 2 acres of some grasses. Data presented in Table 8, based on interview with the farmer, show that the economics of keeping small ruminants, viz. sheep and goats, in saline environments is satisfactory.

Despite the competitive edge of small ruminants in saline environments, the number of goats and sheep did not increase as much greater as was anticipated in the beginning. Several factors that may have contributed in this matter may be:

1. Well to do farmers do not like small ruminants and consider them the business of landless and/or resource-poor farmers. For them the status symbol is buffaloes and cattle.
2. The farmers think keeping small ruminants, particularly goats, require additional man power; it is difficult to stall feed and control them because of their habit of changing positions while grazing.
3. Goats are basically scrub vegetation/shrub eaters and do not prefer forage crops. In fact, they eat only small proportions and trample forage crops in browsing process.
4. Diseases and cold weather, if it commences, take a heavy toll.

Social mobilization for a change in mind-set, credit facilities and other attractions are direly needed to help farmers develop such `Animal Agriculture' enterprises.

Table 8. Budget estimate of a progressive farmer raising goats on *Acacia ampliceps* - based forage production system on saline land.

Area under *Acacia ampliceps*	10 acres
Area under other forage crops*	2
Number of goats	100
Capital cost on goats	Rs. 170,000/-
Other capital cost	Rs. 80,000/-
Total kids born every year	200
Sale price per head per year	Rs. 4000/-
Gross Income per year	Rs. 400,000/-
Recurrent cost per year	Rs. 100,000/-
Net Income per year	Rs. 300,000/-

*Forage crops: Lucerne, Berseem, Para grass, Mott grass, *Sporobolus* and Kallar grass.

4.2.6.2. Saline Aquaculture

SAFPDP farmers at the project sites in Shorkot and Lodhran have pioneered in `Saline Aquaculture’, evaluating/rearing fresh water breeds of fish in saline water, preferably utilizing on-farm salt-tolerant vegetation as a feed source (Figs. 27 & 28). Our calculations show that cost economics of developing new ponds for rearing fish is quite attractive (Table 9).

Fig. 27. A demonstration fish pond at Lodhran site.

Fig. 28. Good harvest of fish can be obtained from saline water.

Table 9. Cost-benefit economics (in Rs.) of one-acre/10 month cycle of Saline Aquaculture activity.

Item/Activity	Input required	Unit cost	Total cost
Establishment of pond	40 Hours	400 per hour	16000
Fish seed	800 Fingerlings	5 per head	4000
Supplementary feed	800 kg	700 per 40 kg	14000
Organic manure (poultry waste, cow dung)	one trolley each	3500 + 2000	5500
Fertilizer (DAP, urea)	one bag each	3200 + 800	4000
Forage (Kallar grass/*Sorghum*, etc.)	400 kg	01 per kg	4000
Diesel expenses for tube well	100 hours	100 per hour	10000
Labor charges (one person part time)		1000 per month	10000
Miscellaneous expenditure (Electricity, etc.)		500 per month	5000
Total expenses			72500
Gross production 1000-1200 kg		100 per kg	100000
Net income			27500

Traditionally, rivers and oceans have been used for fishing in Pakistan. Aquaculture technology is almost a recent introduction. Fisheries Department is helping the farmers to embrace aquaculture enterprises by developing hatcheries at the district level. Since aquaculture fits well with the role of SAFPDP in promoting high-value agriculture, SAFPDP developed a close liaison with Fisheries Department. Fish ponds on increasingly large areas of salt-affected land in Shorkot and Lodhran are a case in point. With material and technical support from SAFPDP, farmers have successfully grown several fish breeds (e.g., grass carp, rohu and gulfam), as poly-culture in saline water with EC ranging from 2 to 12 dSm^{-1}. These results are encouraging; annual income from one-acre farm may provide incomes up to more than Rs. 40,000/- in some cases (Table 10).

Most of the salt-affected soils in Pakistan are ideal places for aquaculture because of being impervious to water due to the presence of sub-surface hard pans and clayey layers. Such areas are underlain with brackish water. In addition to common fish, there is also a strong possibility for rearing shrimps, lobsters and crabs by developing the so called inland marines in areas having highly saline groundwater. Rejected water from fish ponds can be a rich nutrient source for plants. So integration of crop-aquaculture farms may be more appropriate for efficient recycling of nutrients within the farm.

Table 10. Cost/benefit of Saline Aquaculture at a range of pond water salinities.

Name of farmer	Quality of water		Fish breeds	Weight gained/ month (g)	Total weight gained (g)	Total expenses (Rs.)	Gross Income (Rs.)	Net Income (Rs.)
Aurang Zaib Khan Shorkot	EC RSC SAR pH	1.92 4.02 2.34 8.12	Grass carp Silver carp Rohu Mori Thaila	208 188 137 112 85	2180 1980 1470 1220 950	29030	70980	41950
Javid Nawaz 697/39 GB Shorkot	EC RSC SAR pH	2.10 6.44 18.0 8.27	Grass carp Silver carp Rohu Mori Thaila	203 191 128 108 86	2130 1910 1380 1180 960	28870	68900	40030
Gulfraz Khan 496 JB Shorkot	EC RSC SAR pH	2.48 9.95 28.2 8.43	Grass carp Silver carp Rohu Mori Thaila	156 147 117 109 81	1660 1570 1270 1190 910	26440	60450	34010
M. Aslam 411 JB Shorkot	EC RSC SAR pH	6.37 15.3 20.63 8.67	Grass carp Silver carp Rohu Mori Thaila	141 134 112 98 83	1510 1440 1220 1080 930	26380	56940	30560
Haji Sardar 29/M Lodhran	EC RSC SAR pH	8.15 17.8 32.4 8.7	Grass carp Silver carp Rohu Mori Thaila	135 123 106 106 79	1450 1330 1160 1160 890	26050	52260	26210
M. Saeed 409 JB Shorkot	EC RSC SAR pH	12.55 19.7 4.36 8.82	Grass carp Silver carp Rohu Mori Thaila	111 109 79 78 72	1210 1190 890 880 820	25820	47905	22085

4.2.6.3. Apiculture

SAFPDP organized a training course on `Apiculture' at the project sites. Hot areas are generally considered not suitable for honeybees. However, Australian bees are likely to perform reasonably well in our hot saline areas because they are adapted to arid zones. Some of plant species being used in Saline Agriculture production systems flower profusely. Therefore, they may be a good source of nectar and pollen for feeding honeybees.

For example, in *Acacia ampliceps* plantations, large number of nests of wild bees has been found; this species produces a lot of flowers (Fig. 29). There are good possibilities for running honeybee keeping programs in salt-affected areas with adoption of suitable bee types. Farmers expressed a big interest in commercial apiculture enterprise. It is emphasized that honeybees are known to increase crop production by increasing the probability of pollination in several crops, thus indirectly helping farmers to increase their farm production.

Fig. 29. *Acacia ampliceps* at flowering.

4.2.7. Other Activities

SAFPDP also helped the Saline Agriculture farmers in improving their life style. Some examples are given below.

4.2.7.1. Biogas Plants

There was no supply of natural gas at SAFPDP sites. Therefore, the farmers used to cut already scanty trees, or use farm yard manure (FYM) for burning to cook their food. Such activities are well known to enhance land degradation in arid areas. Biogas plants were introduced (courtesy PCRET) at SAFPDP sites (Fig. 30). Some farmers benefited themselves with this opportunity, built their own biogas plants and used FYM as a substrate for methane production. While methane was used in the kitchen, slurry was used to fertilize crops especially vegetables. Some detail of various components of biogas plants at SAFPDP sites is shown below.

Fig. 30. A set-up of biogas plant (left) and burners with flames (right) at a farm in Lodhran.

4.2.6. Socio-Economic Impact

Socio-economic impact of SAFPDP was significant as is evident from various indicators. Area under different crops (rice, wheat and cotton, etc.) in each project village at Shorkot and Lodhran increased and, hence, there was a substantial increase in total cultivated area at the project sites in Punjab (Fig. 31a). There was also a substantial increase in yield of rice, wheat, and cotton (Fig. 31b). There was also a remarkable increase in number of livestock animals in the project areas (Fig. 31c). Most noteworthy increase was observed in some villages at Shorkot. This was due to the fact that there was a large increase in forage production at both sites because of Saline Agriculture interventions. As the confidence of farmers built up, they were keen to invest more on farm machinery that was reflected in increased number of tractors and farm implements in the project areas (Fig. 31d). Such investments further enhanced the pace of work accordingly.

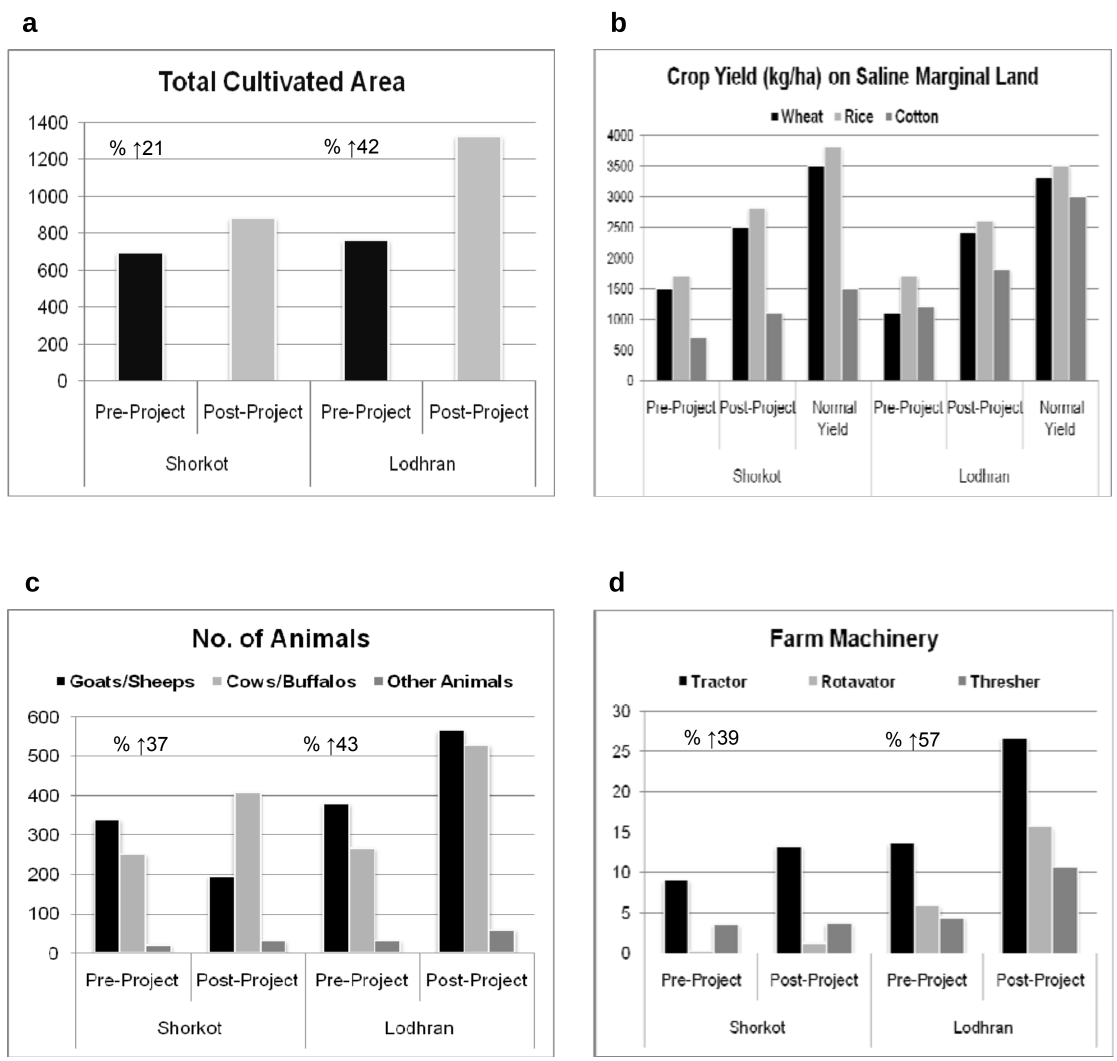

Fig. 31. Increase in total cultivated area, crop yields, livestock animals and farm machinery at project sites; average values for each site are presented. The values shown above the bars are % increase as a result of project activities.

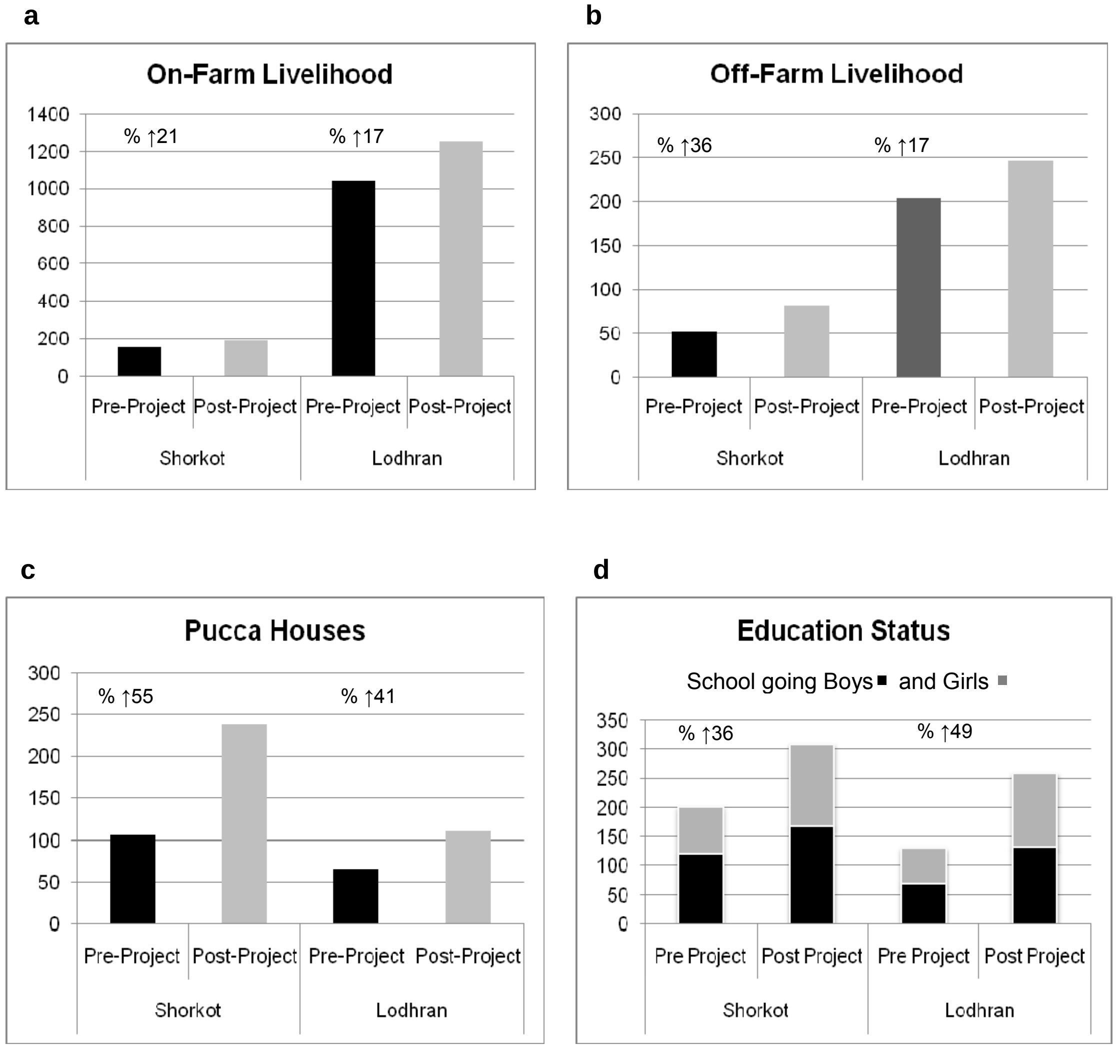

Fig. 32. Some socio-economic indicators showing impact of project activities on the target groups; average values for each site are presented. The values shown above the bars are % increase as a result of project activities.

These developments not only increased on-farm livelihood but also improved off-farm livelihood (Fig. 32a&b) suggesting a greater economic activity in otherwise economically barren areas. Such increases not only improved the poverty ranking but also increased the capital value of land implying confidence of farmers in Saline Agriculture interventions. Overall annual economic impact of SAFPDP interventions on project sites, Shorkot and Lodhran, due to increased incomes has been estimated at Rs. 347 million (Table 13).

Increase in income of farmers was reflected by an increase in the number of Pucca houses (Fig. 32c), with facilities like electricity, household utilities, and proper sanitation. It was heartening to see that at the conclusion of SAFPDP, the number of Primary Schools and also the number of school going children (boys and girls) increased substantially as compared to pre-project period (Fig. 32d). All this must have improved the quality of life of population in the project areas.

Table 13. Estimated economic impact of SAFPDP interventions on Project Sites based on increased annual agriculture production.

Commodities	**Increased income (million Rs.)**
Wheat	56.3
Cotton	31.9
Rice	25.6
Sugarcane	1.8
Forages	52.5
Goats	11.3
Sheep	5.5
Cows	67.7
Buffalos	86.0
Fish	8.3
Total	**346.9**

4.3. General Discussion

SAFPDP (Punjab Component) is a success story. This can be assessed from the fact that most of the project objectives, mentioned on P 7 of this report, were realized during the project period. Let us discuss them one by one.

Objective 1: Disseminate and optimize `Saline Agriculture Technology' with active participation of farmers, line departments, community-based organizations (CBOs) and local students

Saline Agriculture Technology was disseminated at the project sites in Shorkot and Lodhran. It is readily apparent that farmers adopted this technology on thousands of acres of land. The farmers around the project sites were also found embracing this technology. Line departments were involved in the dissemination process and, in fact, EDOs of all relevant departments at the district level were the members of `Site Advisory Committee', responsible for periodic reviews and recommendations on various Saline Agriculture related matters at each site. Farmers were organized as CBOs/CCBs for popularizing the technology among the farming communities. There was a limited success with the involvement of students because of lack of facilities to involve students in the project areas. Nevertheless, some students from University of Agriculture, Faisalabad and a Vocational College from Lahore did complete their apprenticeship and research reports at the project sites.

Objective 2: Maximize economic returns from salt-affected soils by diversification and value-addition to farm products

The farmers were also encouraged to grow crops other than common crops like cotton, wheat and rice. Cultivation of some forage crops, cowpea within rice-wheat and cotton-wheat cropping systems, castor bean and the development of Kallar grass-wheat cropping system are the case in point. Increased number of animals and adoption of Saline Aquaculture at the project sites are good examples of high-value agriculture. The overall economic impact of these interventions was substantial.

Objective 3: Mitigate salinity-associated poverty and food insecurity in rural areas

All socio-economic indicators like income of farmers, on- and off- farm livelihood and overall poverty ranking improved. The number of Pucca houses, electrified houses, household utility items, bath rooms, brick-paved streets, primary education and number of schools were significantly increased. These data do suggest that farmers' incomes increased and quality of life improved with the implementation of SAFPDP. As far as mitigation of food insecurity is concerned, there is a simple argument that since yield of rice and wheat increased with SAFPDP interventions, it helped increase food security at the project sites.

Objective 4: Improve quality of national development programs through nuclear techniques

Saline Agriculture Technology was developed at NIAB, involving nuclear techniques with assistance from International Atomic Energy Agency (IAEA), Vienna, Austria. Animal Healthcare Program, which supplemented Saline Agriculture Technology at the project sites, also used nuclear techniques in its research work. SAFPDP thus indirectly involved nuclear techniques. A more direct application of nuclear techniques was also made in estimating seepage from Trimu-Sidhnai and Haveli twin link canals, passing through SAFPDP site in Shorkot. These techniques were also used in identification of good quality water by estimating water quality up to 100 m depth. This information enables farmers to pump water from relatively safer zones.

Objective 5: Reverse environmental degradation and enhance aesthetic value of wasteland

At the commencement of the project, farmers were in the process of land abandonment because of poor economic returns from salt-affected areas. Uncultivated land in canal commanded areas soon turns more saline expediting land degradation processes. Such lands are easily subjected to wind and water erosion and, in fact, are converted to dust bowls. Not to mention, such places give ugly looks. SAFPDP helped reverse land degradation by re-vegetation and reclamation of salt-affected soils and utilization of water-logged areas at some places. One of the outcomes is increased aesthetic and capital value of land at SAFPDP sites.

Objective 6: Training and capacity building in the communities ensuring gender equity for the realization of above objectives

SAFPDP organized multifarious training courses, skill development programs and farmer field schools for training and capacity building of project farmers on various Saline Agriculture and related/supplementary technologies. They can now handle much better issues on plant and animal production from saline environments. They have also an increased capacity to deal with governmental and non-governmental agencies for their own benefits. Social infrastructure developed by SAFPDP has been registered as Citizen Community Boards (CCBs), eligible for seeking support and funding for area development. With some supervision, from technical persons, these community-based organizations can continue to work effectively. However, for the full education and independent functioning of CBOs, more time was needed.

SAFPDP farmers were also educated on community work and sharing of recourses with the fellow farmers. Participatory nursery raising and joint supervision, maintenance and use of tube-wells are indicators of their enhanced social responsibilities. Limited success was achieved with the involvement of women folk with the project activities because of social taboos. This problem was compounded because different lady Social Mobilizers recruited for SAFPDP did not stay longer at the project sites, due to the inconvenience of working in the remote rural areas. Nevertheless, women folk in the project areas are much more educated on Saline Agriculture, food processing and efficient use of available fuel resources in their areas. The modest success achieved by SAFPDP (Punjab Component) is heartening, suggesting that the right mix of people, technology and extension approaches can deliver genuine and lasting benefits for increased economic returns and improved environmental conditions in degraded areas.

4.4. Review of SAFPDP Activities

For reviewing SAFPDP progress, meetings of Steering Committee headed by the Project Leader were held at NIAB. The meetings of Site Advisory Committees, headed by project Coordinator were held at Shorkot and Lodhran. In addition to visits by the Coordinator from time to time at Shorkot and Lodhran sites, PAEC authorities and NIAB Directors also visited the project areas on different occasions (Fig. 33). Some meetings chaired by NIAB Directors were also organized at NIAB to review the project activities. NIAB also sent Inspection Teams to monitor administrative and accounting matters at the project Site Offices.

Planning Commission reviewed the progress of the project through field visits by its representatives (Fig. 33).

Fig. 33. Member (Science), PAEC (left) and a Representative of Planning Commission, GoP (right) visited project site in Shorkot.

4.5. Evaluation by Planning Commission, GoP

"**On behalf of Planning Commission of Pakistan, it is privilege to express the impression of the project sites. The way the activities have been executed by the dedicated and competent staff, has been an asset. The visit to the field interventions and intensive meetings with the farming community have all been absorbing and rewarding. Such efforts need to be replicated and sustained for bringing about a visible impact in salt-affected ecologies of the country. We wish a great economic future for the community and professional excellence for the project staff"**.

Evaluation Team
Planning Commission
Government of Pakistan

4.6. Lessons Learnt

SAFPDP like projects should be of longer duration, independently run by those who are responsible to deliver. Supporting staff from Administration and Accounts section may also be integrated into the project teams sharing success and failures of the project along with technical staff. More education to farmers is needed on tree planting. The farmers need to change their mind-set that Government should do everything for them. The farmers also need to learn that trees are not all that bad for crop production and with tree planting there are more advantages than disadvantages. They should be taught that environmental benefits of trees are more important than short-term gains. In the long run, in addition to environmental benefits, economic benefits of trees are so great that short-term sacrifices, if any, because of tree competition with crops, become meaningless.

SAFPDP like projects should also help farmers on purchase of inputs and in marketing of farm produce. The farmers in saline areas are surely resource-poor. Therefore, they should have an easy access to credit facilities on soft terms. Roads and other communication systems should also be simultaneously improved in the project areas. Last but not least, the project staff working in the remote areas should be given special pay cum better facilities packages.

4.7. Publications and Publicity

1. Salinity and drainage survey of Punjab Sites
2. Situation analysis PAEC / NRSP
3. Action Plan 2003
4. Quarterly Newsletter `Salinity and Environment'
5. Pamphlets on production technologies of different crops in saline areas (Urdu)
6. Publicity through web site: www.sem.org.pk
7. Publicity among extensionists and general public members were other communicative activities of SAFPDP (Punjab Component).

4.8. National and International Visitors

During its execution, SAFPDP (Punjab Component) hosted several international visitors, in additions to the routine visits by national stakeholders including researchers, extensionists, students, and farmers. Pictures of some of the international visits are shown below (Figs. 34-36).

Fig. 34. Chinese visitors inspecting a cotton field (left) and Participants of an IAEA training course inspecting Kallar grass (right) at SAFPDP sites.

Fig. 35. Australian visitors in a field at Shorkot.

Fig. 36. Scientists from International Center for Biosaline Agriculture (ICBA), UAE.

4.9. Administrative Set-up

SAFPDP was executed under the overall direction of a Steering Committee, chaired by the Project Leader (Fig. 37). The Coordinators were responsible to supervise the project at the provincial level. Site Facilitators, who were assisted by other Field Officers, implemented the development work in the field. A Site Advisory Committee, chaired by the Coordinator was also constituted to review the project at the site level from time to time (Fig. 38).

Fig. 37. A meeting of Steering Committee.

Fig. 38. A meeting of Site Advisory Committee.

4.9. Concluding Comments

SAFPDP focused people for successful execution of its development program and Saline Agriculture interventions led project farmers to some prosperity. Thus, SAFPDP demonstrated that with a right mix of people, adopting participatory approaches and ensuring that such programs provide both economic and environmental benefits could best execute development programs in Pakistan. SAFPDP has also successfully demonstrated that it is an elegant model on how science can effect positive changes in lives of a large number of farmers in a short span of time. It may be argued that the project implementation was in line with the contents of the open letter (mentioned at the outset in Introduction), by the head of United Nations Development Program in Islamabad, to the President of Pakistan, stressing the need for emphasis on prosperity for the people of Pakistan.

Annexure - 1

Technology Transfer to Improve Agricultural Production

The modern agriculture production system consists of certain sub-systems: i) a research sub-system which generates technology, and which provides the updated technical knowledge, ii) an extension sub-system which disseminates technology generated by research, and iii) the users' sub-system which applies the technology and turns it into productive use. The ultimate goal of agricultural research is to increase agricultural output. Basically, this means providing farmers with a wide range of technical information that has been tested in conditions similar to those faced by the farmers.

While much information is available on improved production technologies for increasing crop yields, much remains to be done in sharing various technologies and technical information with the farmers, who actually produce the crops. This is particularly true for saline environments, which have additional problems. It appears that the bigger bottleneck may not be technology generation but its application. The key to information sharing is the existence of an effective advisory or extension service. This service is much less than adequate in Pakistan.

Without active and effective extension programs, this goal cannot be achieved. The major issues/weakness of the extension system elaborated on various forums are: i) field extension staff are not adequately trained and equipped with communication techniques and methods, ii) insufficient operating funds for teaching/training and demonstration materials; equipment and travel funds are not adequate; iii) linkages between researchers, extension staff and farmers are weak; lack of mobility prohibits field staff from reaching the farmers, iv) lack of accountability for extension field functionaries; low salaries result in low morale and job performance, and v) the conditions are miserable under which the extension staff operates. Whatever the argument may be, the fact remains that small farmers have not been benefited from the opportunity of enhanced productivity afforded by modern technologies. Examples exist that poor functional linkages exist between agricultural land and rural development institutions and media and simple but vital technologies are not being transferred to farmers.

The magnitude of the problem can be better understood by appreciating that out of 6.2 million farm units in Pakistan, small-farm families (less than 5 ha) constitute about 86 percent of the farm units. Crop production on this area accounts for about 49 percent of agricultural GDP. Farmers grow a large number of crops. Although, total crop production and per hectare yields have increased substantially over the years, following the introduction of high yielding varieties and increased use of inputs, the actual crop yields are generally regarded as being about 40-70 percent of the yield potential. The research findings indicate that the extension sub-system is not the primary source of information. The farmers get information from one another.

It may be argued that the development of additional land/water resources is more difficult and expensive than in the past and fraught with political repercussions. Also, competition between various users of these land and water resources is becoming much more severe. Thus, efficient use of developed resources is better long-term option than the development of new resources. The best option is to increase crop yields through better management practices. We have best climate, a best combination of land, water and human resources; we should strive to make agriculture an engine of economic growth. For this purpose, an efficient extension service is needed.

As implied earlier, research, extension and farmers are mutually dependent on each other. Without a constant flow of validated and practical research findings, the extension has nothing to deliver to the farmer. Without the farmer both research and extension can close down their expensive operations. For agriculture to advance and making agriculture an engine of economic growth in Pakistan, we may need a new extension strategy for imparting new knowledge to the farmers. We need to be more innovative, committed, sincere and active in establishing better linkages between researchers, extensionists and farmers.

Annexure - 2

Salt Tolerance in Plants

NIAB has a long tradition of collection, selection and studying salt tolerance in potential plant species/genotypes and cultivars. New germplasm is obtained by exploration and collaboration with national and international R&D institutions. For salt tolerance studies on plants, NIAB has also developed a gravel culture technique (Fig. 38). In this technique, an automatic pumping system delivers nutrient solution containing salts of desired concentration and composition in the root-zone of the plants. With this technique, plants can be conveniently grown in quartz gravel filled in cemented tanks at a range of salt concentrations while ensuring uniform salinity and nutrient concentrations. For selecting suitable trees and other plant species, gravel culture studies were conducted on many trees, shrubs, grasses and crop plants.

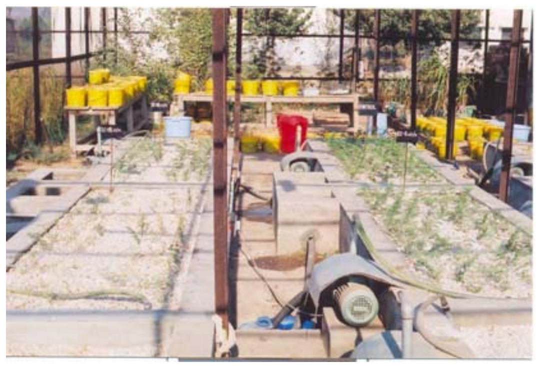

Fig. 38. A gravel culture set-up at NIAB for studying salt tolerance in plants.

The overall picture emerged from these studies is that the maximum amount and kind of salts that can be tolerated by salt-tolerant plants varies among species and even varieties of the species. Many salt-tolerant plants have a special and distinguishing feature; their growth is improved by low levels of salt. Other salt-tolerant plants grow well at low salt levels but beyond a certain level, growth is reduced. The salt tolerance of some of these plants enables them to produce yields under saline conditions that are comparable to those obtained from salt-sensitive corps grown under non-saline conditions. With salt-sensitive plants, each increment of salt decreases their yield. Depending upon the soil or water salinity levels, salt-tolerant plants in the list presented in Table 14 can be identified that are likely to perform well on salt-affected soils.

It is, however, emphasized that such data provide only relative guidelines for predicting yields of crops grown under saline conditions. Absolute yields are subject to numerous agricultural and environmental effects. Interactions between salinity and various soil, water, and climatic conditions all affect the plant's ability to tolerate salt. Some salt-tolerant plants require fresh water for germination and early growth but can tolerate higher salt levels during later vegetative and reproductive stages. Some can germinate at high salinities but require lower salinity for maximal growth. Plants with significant plasticity in tolerance to salts and climate would have a greater potential for success, in natural saline environments.

Not to mention that salt-tolerant plants are, generally speaking, unusual plants. They may contain unusual compounds. An understanding of the nature and concentration of such compounds is essential for two reasons. Firstly, such information would be useful in estimating the health hazards on the animals, if their feed consists of a greater proportion of these plants. Secondly, these unusual compounds may be of some economic value and may thus be useful to commercially extract them by developing suitable techniques.

Table 14. Plant germplasm screened for salt tolerance using gravel culture technique at NIAB.

Species	Root-zone Salinity causing 50% yield reduction	
	EC (dS m^{-1})	% Salt
1. Grasses		
Leptochloa fusca	22.0-14.6	1.41-0.93
Sporobolus arabicus	21.7	1.39
Cynodon dactylon	21.0-13.2	1.34-0.84
Hordeum vulgare	19.5-10.0	1.25-0.64
Sorghum vulgare	16.7-15.0	1.07-0.96
Panicum antidotale	16.0	1.02
Echinochloa crusgalli	15.9	1.02
Polypogon monspeliensis	13.7	0.88
Cenchrus ciliaris	13.63	0.87
Pennisetum purpureum	12.89	0.83
Pennisetum purpureum	11.85	0.76
Avena sativa	11.8-9.1	0.76-0.58
Sadabahar	11.71	0.75
Lolium multiflorum	11.2	0.72
Echinochloa colonum	11.2	0.72
Desmostachya bipinnata	9.0	0.64
Panicum maximum	9.0-8.5	0.58-0.54
Sorghum halepense	7.0	0.45
2. Shrubs		
Suaeda fruticosa	48.0	3.07
Kochia indica	38.0	2.43
Atriplex nummularia	38.0	2.43
Atriplex amnicola	33.0	2.11
Atriplex hortensis	25.7	1.65
Atriplex lentiformis	23.0	1.47
Atriplex undulata	22.5	1.44
Atriplex crassifolia	22.5	1.44
Sesbania formosa	21.4	1.37
Beta vulgaris	19.0	1.22
Lotus carniculatus	16.7	1.07
Trifolium alexandrinum	15.8	1.01
Sesbania aculeata	13.0	0.83
Hasawi rushad	12.5	0.80
Medicago sativa	13.2-12.2	0.84-0.78
Sesbania rostrata	12.0	0.77
Macroptilium atropurpureum	12.0	0.77
Trifolium resupinatum	11.6	0.77
3. Trees		
Acacia sclerosperma	38.7	2.48
Acacia ampliceps	35.7	2.26
Prosopis chilensis	29.4-29.3	1.88-1.87
Casuarina obesa	29.2	1.86
Acacia victoriae	28.3	1.81
Eucalyptus microtheca	27.9	1.78

Continued - - - -

Source: Silver Jubilee of NIAB, 1997.

Species	Root-zone Salinity causing 50% yield reduction	
	EC (dS m^{-1})	% Salt
Acacia nilotica	27.9	1.78
Acacia acuminata	27.7	1.77
Acacia cambagei	27.7	1.77
Eucalyptus striaticalyx	26.2	1.68
Acacia salicina	24.5	1.57
Prosopis cineraria	24.4	1.56
Casuarina glauca	24.4	1.56
Prosopis tamarogo	22.7	1.45
Acacia calcicola	19.9	1.27
Acacia adsurgens	17.5	1.12
Leucaena leucocephala	17.2	1.10
Acacia subtessarogona	13.8	0.88
4. Vegetables		
Aster tripolium	31.7	2.03
Brasssica napus	19.5	1.25
Trigonella faenum-graecum	19.2	1.23
Spinacea oleracea	14.8	0.94
Brassica carinata	14.0-12.5	0.90-0.80
Medicago falcata	13.4	0.86
Brassica juncea	12.4-8.44	0.79-0.54
Brassica compestris	09.9	0.63
Lactuca sativa	09.9	0.63
Eruca sativa	09.6	0.61
Coreandrum sativum	05.7	0.37

Annexure - 3

How SAFPDP Worked

Saline Agriculture development work in Pakistan began with outreach activities of Saline Agriculture scientists interested in addressing the issues of sustainability of agriculture in saline environments. The first contacts were made in Jhumra-Shahkot area with encouraging results. In 2002, the Pakistan Atomic Energy Commission, aiming to expand on its experience in laboratories, at field stations and some farmers' fields, introduced a broader community program under the banner of `Saline Agriculture Farmer Participatory Development Project in Pakistan (SAFPDP)' in response to growing awareness and concern of the wider scientific and farming communities for reduced farm incomes, land value and environmental degradation in saline environments.

The mandate of SAFPDP was to help organize farming communities and to help identify salinity-associated problems on private farms in the project areas and to initiate participatory development processes, leading to rehabilitation of saline environments by involving farming communities. It was thought that it would encourage farmers to ultimately solve their problems on their own, by improving their perception on agro-environment and enhancing their skills, capabilities and capacities. The focus of SAFPDP was firmly on practical ways to achieve environmental restoration while economically utilizing saline land and water resources.

Farming on salt-affected land is not easy. So why do farmers cultivate crops in these extreme saline conditions. For many there is simply no alternative; and water is in very short supply. These farmers long recognized the symptoms associated with problems at early stage and even the causes, but were poorly equipped to deal with them. While some farmers had migrated, several were taking their own positive action, but an efficient approach lacked. They also failed to comprehend the holistic approach and widespread adoption. For farmers who could understand what was needed, the task was just too big and complicated. Throughout the inception of the project, we ensured that farmers need measures they can adopt on their own land with existing resources. The rest technical people did.

The project concentrated on group creation, through a participatory model utilizing adult learning on matters described elsewhere in this report. SAFPDP in some cases emphasized on shifting from a production model to a broader recognition of the value of environmental management. Pakistani farmers have good technical understanding and expertise that allow them to internalize what we shared with them. The farming communities organized as `Saline Agriculture Farmer Associations (SAFAs)' became vibrant, increasingly taking more interest in participatory development work. To some extent SAFA took on some other community roles also, like collective purchase of farm inputs (seeds, fertilizers, etc.).

Sustainable Framework

SAFPDP had to introduce several intervention technologies. In the beginning, the farmers were suspicious of the intensions and interventions of SAFPDP. The sustainable rural livelihood framework calls for creating a greater understanding of just what farmers value. A careful examination of farmers' preferences showed that either these were not sustainable in the long run or were beyond the mandate of SAFPDP. Therefore, SAFPDP avoided a pre-conceived/ready made package to be imposed on the farmers. Attempts were made to introduce various possible options that could work in saline environments.

SAFPDP approach was akin to gathering together a set of tools to deal with salinity problem based on techniques derived from research programs at NIAB and other sister organizations. Each farmer or a farming community, having identified a problem to address could then exchange ideas with the field staff to select the appropriate tool from within the complete toolbox. This approach, backed with training, was likely to bring a high level of ownership towards the problems and resources to address it. It also ensured that local knowledge was included in the development of solutions. The focus was not merely on technology but on people; beginning by listening to farmers as they identify problems of importance to them. Only later new technologies were introduced.

Farmers thrive on good stories. Therefore, SAFPDP encouraged them to share their success stories with each other and visit each other's success stories. Learning by seeing other community groups (SAFAs) in action and through training courses, farmers were hoped to be better convinced and learn from each other through sharing successes and lessons learnt. For this purpose, SAFPDP sites in Shorkot and Lodhran hosted visitors from other farming communities, line departments and of miscellaneous organizations including international ones.

There was also some analogy between the SAFPDP model and social structures in Pakistan. Smallest SAFA groups were often based on familial ties, so working together on SAFPDP initiative was a logical extension. It helped maintain group longevity. The village level SAFAs were tied into site level SAFA. Scaling up of the groups to union council, tehsil council and district levels can materialize a further upward chain of influence by such community organizations. SAFAs were also registered as CCBs, and governments working at any of these levels could work out a complimentary role for serving the farming communities. Local governments were approached to provide development funds to our SAFA groups, registered as CCBs, and eligible for receiving development funds. Local governments are now more autonomous, so some successful attempts were made to convince them to own the Saline Agriculture development work. At the time of conclusion of the project, local governments were thinking to direct local officers of agriculture department to extend the Saline Agriculture development activities beyond the project areas.

Annexure - 4

Contents of Orientation Training Course on Saline Agriculture
(organized and hosted by NIAB, Faisalabad)

1. Formation and Philosophy of Project Team (Dr. Muhammad Salim, NARC Islamabad)
2. Social Organization and Participatory Development (Philosophy, Concept and Practices) and Experience of RSP in Pakistan (Mr. Tahir Waqar, NRSP Islamabad)
3. Saline Agriculture Experience at NIA (Dr. Razi-ud-Din Ansari, NIA Tandojam)
4. Expectations, Fears and Setting the Norms (Dr. Zahoor Aslam, NIAB Faisalabad)
5. Social Mobilizer as a Catalyst (Resource Person, NRSP)
6. Salt-Affected Soils, Their Formation, Characteristics and Soil Sampling Techniques (Dr. Javed Akhtar, UA Faisalabad)
7. Problems/Complications in Plant Production on Salt-Affected Soils (Prof. Masood Qureshi, Consultant, University of Arid Agriculture, Rawalpindi)
8. Introductory Saline Agriculture (Dr. Zahoor Aslam, NIAB)
9. How to Conduct and Record Community Organization Meeting (Resource Person, NRSP)
10. First Dialogue (Resource Person, NRSP)
11. Why Activist? (Meeting with Activists) (Resource Person, NRSP)
12. Saline Agriculture Experience of NIAB (Dr. M. Islam-ul-Haq, NIAB)
13. Agro-forestry for Optimizing Economic Returns from Salt-Affected Soils (Mr. A.R. Awan, NIAB)
14. Effective Communication and Presentation Skills (Resource Person, NRSP)
15. Productive Linkages (Resource Person, NRSP)
16. Terms of Partnership for Participatory Project (Resource Person, NRSP)
17. Forage Value of Salt-Tolerant Plants (Dr. Shahnaz A. Khanum, NIAB)
18. Livestock Feeding Strategies for Pakistan (Dr. Abdul Ghaffar, NARC Islamabad)
19. Introductory Healthcare for Domestic Animals (Dr. Tariq Mahmood Chaudhry, NIAB)
20. Natural Resource Management (NRM): NRSP View (Resource Person, NRSP)
21. Role/Importance of Human Resource Development (Resource Person, NRSP)
22. Conflict Management (Resource Person, NRSP)
23. Agronomic Practices for Mitigating Salinity Effects on Plants in Saline Environments (Dr. Zahoor Aslam, NIAB)
24. High SAR/RSC Water Amendment Technology (Dr. Abdul Ghafoor, UA Faisalabad)
25. Gypsum-A Cheap Amendment for Sodic Soils and Waters (Dr. Muhammad Salim, NARC)
26. Office Management (Resource Person, NRSP)
27. Fertilizer Management in Saline Environments (Mr. Faqir Hussain, NIAB)
28. Soil Fertilization by Biological Means (Dr. Fauzia Yusuf, NIBGE Faisalabad)
29. Genetic Diversity for Salt Tolerance in Plants and Field Selection Procedures (Dr. M. Ahsan-ul-Haq, NIAB)
30. Production Technology of Trees in Saline Environments from Nursery to Adult Stage (Dr. Khalid Mahmood, NIAB)
31. Production Technologies for Major Crops in Saline Environments (Mr. Yousaf Ali, NIAB)
32. Review of the Previous Day and Brief on Action Plan: Saline Agriculture FPDP in Pakistan (Dr. Zahoor Aslam, Course Coordinator, NIAB)
33. A Need for Water Management/Conservation in Pakistan (Dr. M. Mohsin Iqbal, Director NIAB)
34. Bed-and-Furrow Irrigation Technology for Water Economy in Saline/Water-logged Areas (Mr. Zafar-ul-Haq Hashmi, NIAB)
35. Methods of Soil Water Measurement (Neutron Moisture Probe) (Dr. Javed Akhter, NIAB)
36. Planning and Monitoring (Resource Person, NRSP)
37. Honeybee Keeping on Salt-Land Vegetation (Dr. Nasreen Muzaffar, NARC)
38. Estimation of Soil Salinity Using EM-38 Technique (Dr. Javed Akhter, NIAB)
39. Visit to BSRS, Pakka Anna, Faisalabad (Mr. Riaz A. Waheed, NIAB)
40. Prospects of Saline Agriculture in Pakistan (Prof. Dr. Riaz H. Qureshi, Vice Chancellor, UAF)
41. Visit to NARC, Islamabad (Dr. Zahoor Aslam, NIAB)

Annexure - 5

Community Involvement

The problems being faced in development work in Pakistan cannot be solved unless governments work cooperatively with communities. A strategy for a two-way communication is essential. All sectors of the community including landholders, public representatives, community groups, businesses, schools and governments must be partners in producing and implementing a plan. A well-designed participation process must include a combination of community-based advisory and steering committees.

Re-vegetation plans by governmental departments supported by local governments and local communities may constitute a new approach to sustainable land use and vegetation planning. This new approach may be based on current best scientific expertise available in research institutes and potential strength of the communities by motivating the community members individually or collectively. Political acceptance may be usually the final determinant of what mechanisms the projects adopt to improve, re-vegetate, protect and manage agro-environment.

Linking Vegetation Management to Economic Benefits

Governments are in a difficult position having to respond to conflicting short-term (economic) and long-term (environmental) demands for development in their constituencies. Development work involving re-vegetation with trees is surely environment friendly but provides benefits only in the long run. Increased crop production on the model of Green Revolution is economically rewarding in the short-term but entails long-term environmental costs. The following strategy as an effective mechanism in re-vegetation plans may help achieve development while minimizing cost to the environment.

1. Identifying areas for re-vegetation unsuitable for traditional agriculture.
2. Improving but avoiding drastic changes in existing cropping system and adopting a strategy for a gradual diversification, e.g., with agro-forestry and forage plants.
3. Linking environmental improvement with incentives.
4. Arranging value-addition and marketing facilities for the new farm products, originating from environment friendly production systems.

Annexure - 6

Trees for Economic and Environmental Benefits

Experts say that more than 25% of landscape of the country should be covered with trees for both economic and conservation reasons. In our country, area covered by trees is just 4-5%. This too is mostly located in the northern area. The gigantic Indus plain in essence is devoid of trees and is intensively used for crop production. Only a few 'Kikar' and 'Shishum' trees are dotted here and there. Therefore, this plain does not have a tree cover to ameliorate hot winds blowing from south-west to north-east and to resist cyclonic winds and flow of dust. Moreover, our deserts are expanding because of reckless removal of vegetation for forage and fuel needs.

The Indus plain needs a large-scale planting of trees for shelterbelts, soil reclamation and other environment benefits. Tree farming system should be properly blended with crops and livestock production. Microenvironment at farm-level has to be maintained in this way. Although trees are of great economic value but the environmental planning and implementation costs cannot be reckoned merely on economic basis. The assessment should include external cost such as damage to the environment. It should consider aesthetic effects derived from conserving environment. However, the need for agricultural land to feed growing populations makes it unlikely that high-quality land will be used for planting trees. Trees as compact plantations established on salt-affected soils and/or irrigated with saline water would allow better land and fresh water to be reserved for field crops.

Trees for Economic Benefits

Some trees are productive, high yielding and of major economic interest. Their plantations are sustainable sources of raw materials necessary for a variety of industries, e.g., pulp or paper, panel products, match manufacturing, sports goods, plywood, fiberboard, saw wood, fuel-wood, constructional and furniture timber. In some cases, forage can be produced from salt-tolerant tress using land and water unsuitable for conventional crops. The use of fuel-wood from plantings will also save huge quantity of dung, which can enrich agricultural fields.

Trees for Environmental Management

Beneficial effects of trees on soil and surrounding environment and human and animal life are adequately proven. They have protective, productive and aesthetic values for us. The effective role played by plants in environmental protection and amelioration has been immensely appreciated and planting campaigns form an integral and effective method amongst various environmental/ ameliorative measures. Trees can help rehabilitate salt-affected land. Salinized soils under vegetation tend to reduce salt concentration in the top soil because of increased infiltration and reduced capillary rise of water. This would allow farmers to grow field crops for immediate economic returns thus allowing farmers to get short-term economic benefits also from saline wasteland with the help of trees. Such planting is cheaper and lasting and is preferred to various expensive engineering methods.

All know the vital impact of trees on the microclimate, soil erosion and floods. Large plantation makes conditions more favorable for obtaining rainfall. The effect on microclimate and moisture regime in turn affects soil, the amount and type of plant life in different soil layers and depth of rooting. The plants reduce the force of raindrops and splashes and ultimate effect is reduced water erosion. The soils under plantations have greater porosity, encourage absorption and infiltration of water and thus help recharge aquifers. Dense vegetation effectively checks excessive runoff, thus it may have a marked effect in the manner water is released from catchments and thus tampering the floods. Reduced sediment from catchment area under dense vegetation protects waterways and dams from silting in.

A thick stand of vegetation controls wind erosion as the soil is protected from blowing winds mainly because of binding action of roots and reduction in wind velocity by mechanical barrier of plant canopies. Rather a dense stand of trees serves to remove and settle wind borne dust. The leaves, branches and stems act as mechanical barriers and when dust laden wind blows into the vegetation, it loses much of its velocity resulting in the precipitation of much of its dust. Depending upon the plant species, one-hectare plantation has been reported to collect 36-68 tons of dust. Filtering of dust by plants removes water condensation nuclear particles and reduces fog which contains gases injurious for life.

Dense vegetation due to its sheltering and blanketing effect interrupts incoming and reflected light and reduces extremes of soil temperature by its canopy action and interaction of surface litter layers. Diurnal fluctuations in temperature also significantly reduce under dense plant cover. Due to higher evapo-transpiration, plantations increase atmospheric humidity and reduce temperature and air movement.

Trees as a Pollution Scavenger

Trees act as natural filters as they remove (scavenge) pollutants from the atmosphere and thus improve the air quality by absorbing hazardous gases, particles and soot from the smoke. Global temperature is increasing because of green house effect; CO_2 is one of the major components of green house gases. To prevent global warming, trees need to be planted in billions as they absorb CO_2. Plantations act as pollution sinks in two ways – as air filters and as air ventilators. Trees cause air current and eddies that help to ventilate an area that might otherwise have very still air. The forest soil with its microbes and vegetative cover also acts as natural filters by absorbing noxious materials.

A dense stand of plantation is helpful in absorbing and reducing noise and in mitigating effects of noise. Its significance may be gauged from the fact that noise increases blood pressure, pulse rate and affects the frame of mind leading to depression and dulling of one's spirits, resulting in excessive fatigue, headaches and loss of hearing. A dense stand of plants with its flowers and foliage is ideal for mental recreation. In its quiet solitude, man finds peace and solace and the continuously changing views inside a plantation may divert him from the tension of daily life.

Annexure - 7

Water Management

Currently, around 75-80% of the worldwide fresh water resources are consumed by irrigation agriculture. This level of consumption cannot be sustained in the future because of increasing competition for water from other sectors and the variation in rainfall patterns and global warming as a result of climate changes.

Approximately one-third of populations in developing countries live in water deficit regions. Because of insufficient water supplies, the agricultural, domestic, industrial and environmental needs are not fully met. Competition among different sectors for scarce water resources and increasing public concern for human health and livestock performance has focused more attention on water management. Thus, improving water management in agriculture is crucial for increased food security and alleviation of rural poverty. This requires the involvement of novel water management practices and soil moisture conservation measures, as well as an increase in water productivity and water use efficiency. Use of groundwater in Pakistan has increased tremendously in recent years. Unfortunately, 75-80% of this water is brackish and increases sodicity hazards, leading to increased land degradation. Sustainable use of this water can be greatly increased by acidifying this water with sulfurous acid generator or by application of commercial mineral acids. Reducing the wasteful use of water is also likely to help. There are several water saving technologies like precision land leveling, raised beds, bed-and-corrugation, zero tillage and pressurized irrigation systems. Drip irrigation is the most efficient among them.

A large-scale use of drip irrigation system will improve agricultural water use efficiency and crop water productivity and at the same time will minimize water wastage through evaporation; deep drainage and off-site runoff, thus reducing/mitigating agricultural impacts on the groundwater quality and down stream water bodies. Drip irrigation will also help to reduce the demand for fertilizers and prevent the accumulation of soil nutrients, which can be lost as runoff or deep drainage into receiving aquifers. SAFPDP engaged itself also in new initiatives on water management in Saline Agriculture through development work supported by a research program at NIAB. Building on these accomplishments, and research experience and expertise, NIAB is also planning activities that will address land-water management issues both at a landscape and farm-level scales to enhance sustainable agricultural production, preserve land-water-soil nutrient resources and protect the environment.

Annexure - 8

Traditional and High-Value Agriculture

Pakistan is a land of much splendor. The scenery changes northwards from coastal beaches, lagoons and mangrove swamps to sandy deserts, desolate plateaus, fertile plains, dissected uplands and high mountains with beautiful valleys, snow covered peaks and eternal glaciers. This variety of landscape divides Pakistan into six major physiographic units - Northern High Mountainous Region, Hindu Kush and Western Low Mountainous Region, Potwar Uplands and Salt Range, Balochistan Plateau, Indus Plain and Cholistan - Thar Desert. The Indus River System drains the whole land, excluding most of Balochistan.

The Indus Basin is prime agricultural land in Pakistan. The climate in this area is conducive for crop production whole of the year provided water can be made available when and where needed. The farmers are hard working and have a long cumulative experience of farming on these lands.

Development of the gigantic Indus irrigation system in Pakistan with huge investment and massive engineering efforts on 16 mha of irrigated land is the largest single irrigation system in the world. It contains some of the world's largest infrastructural works and includes three major storage reservoirs, 20 diversion structures, 12 link canals, 48 main canals and some 89000 water courses. The length of the irrigation network of canals is about 63000 km. This is more than 1.5 times the length of the equator.

It is, therefore, no wonder if agriculture is the largest segment of Pakistan's economy. Agriculture, which is taken here in its broad sense to include cropping, horticulture, forestry, livestock and aquaculture, etc., contributes 25 percent to GDP of Pakistan. Agriculture is also the main source of livelihood for the rural populations. The bulk of 67 percent of population living in rural areas is dependent on it for livelihood. Agriculture directly or indirectly provides more than 70 percent of exports earning and around 48 percent employment in the country. Despite the sustainable role agriculture plays in the economy of Pakistan, it has not received its due share in developing and consolidating agricultural production and the sad fact is low crop yield with a high per-hectare yield gap compared to developed countries or well managed private or experimental farms even in Pakistan.

Population in Pakistan is more than 160 million and is growing at a high rate, and its land and water resources are unable to sustain them. The prime farmland and good quality water are already more or less fully utilized. Traditional agriculture planning is unlikely to bring major economic benefits. Most farmers are not going to get richer by growing cereals when already world markets are glutted with the subsidized production of rich countries' farmers.

Whereas agricultural policy in Pakistan is still rooted in the goal of self-sufficiency in grains, consumption patterns are changing fast from cereals toward high-value agricultural products such as livestock, fish, fruits and honey, etc. The shift in consumption pattern is the result of rising incomes and changing taste and preference of consumers, in addition to growing urbanization. This shift is observed not only in the urban areas and high income strata but in rural areas and low income groups as well. Demand for high-value food commodities is projected to grow still more, under the existing scenario of income growth. Consumption patterns are also changing in regional countries, so the new export market opportunities exist for many of the same products. Therefore, our agriculture should and is gradually diversifying in favor of high-value food commodities so much that the production of milk, meat, poultry, fish and honey has increased, albeit, slowly during the last two decades.

Furthermore, higher-value agriculture products have higher employment elasticity and can be suitable for small holders if they can participate. This can diminish poverty quickly with growth in agriculture and rural development. In this new situation, more of the energies and resources of the agricultural sector can be unleashed to produce the kinds of high-value foods and products that are now in high demand in the country and that have new export market opportunities. A reinvigorated agricultural and agri-business sector could thus be a major engine of income and employment growth for the country. For this to happen at a fast rate, three important challenges have to be overcome.

The first challenge is to further support the promotion of agricultural diversification, processing, and commercialization. Farmers must shift into higher-value products to increase their incomes. A set of public policies and investment is required to fully unleash this new potential. This set must include additional public investment in the kinds of rural infrastructure. Moreover, technology is needed for these new high-value activities, improvements in marketing and distribution systems for higher-value and more perishable foods, and further enhancement of agro-industrial sector. The private business sector can and should play a dominant role in these higher-value market chains, and public policy must strengthen the enabling environment.

The second challenge for the `new' high-value agriculture is to make it pro-poor. Left to market forces alone, the major beneficiaries of the new high-value agriculture will be mostly the larger and commercially oriented farms. Fortunately, there is a great opportunity to guide the new high-value agriculture so that small farmers can be major participants. Achieving broad participation requires improving social infrastructure and education in addition to physical infrastructure in many less-favored regions and communities, ensuring that small farmers get the technologies and key inputs they need, and promoting producer marketing organizations that can link small farmer to the new market chain (super markets, contractors, processors, exporters, etc.). Small farmers cannot do all these things on their own, and the public sector, private sector, and NGOs all have important role to play. Because high-value agriculture demands more working capital, which small farmers often lack. A major effort must be made to reform the rural credit delivery system to reach small holders. There is a need for innovative institutions promoting such coordination between farms and firms, thus reducing transaction cost and market risks and would also act as a conduit to funnel more credit into this venture, especially for small holders. This system would help lay foundation for competitive agriculture in which small holders can also participate and prosper. Public policy can make a major contribution by facilitating farmers' organizations, standardization, transparent food safety policy, and contract security between farmers and the processing and retail industry.

The third challenge is to overcome many of the environmental problems that now plague agriculture, e.g., salinity problem. Farmers must also learn to use less water and to be more efficient in the use of the natural resources. Land degradation and deforestation must also be contained. A shift toward more diversified and higher-value farming systems will help both because many of the new crops need less water and because, by increasing returns to land, small farmers will have less need to over exploit poor land.

About NIAB

Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad, established in 1972, is a research and development centre functioning under the auspices of Pakistan Atomic Energy Commission. It conducts research on applied problems in the field of agriculture and biology using nuclear and other related techniques. Research Programs are focused on crop germplasm improvement, crop protection, fertilizer and water management for major crops, sustainable use of salt-affected wastelands and saline waters, and improving animal health, nutrition and reproduction.

For details, please visit: **www.niab.org.pk**

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