ON FARM WATER MANAGEMENT LEARNING RESOURCE FOR FARMERS & EXTENSION AGENTS

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ON FARM WATER MANAGEMENT

LEARNING RESOURCE

FOR FARMERS & EXTENSION AGENTS

This learning resource manual is written for farmers and extension agents working with farming communities in Pakistan. It provides guidance for farmers wanting to learn how to improve water use on farm and increase crop yields according to the water statistics in Pakistan particularly Sindh. This manual is written by Management & Development Foundation (MDF) for farmers of Sindh, especially for those who are being engaged as part of the Australian funded groundwater project.

The options for improving on-farm water management covered in this manual are:

1. Raised bed farming
2. Conservation Tillage
3. Conjunctive Use Strategies – Understanding the Risks of using Poor Quality Groundwater
4. Waterlogging and Salinity Management
5. Irrigation Scheduling
6. Drought-Tolerant Crops and Low Delta Crops
7. Best Practice Strategies for Irrigation
8. How Salinity of irrigation water affects crop yields
9. Appendix 1 – Conjunctive use of canal water and tubewell water

1. **Raised Bed Farming**

In canal-irrigated areas of Pakistan especially Sindh, farmers get fixed turn time to irrigate their crop once in a week, which is not enough to irrigate their whole cropped area, hence farmers rely on either tubewell water or rainfall.

Traditionally the majority of agriculture fields are irrigated using flood irrigation method which has 30–50% irrigation efficiency.

It has been observed that in recent years there has been water shortage due to which the crops are affected and farmers are not able to achieve desired yields.

Because of uncertainty and limited water availability at critical growth stages, farmers tend to apply more water to crops when water is available, regardless of the need of the crop at growth stages, which affects the crops growth negatively.

Availability of water is reducing day by day, and there is a need to adopt water-saving techniques.

Furrow-irrigated raised bed technology is one of the efficient irrigation methods in which water moves in furrow, and the crop is planted on raised beds.

In USA and India, farmers have shifted to a bed and furrow system for wheat planting due to scarcity of water, whereas only a few farmers in Sindh have adopted this practice. The Nawazabad Farm and Asim Agriculture Farm, located near Tando Allahyar district, are modern farms in Sindh where raised bed farming is practiced and the crop yields are higher and irrigation water is being saved for more cropping.

The technique benefits the farmer in:

- improvement in irrigation and nutrient management,
- saving water,
- better crop stand,
- lower seed rate, and
- reduction in lodging.

Bed and furrow planting systems improved water distribution, reduced water requirement for irrigation, improved water use efficiency in the rice-wheat cropping system of Indian agriculture fields.

In Pakistan, wheat sown on 70 cm bed and furrow system in the rice-wheat area of Punjab produced good yields as traditionally the yield was around 29 Maunds per acre but due to Raised Bed System the yield increased to 35 Maunds per acre (17% yield increase) with 30-35% water saving in comparison to traditional watering. This shows that with less water more yields can be achieved through raised bed cultivation1.

The Water Management Research Center at University of Agriculture, Faisalabad, introduced bed and furrow planter to plant four wheat rows on a 90 cm bed and furrow system, and the results showed around 40% saving in irrigation water and 18% higher yield with raised bed planting in comparison with flat sowing2.

1. [1] R. A. Mann and C. A. Meisner, Proceedings of the National Workshop on Rice-Wheat Systems in Pakistan, A Rice Wheat Consortium Paper Series 15, 2003.

   2 A. Majid, A. Muhmood, A. Niaz et al., "Bed planting of wheat (Triticum aestivum L.) improves nitrogen use efficiency and grain yield compared to flat planting," Crop Journal, vol. 3, pp. 118–124, 2015.
   N. Ahmad and N. Mahmood, "Impact of raised bed technology on water productivity and logging of wheat," Pakistan Journal of Water Resources, vol. 90, pp. 7–15, 2005.
   M. A. Shahid, N. Ahmad, M. Saleem, and B. Akhtar, "Investigating optimum number of irrigations for wheat under raised bed Technology in a semi-arid climate," International Journal of Applied Agricultural Sciences, vol. 3, pp. 89–93, 2011.

2. Conservation Tillage

The soil preparation for crop production is commonly accomplished by using mechanical and other means for plowing, digging, overturning, shoveling, hoeing, and raking. Small-scale farmers use conventional hand tools and often tools pulled by animals; however, farmers are now diverting their preferences toward the use of tractors and other machinery.

The overall goal of conservation tillage is to increase crop production while conserving resources (soil and water) and protecting the environment.

Conservation tillage, a progressive approach, presents innovative strategies and methods to tackle the remnants of ex-crop's residues, which can be used to get extra benefits remained on the soil surface.

This extra benefit provided in slowing the water movement, which ultimately reduces the amount of soil erosion and nutrient depletion.

The most common conservation tillage practices are no-tillage, ridge-tillage, and mulching-tillage.

In fact, no-tillage is a way of growing crops without disturbing the soil as preparatory operation.

This practice involves leaving the residue from last year's crop undisturbed and planting directly into the residue on the seedbed. This is direct drilling of seeds in the land with crops residue which helps in slowing the water movement, reducing soil erosion and soil compaction.

Conversation tillage reduces the machinery steps which helps the farmers in reduced labor requirements such as less ploughing and planting seeds into undisturbed crop residues and soil complements in releasing less carbon emissions and improving the soil ecosystem.

Cover crops – "green manure" – can be used in a conservation tillage system to help control weeds.

Conservation tillage benefits farming by minimizing erosion and increasing soil fertility due to organic matter content in ex-crop residues thereby improving yield of the crops.

Conservation Tillage is believed to be helpful to boost the growth of micro-organisms and their mixing with crop harvest residues and soil organic matter. In addition, requirement for herbicides and fertilizers are reduced. The conservation tillage is in practice in Punjab, however, the knowledge is also being transferred to Sindh for adoption of Conservation Tillage on agriculture fields.

3. Conjunctive Use Strategies – Understanding the Risks of Using Poor Quality Usage of Groundwater for Irrigation

Conjunctive use is the blended use of tube-well and canal water. In Pakistan, canal water used for irrigation is of better quality (low in salts) compared to groundwater which can vary from fresh to brackish to saline.

Usually conjunctive use of surface and groundwater is considered within a river basin management programme - i.e. both the river and the aquifer belong to the same basin.

Most groundwater exploitation in Pakistan occurs via conjunctive use with surface water.

Irrigated agriculture using only groundwater is limited mainly to three situations:

- areas not supplied by canal commands
- small systems outside the Indus Basin
- at the tail end of canal commands that have lost access to surface water through inequitable distribution of canal water supplies.

The most productive areas of the Indus Basin commonly incorporate conjunctive use of canal water and high to medium quality groundwater.

Conjunctive use of groundwater and surface water allows farmers to cope with unreliable surface water supplies and to achieve more secure and predictable yields.

However there are adverse impacts of conjunctive use where poor quality groundwater is utilized adding large amounts of salt in the root zone, and hence causing additional salinization problems to those arising from shallow water tables.

In some areas, the salinity of the groundwater resource is such that there is full reliance upon canal deliveries to sustain irrigated agriculture.

Even in areas where groundwater is deemed to be usable, the brackish nature of the resource commonly requires mixing with surface water prior to application to crops.

Moreover the farmers are not fully aware of the ratios required when mixing the two water types and hence negative consequences of irrigating with high salinity water have been observed.

The canal and tubewell waters should be mixed in the ratio of 2 :1, which means two parts of canal water for every one part of tubewell water, or in other words twice as much canal water compared to tubewell water. However, in locations where groundwater is more saline then the canal and tube-well should be mixed in ratio of 3:1. The use of blended water in the right quantities minimises the build up of salts in the crop root zone which supports in increasing the crop growth and subsequently yields. Appendix I shows how to calculate these ratios and also provides a simple ready reckoner to estimate these ratios based on salinity of canal water and groundwater.

4. Waterlogging and salinity management

Waterlogging and salinity are two of the outcomes of canal irrigation in Pakistan. When only inundation canals were used, water for crops was only available during the summer season. A balance was maintained between the precipitation and evapotranspiration that kept the water-table low.

With the introduction of perennial canals, water was available throughout the year resulting in a rise of the water-table.

Salts in the soil also rise to the surface with the watertable.

The water on reaching the surface evaporates and the salts are deposited on the surface, rendering the land unsuitable for farming.

The rise of the watertable to the surface level is called waterlogging and the appearance of salty patches is called salinity.

Waterlogging and salinization are major impediments to the sustainability of irrigated lands and livelihoods of farmers, especially smallholder farmers, in the affected areas of the Indus Basin.

These problems are the result of a multitude of factors, including seepage from unlined earthen canals, inadequate provision of surface and subsurface drainage, poor water management practices, insufficient water supplies and use of poor quality groundwater for irrigation.

Since the early 1960s, several efforts have been made to improve the management of salt-affected and waterlogged soils. These include:

- lowering groundwater levels through deep tubewells;
- leaching of salts by excess irrigation;
- drainage of water from waterlogged areas in Left Bank Outfall Drain (LBOD);
- application of chemical amendments (e.g. gypsum, acids, organic matter); and
- use of biological and physical methods.

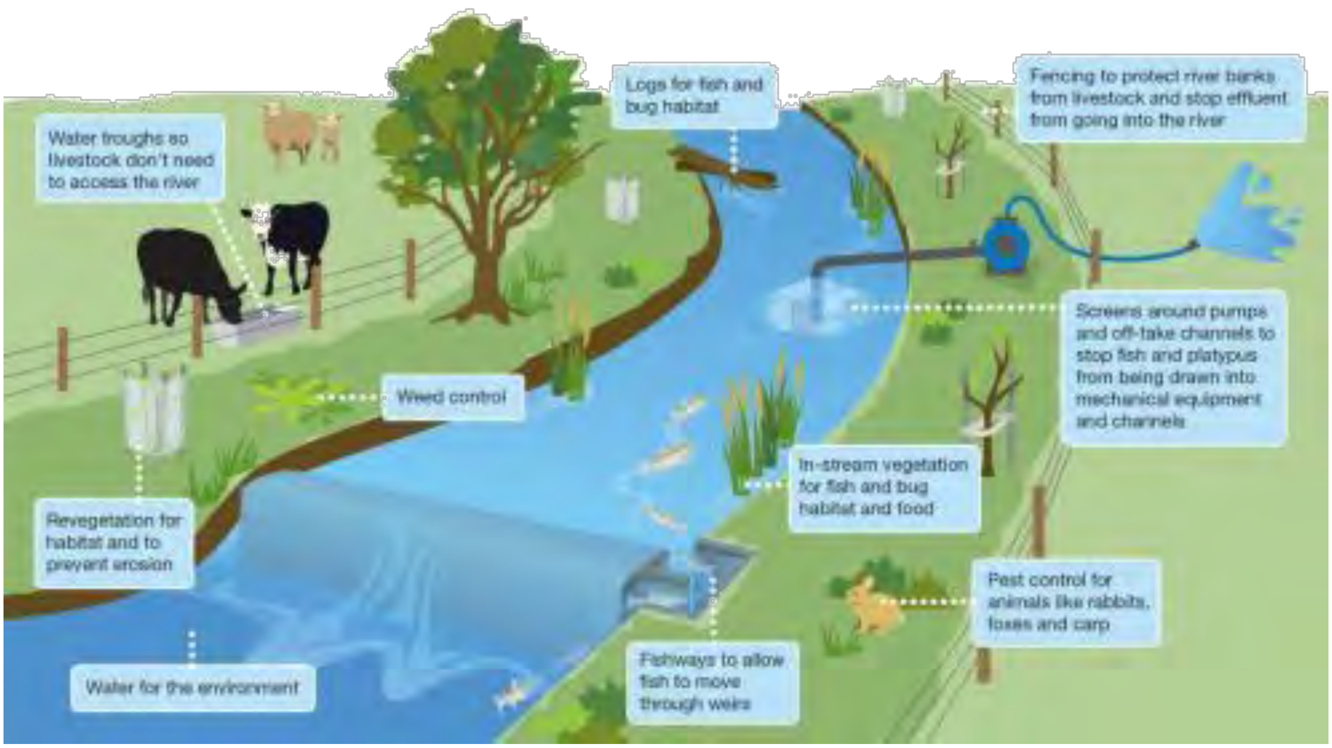
These locations are at the border of Shaheed Benazirabad, Naushehro Feroze and Khairpur districts where salinity is rampant because of canal water shortages in these locations, Tail End of Canals, coupled with brackish water underground which is considered hazardous for cropping by farmers.

Section 8 shows how increasing salinity of irrigation water reduces yields for a range of different crops.

5. Irrigation Scheduling

Irrigation scheduling is the process used by irrigation system managers to determine the correct frequency and duration of watering.

Irrigation scheduling is needed for the efficient use of water, and is just as important as seed, fertilizer and other inputs. Irrigation scheduling is the process of determining when to irrigate and how much water to apply per irrigation. There are certain benefits of proper irrigation scheduling such as improved crop yield and its quality, water and energy conservation and lower production costs.



To manage efficient use of water, irrigation scheduling of crop is necessary, which determines when and how much irrigation water to apply to a particular crop in existing agro-climatic conditions per irrigation. In practice, over irrigation is done by farmers due to lack of awareness about crop water requirements under the fixed interval system of water distribution. The fixed water interval system is distribution of water in 7 days/week in which the water allocation is divided among water users/farmers according to the landholding in time duration – Peher – as per local irrigation practices.

The real goal of irrigation use in soil is to supply sufficient water to keep the plant growth normal. However, for optimum yield of wheat, it is necessary to irrigate wheat crop at proper timings and proper stages of growth and maturity and in quantities that match crop water requirements.

Crop water use is expressed in acre inches, where an acre inch is the amount of water required to cover one acre of land with one inch of water. For normal wheat crop under optimum grown conditions, 4-6 irrigations are sufficient. First irrigation should be applied 3-4 weeks after sowing, and subsequent irrigation should be applied at 21 days intervals. The wheat growing farmers share that the highest wheat yields are obtained from minimum four to five irrigations.

Watercourse No. 61 – L

S. No	Name of Farmer	Survey No.	Irrigable Area (Acre)	Time in Peher (1 Peher = 3 hours)
1	Faisal Memon	138/2	12	3
2	Shakeel Abdullah	119/1	17	4
3	Haji Ali Abbas	128/1	14	5
4	Muzafar Bhatti	128/2	6	2
5	Javed Ali Magsi	128/3	18	3
6	Shahryar Khan	128/4	24	8
7	Aslam Shar	128/5	13	7
8	Khalid Saifullah	126/1	45	11
9	Mubeen Marri	126/2	32	6
10	Allah Rakhyo Marri	125/1	9	4
11	Jan Muhammad	125/2	17	2
12	Hamid Khand	124/1	4	1

Peher is a local word used in Sindhi language in irrigation system which means that 1 Peher is equal to 3 hours' time. In addition the allocation for orchards is double than the allocation for crops.

Irrigation Frequency and Scheduling in Wheat	
Irrigation Frequency	Days after Sowing
1st Irrigation	21
2nd Irrigation	42
3rd Irrigation	63
4th Irrigation	84
5th Irrigation	105
6th Irrigation	126

6. Drought-Tolerant Crops and Low Delta Crops

At present, non-availability of sufficient irrigation water is a burning issue all over in Pakistan. Therefore, cultivation of drought resistant crops is today's need, for obtaining optimum crop production and to support economy of the country as much as could be possible.

No doubt, water is the most important plant nutrient and constitutes the greater part of plant weight, hence is absolutely essential for plant life.

Apparently even dry plants contain an appreciable amount of water because water is basic need and works as the nutrient solvent.

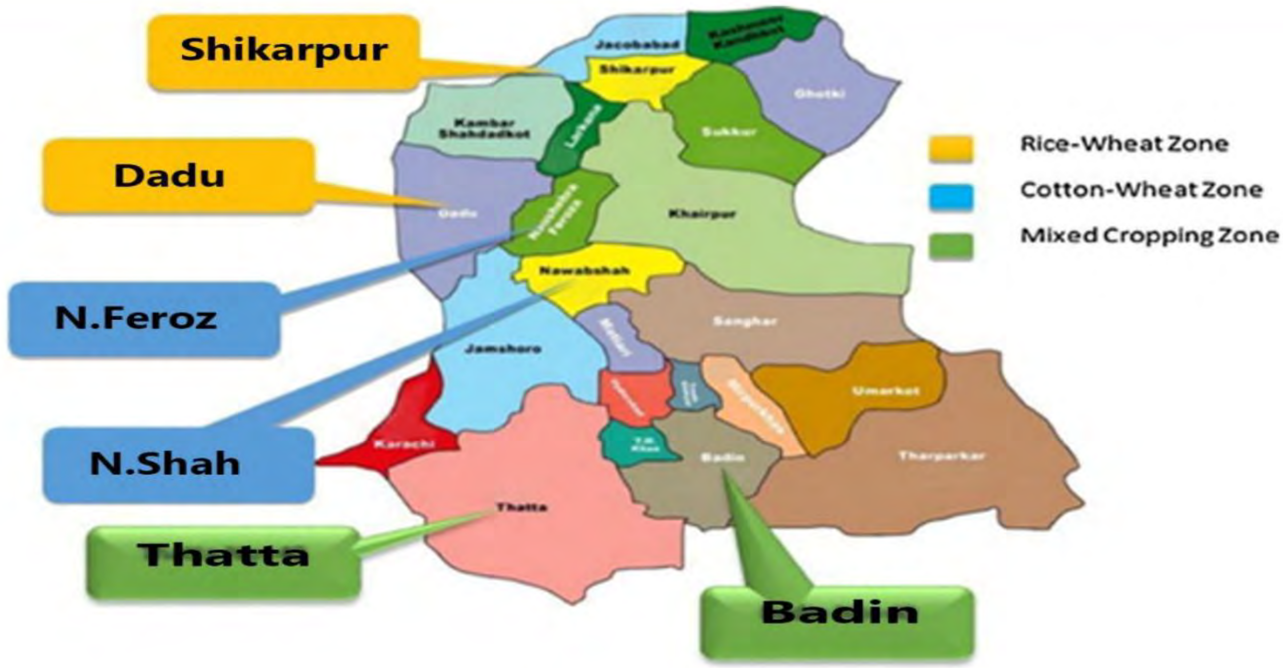
In fact, plants use more water than any other substance they absorb, therefore water in sufficient quantity is vital for all plants.

The function of soil moisture in plant growth is very important.

When soil moisture is not enough, drought condition prevails leading to ultimate death of the plant. The availability of nutrient is controlled by the moisture content of the soil.

The agriculture of Pakistan is characterized by two main cropping seasons, namely, the Kharif (summer crops) from April to September; and Rabi (winter crops) from October to March.

Wheat is the main crop of Rabi season and barley, chickpea, lentil, grasspea, mustard, linseed and senji requires comparatively less water in Rabi season.



Rice, maize, sugarcane and cotton are considered the major crops of Kharif, however, the Kharif crops whose survival depends on less or minimal water needs are sorghum, millet, mungbean, mash, cowpea, sunflower, sesame, clusterbean, sesbania and moth.

Mono cropping, sequence cropping, mixed cropping, inter-cropping and relay cropping systems are practiced by growers (farmers), especially those with small holdings, to maximize crop production per unit area.

Intercropping is an agricultural practice in which two or more crops are grown together in the same field. Mixed cropping is growing of two crops (eg. corn and soybeans) intermingled together in the same field, It is a special type of intercropping. Relay cropping is a special version of double cropping, where the second crop is planted into the first crop before harvest, rather than waiting until after harvest as in true double-cropping. The cropping pattern is largely determined by water availability and the climatic conditions as adaptation of crops. The horticulture needs to be strengthened in Sindh as it contributes to better yields, availability of food, water saving and better income growth.

7. Best Practice Strategies for Irrigation

Irrigation is the artificial application of water to the soil through various systems of tubes, pumps, and sprays. Irrigation is usually used in areas where rainfall is irregular or dry times or drought is expected.

There are many types of irrigation systems, in which water is supplied to the entire field uniformly.

Irrigation water can come from groundwater, through springs or wells, surface water, through rivers, lakes, or reservoirs, or even other sources, such as treated wastewater or desalinated water.

As a result, it is critical that farmers protect their agricultural water source to minimize the potential for contamination.

There are many different types of irrigation systems, depending on how the water is distributed throughout the field.

Some common types of irrigation systems include:

- **Surface irrigation** – Water is distributed over and across land by gravity, no mechanical pump involved;
- **Localized irrigation** – Water is distributed under low pressure, through a piped network and applied to each plant;
- **Drip irrigation** – A type of localized irrigation in which drops of water are delivered at or near the root of plants. In this type of irrigation, evaporation and runoff are minimized;
- **Sprinkler irrigation** – Water is distributed by overhead high-pressure sprinklers or guns from a central location in the field or from sprinklers on moving platforms;
- **Center pivot irrigation** – Water is distributed by a system of sprinklers that move on wheeled towers in a circular pattern. This system is common in flat areas of the United States;
- **Lateral move irrigation** – Water is distributed through a series of pipes, each with a wheel and a set of sprinklers, which are rotated either by hand or with a purpose-built mechanism. The sprinklers move a certain distance across the field and then need to have the water hose reconnected for the next distance;
- **Sub-irrigation** – Water is distributed across land by raising the water table, through a system of pumping stations, canals, gates and ditches. This type of irrigation is most effective in areas with high water tables; and
- **Manual irrigation** – Water is distributed across land through manual labor and watering cans. This system is very labor intensive.

The estimated cost of High Efficiency Irrigation System Technologies in Pakistan are:

Drip Irrigation System for Vegetables per Acre is Rs. 230,000	*Drip Irrigation System for Orchard per Acre is Rs. 100,000*
Sprinkler Irrigation System per Acre is Rs. 250,000	*Rain Gun Irrigation System per Acre is Rs. 95,000*

8. How salinity of irrigation water affects crop yield

The tables below shows how the potential yield of different crops can be reduced with increasing salinity of irrigation water. The table shows that Barley and Cotton are more salt tolerant than maize or sugarcane. So if you are using groundwater where salinity levels are high then you may want to consider which is a suitable crop for you to grow. To get maximum yield from your crops farmers need to minimise using water of high salinity, and where possible use surface and groundwater conjunctively to minimise the risk of salinity build up in the root zone.

We test the salinity of irrigation water using an EC meter. The EC meter measures the electrical conductivity of water. As the salts in the water become higher the EC value also becomes higher.

Salinity Level	ppm	mS/cm	µS/cm
Fresh water	<1000 ppm	<1.5	<1500
Brackish water	1000-3000	1.5-4.5	1500 - 4500
Saline water	>3000	>4.5 mS/cm	>4500

Units of salinity: ppm = parts per million;
mS/cm milli Seimens per cm; **µS/cm micro Seimens per cm**

Table 1. Yield reduction with increasing salinity for field crops (ECw mS/cm)

Yield Potential with increasing EC -------->	100%	90%	75%	50%	0%
FIELD CROPS	ECw	Ecw	ECw	ECw	ECw
Barley (Hordeum vulgare)4	5.3	6.7	8.7	12	19
Cotton (Gossypium hirsutum)	5.1	6.4	8.4	12	18
Sugarbeet (Beta vulgaris)5	4.7	5.8	7.5	10	16
Sorghum (Sorghum bicolor)	4.5	5	5.6	6.7	8.7
Wheat (Triticum aestivum)4,6	4	4.9	6.3	8.7	13
Wheat, durum (Triticum turgidum)	3.8	5	6.9	10	16
Soybean (Glycine max)	3.3	3.7	4.2	5	6.7
Cowpea (Vigna unguiculata)	3.3	3.8	4.7	6	8.8
Groundnut (Peanut) (Arachis hypogaea)	2.1	2.4	2.7	3.3	4.4
Rice (paddy) (Oriza sativa)	2	2.6	3.4	4.8	7.6
Sugarcane (Saccharum officinarum)	1.1	2.3	4	6.8	12
Corn (maize) (Zea mays)	1.1	1.7	2.5	3.9	6.7
Flax (Linum usitatissimum)	1.1	1.7	2.5	3.9	6.7
Broadbean (Vicia faba)	1.1	1.8	2	4.5	8
Bean (Phaseolus vulgaris)	0.7	1	1.5	2.4	4

Table 2. Yield reduction with increasing salinity for vegetable crops and grasses (ECw mS/cm)

Yield Potential with increasing EC -------->	100%	90%	75%	50%	0%
VEGETABLE CROPS AND GRASSES	ECw	ECw	ECw	ECw	ECw
Squash, zucchini (courgette) (Cucurbita pepo melopepo)	3.1	3.8	4.9	6.7	10
Beet, red (Beta vulgaris)5	2.7	3.4	4.5	6.4	10
Squash, scallop (Cucurbita pepo melopepo)	2.1	2.6	3.2	4.2	6.3
Broccoli (Brassica oleracea botrytis)	1.9	2.6	3.7	5.5	9.1
Tomato (Lycopersicon esculentum)	1.7	2.3	3.4	5	8.4
Cucumber (Cucumis sativus)	1.7	2.2	2.9	4.2	6.8
Spinach (Spinacia oleracea)	1.3	2.2	3.5	5.7	10
Celery (Apium graveolens)	1.2	2.3	3.9	6.6	12
Cabbage (Brassica oleracea capitata)	1.2	1.9	2.9	4.6	8.1
Potato (Solanum tuberosum)	1.1	1.7	2.5	3.9	6.7
Corn, sweet (maize) (Zea mays)	1.1	1.7	2.5	3.9	6.7
Sweet potato (Ipomoea batatas)	1	1.6	2.5	4	7.1
Pepper (Capsicum annuum)	1	1.5	2.2	3.4	5.8

Lettuce (Lactuca sativa)	0.9	1.4	2.1	3.4	6
Radish (Raphanus sativus)	0.8	1.3	2.1	3.4	5.9
Onion (Allium cepa)	0.8	1.2	1.8	2.9	5
Carrot (Daucus carota)	0.7	1.1	1.9	3	5.4
Bean (Phaseolus vulgaris)	0.7	1	1.5	2.4	4.2
Turnip (Brassica rapa)	0.6	1.3	2.5	4.3	8
Wheatgrass, tall (Agropyron elongatum)	5	6.6	9	13	21
Wheatgrass, fairway crested (Agropyron cristatum)	5	6	7.4	9.8	15
Bermuda grass (Cynodon dactylon)7	4.6	5.6	7.2	9.8	15
Barley (forage) (Hordeum vulgare)4	4	4.9	6.4	8.7	13
Ryegrass, perennial (Lolium perenne)	3.7	4.6	5.9	8.1	13
Trefoil, narrowleaf birdsfoot8 (Lotus corniculatus tenuifolium)	3.3	4	5	6.7	10
Harding grass (Phalaris tuberosa)	3.1	3.9	5.3	7.4	12
Fescue, tall (Festuca elatior)	2.6	3.6	5.2	7.8	13
Wheatgrass, standard crested (Agropyron sibiricum)	2.3	4	6.5	11	19
Vetch, common (Vicia angustifolia)	2	2.6	3.5	5	8.1
Sudan grass (Sorghum sudanense)	1.9	3.4	5.7	9.6	17
Wildrye, beardless (Elymus triticoides)	1.8	2.9	4.6	7.4	13
Cowpea (forage) (Vigna unguiculata)	1.7	2.3	3.2	4.8	7.8
Trefoil, big (Lotus uliginosus)	1.5	1.9	2.4	3.3	5
Sesbania (Sesbania exaltata)	1.5	2.5	3.9	6.3	11
Sphaerophysa (Sphaerophysa salsula)	1.5	2.4	3.8	6.2	11
Alfalfa (Medicago sativa)	1.3	2.2	3.6	5.9	10
Lovegrass (Eragrostis sp.)9	1.3	2.1	3.3	5.3	9.3
Corn (forage) (maize) (Zea mays)	1.2	2.1	3.5	5.7	10
Clover, berseem (Trifolium alexandrinum)	1	2.2	3.9	6.8	13
Orchard grass (Dactylis glomerata)	1	2.1	3.7	6.4	12
Foxtail, meadow (Alopecurus pratensis)	1	1.7	2.7	4.5	7.9
Clover, red (Trifolium pratense)	1	1.6	2.4	3.8	6.6
Clover, alsike (Trifolium hybridum)	1	1.6	2.4	3.8	6.6
Clover, ladino (Trifolium repens)	1	1.6	2.4	3.8	6.6
Clover, strawberry (Trifolium fragiferum)	1	1.6	2.4	3.8	6.6

Table 3. Yield reduction with increasing salinity for fruit crops (ECw mS/cm)

Yield Potential with increasing EC -------->	100%	90%	75%	50%	0%
FRUIT CROPS10	**ECw**	**ECw**	**ECw**	**ECw**	**ECw**
Date palm (phoenix dactylifera)	2.7	4.5	7.3	12	21
Grapefruit (Citrus paradisi)11	1.2	1.6	2.2	3.3	5.4
Orange (Citrus sinensis)	1.1	1.6	2.2	3.2	5.3
Peach (Prunus persica)	1.1	1.5	1.9	2.7	4.3
Apricot (Prunus armeniaca)11	1.1	1.3	1.8	2.5	3.8
Grape (Vitus sp.)11	1	1.7	2.7	4.5	7.9
Almond (Prunus dulcis)11	1	1.4	1.9	2.8	4.5
Plum, prune (Prunus domestica)11	1	1.4	1.9	2.9	4.7
Blackberry (Rubus sp.)	1	1.3	1.8	2.5	4
Boysenberry (Rubus ursinus)	1	1.3	1.8	2.5	4
Strawberry (Fragaria sp.)	0.7	0.9	1.2	1.7	2.7

APPENDIX I

Conjunctive use of Canal water and Tubewell Water

Conjunctive use is the blended use of tubewell and canal water. In Pakistan, canal water used for irrigation is of better quality (low in salts) compared to groundwater which can vary from fresh to brackish to saline. When using groundwater farmers need to be aware of

1. Total quantity to water they want to apply
    a. Volume of canal water (V_{CW})
    b. Volume of tubewell water (V_{TW})
2. Salinity of canal water (μS/cm) EC_{CW}
3. Salinity of tubewell water (groundwater) (μS/cm) EC_{TW}
4. Desired salinity of blended water for application (μS/cm) EC_{BW}

Example - Estimating the mixing ratio of canal and tubewell water

Salinity of canal water EC_{CW} = 300 (μS/cm)

Salinity of tubewell water EC_{TW} = 2400 (μS/cm)

Desired salinity of blended water for application (μS/cm) EC_{BW} = 1000

Now calculate the ratio for the two waters

$$\frac{\quad}{\quad} = \frac{-}{-}$$

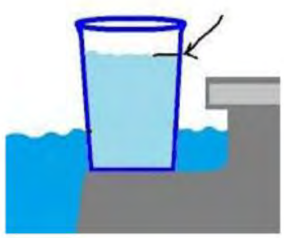
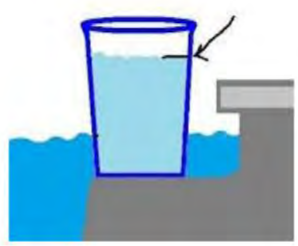
$$\frac{\quad}{\quad} = \frac{2400 - 1000}{1000 - 300} = \frac{1400}{700} = \frac{2}{1}$$

The canal and tubewell waters should be mixed in the ration of 2 :1, which means two parts of canal water for every one part of tubewell water, or in other words twice as much canal water compared to tubewell water.

The use of blended water in the right quantities minimises the build up of salts in the crop root zone

Blending of canal and tubewell water 2:1 ratio

For every one bucket of tubewell water use two buckets of canal water

Total water	=		+		+	

Different forms of Conjunctive use practised by farmers in Pakistan

Another form of conjunctive use practised by farmers in Pakistan is to use tubewell water when canal water is scarce and to apply canal water for the last irrigation which helps flush out salts accumulated in the root zone.

Desired salinity of Irrigation water 1000 µS/cm

Salinity of tubewell Water (µS/cm)	Salinity of canal water (µS/cm)		
	200	250	300
2000	1.5	1.5	1.5
2500	2.0	2.0	2.0
3000	2.5	3.0	3.0
3500	3.0	3.0	4.0
4000	4.0	4.0	4.0