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Linkage of Water Shortage and Fruit Orchards Deterioration: A Case Study of Tehsil Fort Abbas, Bahawalnagar, Pakistan

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Abstract: Water shortage is currently considered as a major problem for both human and agriculture. The present study was conducted in tehsil Fort Abbas, Bahawalnagar with objectives to highlight the irrigation water shortage as a main reason of orchards' deterioration and to find out different reasons and solutions of irrigation water shortage. Study was based on planned questionnaire and driven by performing in-depth interviews and discussions. A total of 150 farmers were interviewed and trees were examined by different aspects. Results showed that water shortage was the most promising factor for the deterioration of fruit orchards in tehsil Fort Abbas followed by occurrence of orchards diseases. Majority of the farmers apply canal water by flooding method for irrigation while rapid increase in installations of tube-wells was observed in the farming community to overcome shortage of canal water. More efficient irrigation methods like furrow and Drip irrigation were gradually being adopted for effective water use and management. However there was a dire need of water courses and canals improvement to reduce huge water loses. Farmers were aware of water shortage as a serious problem and it could be concluded that orchard farming can be made more profitable business in tehsil Fort Abbas if water is properly managed using advance irrgation techniques. Plantation of fruit orchards can only be recommended in areas of proper access and availability of sufficient irrigation water.

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1. Introduction

Water shortage is the world's most pressing problem in the current century. Particularly, the problem is much aggravated in semi arid and arid regions of the world (e.g. Pakistan) and reducing the availability of agricultural lands and water resources (Aguado et al., 2012). Crises due to freshwater shortage are considered as serious threat to sustainable development, natural environment, health and welfare of human beings; as a result, governments are required to change their policies on water resources and adopt participatory approaches to water management, to engage farmers in all steps and levels of water and environmental management (Shahroudi et al., 2008). Water is also equally essential for farming and necessary to guarantee water supply for poverty reduction particularly in rural areas, because poverty reduction leads to food security (Mohammadi et al., 2009). A recent study conducted in Jordan found that decreasing water supply by 20% would be accompanied by a decline in the total cultivated area by about 14% and eventually would lead to a decrease in the total net income (Hamdan and Salman, 2005). Regarding the fact that water shortage is mostly observed in the agricultural sector, efficient use of water resources in this sector, or agricultural water management is therefore inevitable. It is found in Greece that the efficiency of irrigation is very low therefore only 55% of the water is used by the crop (Chartzoulakis, 2014). A recent study conducted in Harran Plain, Turkey also concluded that majority of the farmers (61.6%) have a negative opinion about sufficiency and regularity of investment and management decisions of water user associations (WUAs). (Mohammadi et al., 2009; Tahamipour and Kavoosi, 2012; Aydogdu et al., 2015). Management generally implies running and controlling something, particularly by using communication tools, relying on law. Therefore, optimum water management for agriculture entails managing water resources in a way that would enable farmers and users of water resources to fulfil their needs without threatening future needs. Thus, horticulture being an integral part of agriculture, involves intensive plant cultivation for human use. It

is practiced from the individual level in an orchard up to the activities of a multinational corporation. An orchard is an intentional planting of trees or shrubs that is maintained for food production and comprised fruit or nut-producing trees which are grown for commercial production. They are also sometimes a feature of large gardens, where they served as an aesthetic as well as a productive purpose (Luther, 1989). Trees or shrubs that are planted together intentionally to maintain food production are known as orchards. They take long time, in their establishment and maturity period. Investment and careful planning are also essential to ensure economic success **e.g.** for a mango tree in sandy type of soil 2 to 3 times irrigation is required per week in summer season (Marini, 1997; Diczablis et al., 2006). Similar studies were carried out on water requirements and irrigation of mature trees in Nelspruit area which is situated in the Eastern Low veldt of South Africa, where total seasonal water requirement of the mature trees under optimal irrigation was approximately 9.71 acre feet (AF)/ha/year (Mostert and Hoffman, 2008). Likewise, the irrigation of a citrus orchard on average must be done within 12-14 days (Rashid and Salim, 1989). It is found that mature trees of citrus use about 17 gallons of water per day in the winter and 135 gallons of water per day in the summer (Wright, 2000). Field measurements in Florida (USA) have shown that the trees needed 965.2-1117.6 mm of water per year depending on tree size and this does not include water lost through deep percolation (Robert, 1990). In case of crop water requirement of guava yearly average water requirement was estimated to 206 mm after subtracting the effective rainfall whereas, the Chinese Jujubes required about 3–5 mega liters of water per hectare (ML/ha) in summer (Singh et al., 2010; Rachelle, 2012). Moreover, there are some water availability restrictions also existed in the semi-arid areas where the production of tropical fruits is more intense e.g. mango growing areas in the world have increased about 42.5% but the mean fruit yield has increased only 1.3% from 7.5 to 7.6 ton/ha (FAO, 2003). In similar way, orchards in tehsil Fort Abbas (Bahawalnagar) are also being affected in many ways but the shortage of water has played leading role to deteriorate them by making them dry and more prone to diseases attack (Ghaffar, 2013). Water shortage now has become a very serious problem for farmers especially for the plantation of fruit trees as they required more water as compare to other crops in arid and semi-arid regions (e.g. Pakistan) and regular irrigation is necessary for better production. Despite, the sufficient availability of irrigation water has remained a major need of this area even drinking water is fetched out from long distances in near past; in this regard groundwater tapping is being done for both irrigation and drinking purposes. Groundwater exploitation for agriculture, urban, and industrial usages is intensively hampered in many areas of the world by encroaching of saline groundwater in reaction to fresh water withdrawals (Gupta and Gaikwad, 1987; Wirojanagud and Charbeneau, 1985; Sarma et al., 1987; Motz, 1992). Intrusions of briny groundwater are numerous in aquifers of coastal areas, however sometimes they may be found in inland aquifers also (Dagan and Bear, 1968; Rushton, 1980).

Keeping in view such environmental, soil, and ground water conditions, it can be inferred that not only shortage of irrigation is affecting orchard fields and other crops this issue is further aggravated by salinity and water logging. Although there are other reasons of orchards deterioration existed but the short supply of irrigation is the most agitating factor in the study area and therefore it has been focused throughout the study while keeping in touch at national and local level in relation to fruit farms. The main objectives of the study orchard's deterioration due to water shortage in the target area and explore potential solutions. The irrigation as a main reason of and to find out different reasons and solutions of irrigation water shortage in the target area.

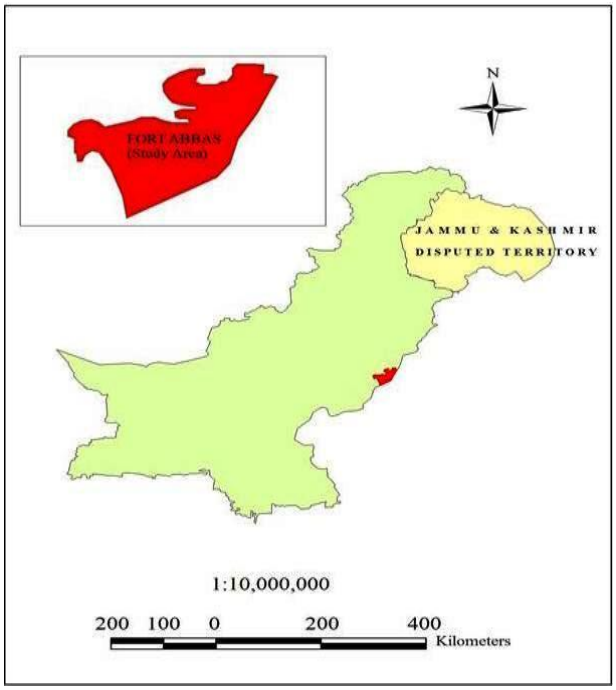

Fig. 1: Location Map of tehsil Fort Abbas (29° 11' 33" N to 72° 51' 13"), Pakistan

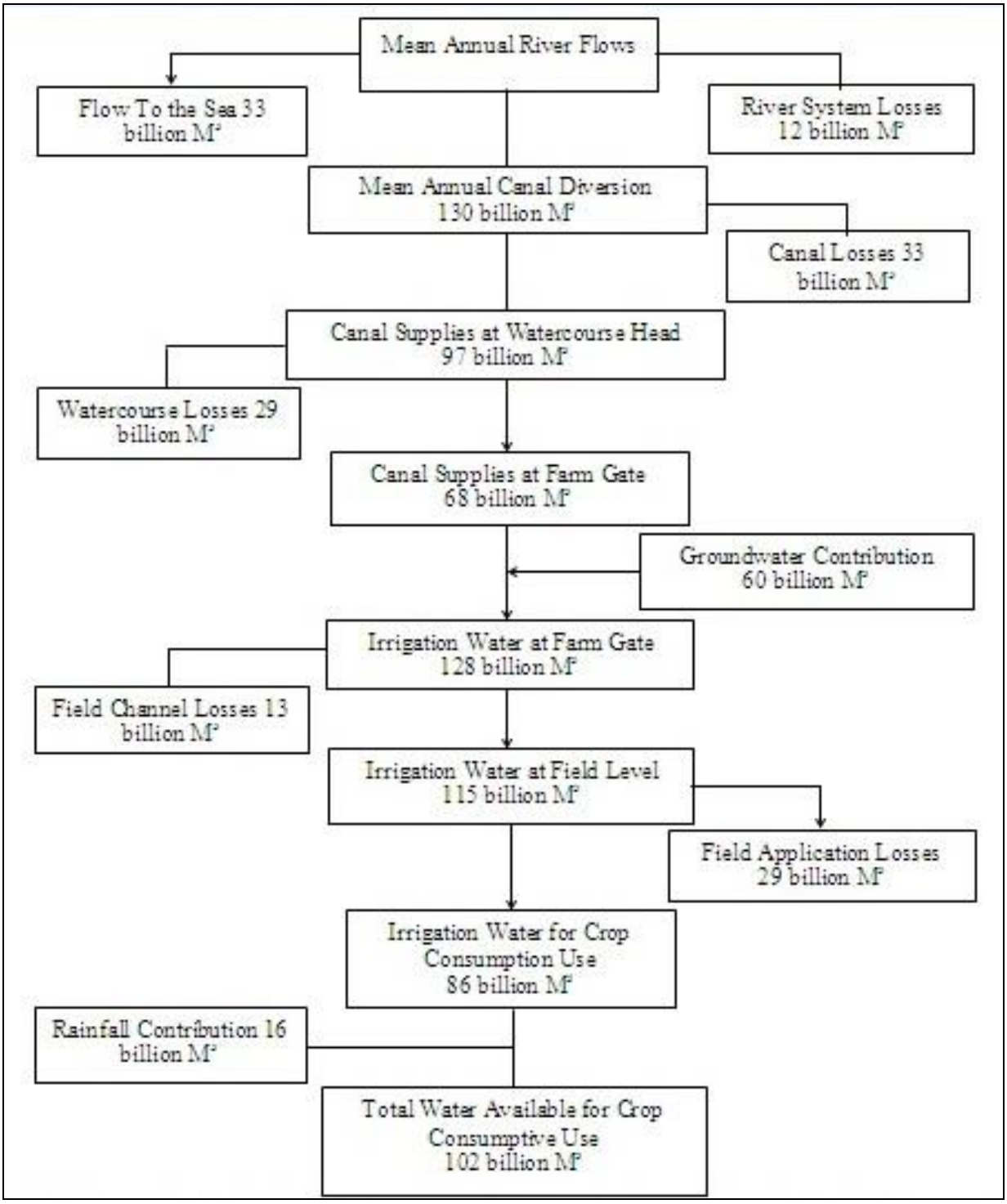

Fig. 2: Water Budget of the IBIS based on mean annual river flows and mean annual canal diversions (billion-cubic meter)
Source: Modified from Hussain et al., 2011.

2. Materials and Methods

2.1 Study area

Tehsil Fort Abbas (study area) is one of the tehsils of district Bahawalnagar and is biggest by area. The geographical location of the study area tehsil Fort Abbas is 29° 11' 33" N to 72° 51' 13" E (Fig. 1). Tehsil Yazman of district Bahawalpur lies in its west. Its Northern and North-Eastern parts are settled while Southern part comprised mostly by Cholistan desert. The desert area has good potential for agriculture but shortage of water is a major hindrance in cultivation.

2.2 Data collection and sources

Tehsil Fort Abbas of district Bahawalnagar is currently facing acute water shortage especially pertaining to orchard farming and other agricultural uses. A well planned questionnaire was prepared to collect first hand information regarding the area, type of fruit orchard, water resource, irrigation methods, irrigation time and interval and to assess the water shortage as a main cause of orchard's decline. A total of 150 orchard farmers were selected as samples and personally interviewed by selecting 10 farmers from each union council (UC) and allowed to mention all the possible causes of water shortages they faced or which were prevailing. The farmers were categorized randomly into small and large orchard farmers. It was also tried to take equal number of orchard farmers from each category and two from each village. A pilot survey was conducted to test the farmers' background knowledge, necessary information and to know about ground realities. On the other hand, requisite secondary data were also obtained from different sources to support and supplement the research and to visualize the different situations regarding irrigation water shortage and orchard's decline. Among these, notable sources were district irrigation department; district censes report of Bahawalnagar 1998, agricultural statistics of Pakistan 2012-13, district revenue department and agricultural statistics of district Bahawalnagar. Although, employed secondary data were used genuinely but modified also according to the demands of the study.

2.3 Analysis of data

It is observed that fruit farms in the study area were varied in size, therefore they were categorized to ease the data collection process and to obtain better results. This technique was followed throughout the research making three to five categories (options) for each question in such a manner that the values told by the farmers should possibly fall in one of the three to five class boundaries (ranges). In order to determine the water shortage as a main reason of orchard's decline, two statistical techniques e.g. simple percentage and mean comparison were used as these are seems quite reasonable to achieve the desired objectives of the study by using SPSS 17 software. In case of simple percentage, tables were prepared containing frequency and percentage in rows while the categories (values) in columns. Spatial data (coordinates) were recorded through handheld global positioning system (GPS) to show the geographical location of tehsil Fort Abbas and the surveyed fruit farms. The maps of the study area and orchard farms were prepared using ArcGIS 9.2 software. Beside fruit orchards, other important features like canals, roads, desert and city also shown in maps and discussed necessarily.

3. Results and discussion

At the time of planting an orchard less but regulat ed controlled irrigation is required and the water requi rements of an orchard changes as orchard's growth m aximizes. Mostly the mature orchards were reported f or more shortage of water as compared to the young which were negligibly reported for water shortage. W ater requirements of different fruit trees could be diffe rent even from the day of plantation to the coming ye ars but it is ultimately accepted that with increasing bi omass of an orchard its water requirements are also in creased. Water losses from national to local level and provision to fields for crop consumptive use is an imp ortant indicator to understand the whole irrigation sys tem. In this regard, water budget scheme of the Indus basin irrigation system (IBIS) signify the actual water availability and supply based on mean annual river fl ows and mean annual canal diversions (Fig. 2). Mean annual river flows refers to the total amount of water which is received by rivers of our country and used fo r our national purposes but a large amount of water is wasted before its diversion to canals.

3.1 Important crops, fruits and irrigation resources

The soil of tehsil Fort Abbas is very fertile, but there is a shortage of water, because of which a vast area of fertile land is still remained uncultivated. Wheat, cotton, and sugarcane are important crops of tehsil Fort Abbas while different types of fruit orchards are grown particularly around the city like citrus and mangoes. The irrigation in the study area is done mostly by the canal water (66%) while tube-well irrigation is also practiced which is rising day by day. Irrigation improves agricultural activities by providing food supply and helps the economic affairs in many arid regions (Vincente et al., 2009).

Table 1. Temporal Fluctuation in Area under Fruit Production and Annual Fruit Production in Pakistan (2001-02 — 2012-13).

Years	Fruit Area (ha)	Four Year Average	Fruit Production (1000 tones)	Four Year Average
2001-02	819,828		744.47	
2002-03	828,889	829,694	721.19	733.28
2003-04	834,671		734.13	
2004-05	835,388		733.32	
2005-06	844,550		714.76	
2006-07	832,961	846,984	691.12	707.23
2007-08	853,365		717.88	
2008-09	857,060		705.15	
2009-10	857,093		693.05	
2010-11	800,964		692.66	
2011-12	829,616	831,797	679.68	681.889
2012-13	839,517		662.16	

Source: Govt. of Pakistan, 2013.

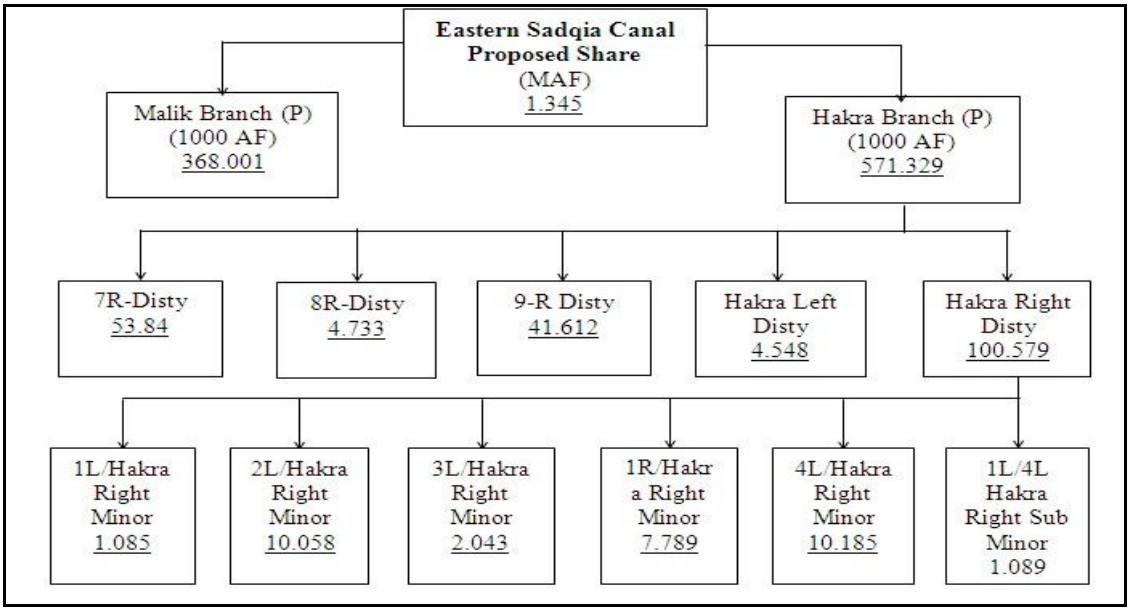

Fig. 3: Actual and tentative distribution of water to tehsil Fort Abbas by Hakra Branch Canal and Ditsy, 2012-13
Source: Department of Irrigation, 2013 (Arranged by Authors).

Hakra is the only canal which provides most of the water to the area; further divided in to *7.R*, *9.R*, *Hakra Left* (H.L) and *Hakra Right* (H.R) which enters in to the tehsil from North-East (Fig. 3). Different irrigation methods are adopted but flooding method is widely used. It is needed to widen the canal for the proper provision of water especially for agriculture on the basis of requirements and survival.

3.2 Fruit area

The fruit farming activity is an important part of agriculture sector but compared to water availability it is also deteriorating and shows a declining trend. The production of the fruits at national level is increasing to some extant but this slight increase is due to the increase in area under fruit orchards rather more availability of water for irrigation. Per acre yield of the fruits is not increasing but shows a slightly downward fall. Area under fruits and production in Pakistan from 2001-02 to 2012-13 is depicted a slightly positive sign of area increase and a negative sign of production decline (Table 1). Moreover, being as the largest tehsil of district by area, Fort Abbas constituted by a large fruit area and production of the district Bahawalnagar.

3.3 Irrigation Water availability and distribution

The amount of water which is received at our main irrigation canals is about 130 billion M^3 from which 33 billion M^3 is wasted in these canals by different processes like evaporation and percolation as most of our canals are not concrete made (Hussain et al., 2011).

Table 2. Yearly allocation of water to tehsil Fort Abbas (2000-01 — 2013-14)

Years	7R-Disty		8R-Disty		9-R Disty		Hakra Right Disty		Hakra Left Disty		Total (1,000 AF)
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	
2000-01	99.80	70.72	09.01	06.89	90.17	62.39	197.6	139.0	08.90	06.01	690.49
2001-02	95.87	68.69	08.79	06.33	87.91	60.70	189.4	137.6	08.87	05.67	669.83
2002-03	93.17	66.48	08.71	06.29	85.90	60.03	183.0	135.0	08.69	05.47	652.74
2003-04	89.21	64.56	08.68	06.24	83.09	59.89	178.2	133.1	08.63	05.29	636.89
2004-05	86.19	63.00	08.52	06.03	79.05	56.91	169.3	129.5	08.37	05.18	612.05
2005-06	83.13	60.90	08.28	05.99	78.55	54.89	167.9	127.3	08.19	05.05	600.18
2006-07	81.57	59.98	07.94	05.97	76.04	53.50	167.1	123.2	07.99	05.91	589.2
2007-08	80.90	59.80	07.87	05.88	77.40	52.77	163.9	121.4	07.95	05.77	583.64
2008-09	80.92	58.98	07.78	05.48	73.03	49.08	161.7	119.6	07.88	05.29	569.74
2009-10	80.22	55.80	07.67	05.12	71.98	47.09	161.2	110.4	07.22	05.88	552.58
2010-11	78.90	54.02	06.93	04.99	67.05	45.71	157.9	105.3	07.00	04.87	532.67
2011-12	77.60	53.98	06.78	04.96	65.95	43.58	155.0	102.8	06.98	04.79	522.42
2012-13	77.00	53.84	06.63	04.73	63.40	41.61	150.0	100.6	06.92	04.55	509.28
2013-14	77.02	53.04	06.03	04.30	62.00	40.00	151.2	98.10	05.89	04.64	502.22

Source: Department of Irrigation, 2014 (Arranged by Authors).

Fig. 3 shows the availability and provision of water in tehsil Fort Abbas, the actual and tentative distribution program of Rabi season 2012 of the Eastern Sadqia canal has been proposed. It can be inferred from the Fig. 3 that 1.345 million acre feet (MAF) water was proposed to Eastern Sadqia (ES) canal during the Rabi season 2012-13. The proposed shares of the ES canal was divided between the branch canals of Malik and Hakra and both were given the amount of water 368.001 and 571.329 thousand acre feet (TAF) respectively. The amount of 571.329 TAF water of Hakra branch were further divided among 5 different branches namely 7R-Disty with proposed share of 53.84 TAF, 8R-Disty with proposed share 4.733 TAF, 9-R Disty with a proposed share of 41.612 TAF, Hakra Left Disty with a proposed share of 4.548 TAF and finally the Hakra Right Disty with a proposed share of 100.579 TAF. All these 5 branches irrigate the agricultural lands of tehsil Fort Abbas. The main branch, Hakra Right Disty has further been divided into 5 Minors and 1 Sub Minor.

The sum of total amount of water received to tehsil Fort Abbas can be calculated by adding the waters of 5 branches (Disty) of Hakra Branch Canal which equals to 205.312 TAF of water. This actual and tentative distribution program for Hakra Branch for the year 2012-13 (Rabi) is visualized in Fig. 4 showing the allocation (quantity) of water to Hakra Branch and its distribution through different branches, ditties, minors and sub minors to agricultural lands and orchards of the tehsil Fort Abbas.

Hakra Branch canal after entering in to the tehsil branches out at different in both right and left sides to irrigate vast and fertile agricultural areas of the tehsil. It 1st branches out as 1R (First Right) Disty with an amount of 7,789 acre feet (AF) of water and irrigates the North Eastern side of the tehsil which is adjacent to the tehsil Haroonabad. The 2nd Disty is 7R which containing 53,840 AF of water irrigates the areas of Khichi Wala which is a sub-tehsil of Fort Abbas.

The 3rd distributary is 8R and it carried an amount of 4,733 AF of water and covered the areas between the 7R and 9R and is relatively a small distributary. The 9R is the fourth Disty with an allocation of 41,600 AF water, irrigated the southern and northern sides of the *Khichi Wala* and Fort Abbas respectively. Then below 9R the Hakra Canal bifurcated in to Hakra Left Disty (H.L) and Hakra Right Disty (H.R). Hakra Right continued to move westward and irrigated a vast area along both sides with having a number of water courses. It runs further westward and gets divided in to 4 left minors, 1 right minor and a sub-minor.

The first left minor (1L) carried water about 1,085 AF and irrigated the immediate western side of the city and runs further in south east direction. The second left minor 2L was allocated with an amount of 10,058 AF. It runs straight to some distance and then moves parallel to its source and irrigated agricultural lands mostly. The 3L originated some distance before the Mroat (sub tehsil) area and carried an amount of 2,043 AF and irrigated less area as compare to other minors. The 4L minor is originated in the vicinity of Marot; amount of allocated water was 10,185 AF and irrigated agricultural lands of Mroat area. 1L/4L is a sub-minor of 4L and originated from it in the middle length, carried an amount of 1,089 AF and irrigated the area south of the 4L. The only one right minor 1R originated between the 3L and 4L minors but in the right (North) direction, carried 7,789 AF water and irrigated the northern side of the Mroat city.

3.4 Relationship between orchard area and water availability

The availability and effective use of water as a major input directly linked with the amount of agricultural production (Ahmed et al., 2007). Table 2 make it clears that the years in which water availability is reduced the corresponding fruit area is also decreased which infers that water availability key to determine the health of fruit orchards and other horticulture activities.

Table 3. Annual fluctuation in Area under fruit production of Tehsil Fort Abbas (2000-01—2013-14)

Years	Rabi*	Kharif**	Total Area (Acres)
2000-01	2,755	2,806	5,561
2001-02	2,751	2,909	5,660
2002-03	2,625	2,696	5,351
2003-04	2,691	2,654	5,345
2004-05	2,499	2,519	5,018
2005-06	2,547	2,659	5,202
2006-07	2,517	2,519	5,036
2007-08	2,489	2,543	5,032
2008-09	2,403	2,560	4,963
2009-10	2,348	2,291	4,639
2010-11	2,272	2,175	4,447
2011-12	1,962	1,569	3,531
2012-13	1,514	1,676	3,190
2013-14	1,791	1,625	3,476

Source: Department of Revenue, 2014. *****Rabi Fruits: Guava, Kinow, Orange, Lemon, Feutrell's early, Mango and Miscellaneous. *****Kharif Fruits: Mango, Phalsa, Dates, Feutrell's early, Kinow, Guava and Miscellaneous

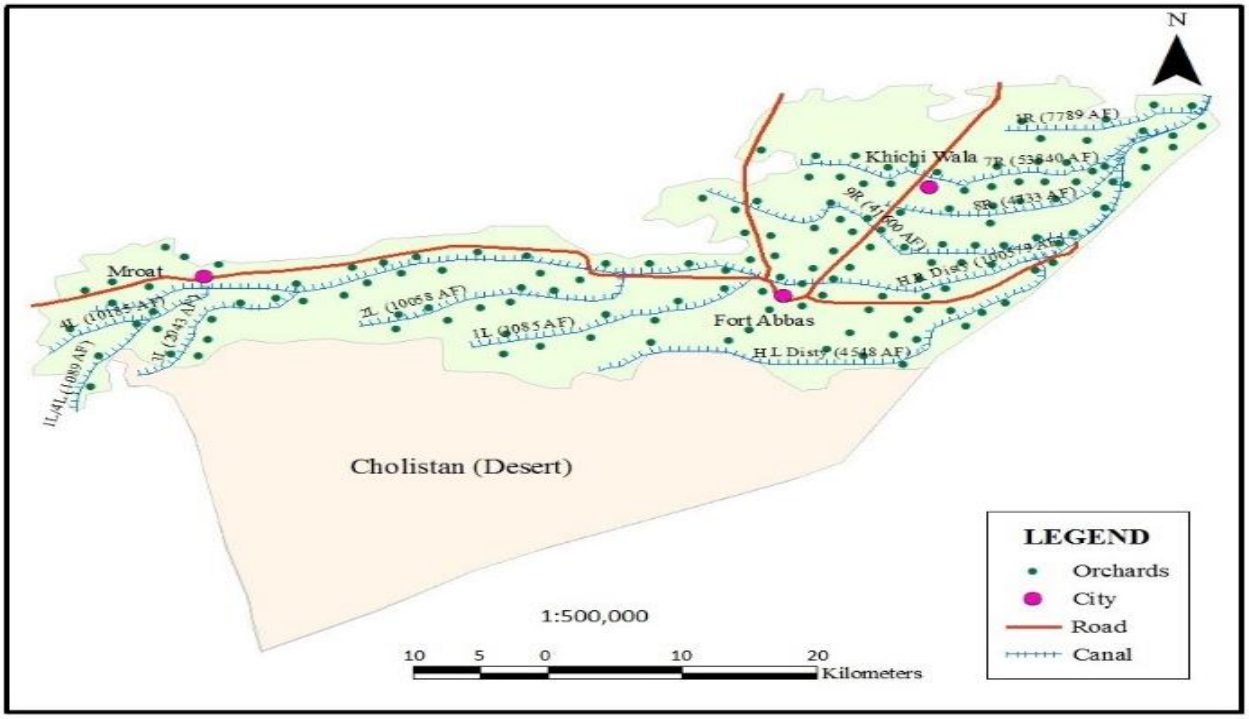

Fig. 4: Distribution of canals with allocated water (Rabi 2012-13) and the sampled orchards in tehsil Fort Abbas (29° 11' 33" N to 72° 51' 13"). Source: Modified from Govt. of Pakistan, 1998.

During the last 14 years from 2000-01 to 2013-14, the quantity of allocated water of tehsil Fort Abbas is significantly decreased as 2000-01 the allocated water of the tehsil was 690.49 TAF and it reduced to 502.22 TAF in 2013-14 and directly affected the area under fruit orchards that has also been decreased, as in the year 2000-01 the total area under fruit orchards was 5,561 acres and in 2013-14 it has been reduced up to 3,476 acres (Table 3). This sharp decline minified the area of fruit orchards about 2,100 acres in last 14 years. Other than shortage of water, the possible reasons for this decrease could be numerous including the attack of diseases (Die back, Malformation) in dry conditions, cutting of trees for crops and development purposes etc (Ghaffar, 2013; Mohsin et al., 2014). It had also been apparent that the supply of water during last 14 years is more uniform as compared to orchards area (Table 2).

The comparison of these two variables reveal a relationship between them that the availability of irrigation likely determined the size of area under fruit farms and if irrigation is abundant area would be more and if irrigation is limited area would become less. A recent study suggested that olive trees were strongly responsive to both irrigation amount and time (Tognetti et al., 2005). It is also found that optimizing cropping patterns and the allocation of irrigation water has a considerable potential to increase the financial return from agriculture (Doppler et al., 2002). If we compared size of the fruit area with the quantity of allocated water during last 14 years than it is evident that the orchards are being deteriorated more rapidly as compared to increasing shortage of water. Such trend could be threaten for the horticulture activity of the tehsil and if size of orchards area keeps on decreasing at such a rate, it can be estimated that within next 25-28 years, there would be a small area under fruits in tehsil Fort Abbas.

Table 4 shows the percentage share of different surveyed fruit orchards. The citrus fruits were grown about 35% of total area followed by mango with about 33% covered area, while guava round about was 9% and the jujube was only 7%. Mix fruit orchards were also found about 15% in which mango and citrus mix orchards were more in numbers and area than any other type. Among water resources the most widely used resource by farmers was canal, which was above 66%, while Tube-Well was 19%. Although, farmers were willing to install tube-wells but it need to invest huge capital. Flood water was given only to 5% area, while area irrigated by other resources like wells and runoff water was only 9%. A previous study also certified that more than 90% of extracted ground water is used for irrigation purposes in Pakistan (Ahmed, 1993).

Table 4. Relative share of different aspects of fruit orchards

Questions (Titles)	Variables (Categories)	Share (%)	Total
Area of Different Types of fruit Orchards	Mango (*Mangifera indica* L.)	33.7	150
	Citrus (*Citrus mandarin*)	34.7	
	Guava (*Psidium guajava* L.)	9.3	
	Jujube (*Zizyphus mauritiana*)	7.3	
	Mix*	15.3	
Usage of Irrigation Sources	Canal	66.0	150
	Tube-well	19.3	
	River	5.3	
	Others*	9.3	
Usage of Irrigation Methods	Flooding	62.7	150
	Furrow	34.7	
	Drip	2.9	
	Sprinkling	0.7	
Different Causes of Orchard's Deterioration	Irrigation Water Shortage	56.7	150
	Diseases Occurrence	30.0	
	Low Profit	9.3	
	Storms Occurrence	4.0	
Different Forms of Irrigation Water Shortage	National Water Shortage	36.0	150
	Less Water Allocation	29.3	
	Non-registration of Orchards	21.3	
	Loss of Irrigation Water	13.3	
Different Solutions for the Shortage of Irrigation Water	Registration of orchards	46.0	150
	Improvement of Water Courses	24.0	
	Ground Water Tapping	24.0	
	Rainwater Harvesting	6.0	

*Mango, Citrus, Mango, Guava, Citrus, Guava, Mango, Citrus, Guava.**Turbines, *Tobas*, Floods, and Rain Harvested Water.

Share of different irrigation methods used in the study area are shown is the Table 4. Among four types of irrigation methods used in the study area the most widely used method was flood irrigation, which was about 62%. Farrow irrigation was relatively less used which was above 34%. Others methods of irrigation like drip and sprinkler irrigation were little used. Drip irrigation method was introduced recently and it was given better results in two or three fruit farms where it was practiced. In addition to this, drip irrigation offers many unique agronomic, agro technical and economic advantages to farmers (Nakayama and Bucks, 1986). Share of average annual rainfall in farmers' opinion were very low and scant. The amount and sufficiency of rainfall as satisfactory and un-satisfactory in study area was highly directed toward un-satisfactory or inadequate amount of rainfall received. This is also a matter of fact that in Pakistan, rainfall is highly varied as one move from north and northeast to south and southeast (Ahmed et al., 2007).

3.5 Factors of water shortage

Among four different factors of orchards deterioration the water shortage accounted about 57% followed by diseases occurrence (Table 4). Crop growth is dependent upon water which may be supplied by rainfall or irrigation resources. To achieve maximum plant growth, soil moisture levels should fluctuate only within a narrow range between field capacity and permanent wilting point (Carruthers and Clark, 1983). Incidents of plant diseases had a share of 30% in depletion of fruit area. Low profit from fruit farms was also a factor which is giving way to farmers to replace fruit farms with other crops. Storms were also quite responsible for the deterioration of mango farms and jujube (Table 4). Shortage of water is an issue highlighting from national to local levels. Low rainfall/snow fall, less storage capacity, changing crop pattern and effects of urbanization/industrialization are considered the main reasons of shortage of irrigation water (Views to News, Nov. 6, 2009). Less volume of allocated water was ranked 2nd among the farmers which meant uneven allocation and distribution of water. While about 21% farmers reported that their orchards were not registered for allocated irrigation water and 13% argued the loss or wastage of irrigation water as a responsible factor of water shortage although ground realities were slightly differ from that situation but it couldn't fully ignored. Table 5 shows the water inflow, outflow and net loss of water in tehsil Fort Abbas and it become cleared that net loss of water gradually decreasing from 138.07 TAF in 2000-01 to 101.03 TAF in 2013-14.

These figures manifest that loss of irrigation water is also one of the major responsible factor of water shortage and their ultimate effect on fruit trees growth and production scenarios. Farmers were also proposed various possible suggestions for concerned authorities to resolve the problem of shortage of water. Results show that 46% of the farmers were concentrate on the 1st option as "allocation of extra water for irrigation" by registering their orchards. Suggestions of "improvement in water courses" and "ground water up-take" were emphasized 24% farmers each. A recent study in Pakistan also highlighted two main causes of water shortage; the prolonged drought and the ground negligence in the development and miss-management of water resources (Pakissan, 2013). Lastly, rain water harvesting was suggested only 6% farmers. Rain water harvesting was reported only in southern and western side of the study area comprising Cholistan desert. The orchard farmers were using different irrigation methods according to requirements of the fruit forms and on the basis of suitability and affordances also. Table 4 shows that furrow irrigation method is mostly used for different types of fruit crops with a mean value of (2.65) which is higher

than the flooding and drip irrigation methods respectively and the use of different irrigation methods for different type of water resources. Results make clear that tube well water resource was more used by variety of different irrigation methods. Canal was 2nd and river was at 3rd rank respectively.

The fruit types were not equally sensitive to shortage of water. The mango tree was less sensitive to shortage of water as compared to citrus while jujube was less sensitive as compared to guava. However, mix farms were most sensitive of all to shortage of water probably of varied water requirements of different fruit trees in a mix orchard.

Different fruit trees have different water requirements so depending on the water available for fruit farms water shortage was reported differently for all type of fruits. Therefore, situation was reverse to expected results to some extent. Table 6 shows comparison of means, from which it is evident that water shortage is differently sensitized by different fruit orchards.

The high sensitive values of guava and jujube to shortage of water are perhaps due to the nature of both fruits that when they face dry conditions they become more prone to diseases and are deteriorated at a higher rate. To find out different reasons of irrigation water shortage, related section of questionnaire was thoroughly studied and analyzed. The responsible factors of shortage of water can be termed as natural or physical and cultural or human and are contributing significantly to create shortage of water in tehsil Fort Abbas (Fig. 5).

Table 5. Annual inflow, outflow and loss of allocated water in Tehsil Fort Abbas 2001-14

Years	Total Inflow (000 AF)	Total Outflow (000 AF)	Total Loss (000 AF)
2000-01	690.49	552.42	138.07
2001-02	669.83	533.79	136.04
2002-03	652.74	520.69	132.05
2003-04	636.89	505.37	131.52
2004-05	612.05	485.01	127.04
2005-06	600.18	481.09	119.09
2006-07	589.20	466.12	123.08
2007-08	583.64	465.51	118.13
2008-09	569.74	458.62	111.12
2009-10	552.58	443.51	109.07
2010-11	532.67	422.63	110.04
2011-12	522.42	414.31	108.11
2012-13	509.28	400.24	109.04
2013-14	502.22	401.19	101.03

Source: Department of Irrigation, 2014 (Arranged by Authors).

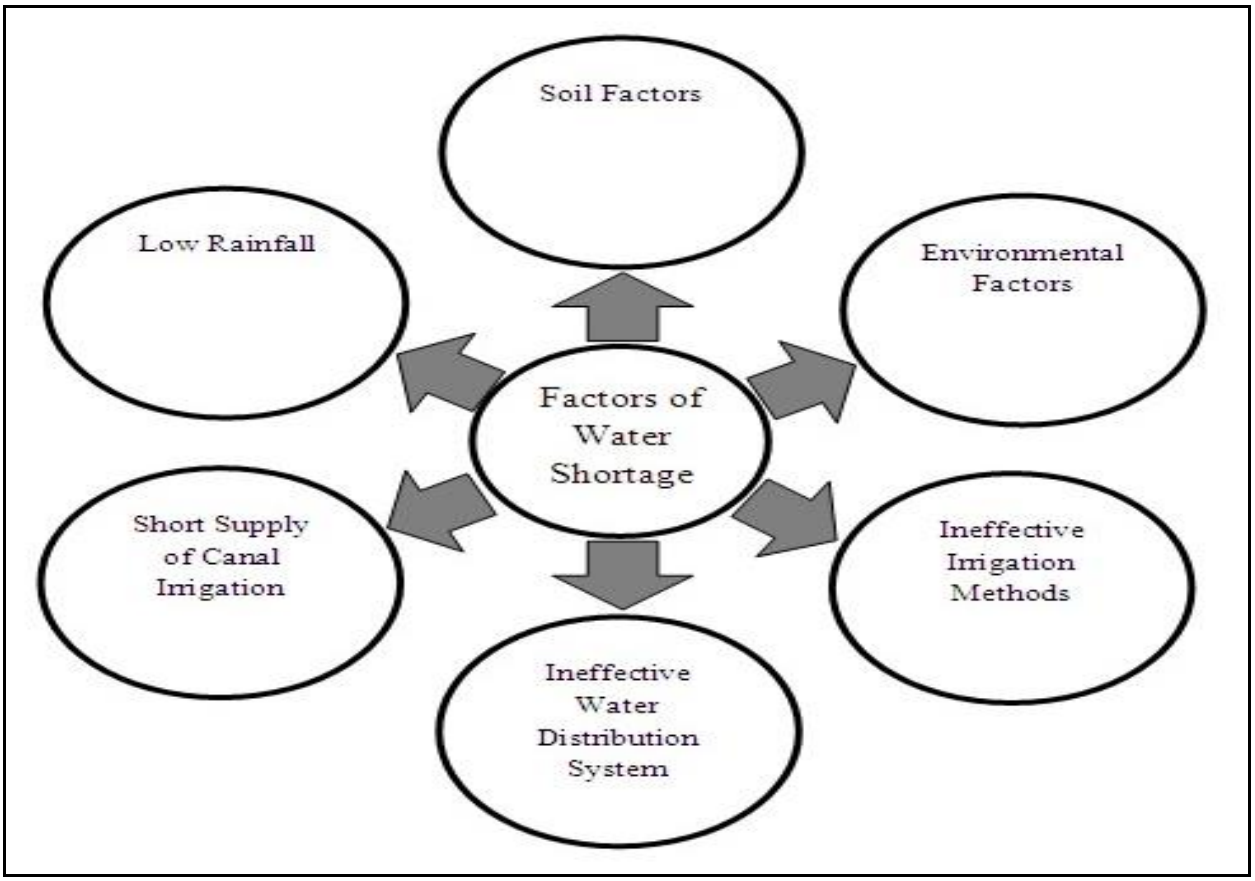

Fig. 5: Factors causing irrigation water shortage for orchards in the study area.

Table 6. Mean analysis of different aspects of fruit orchards

Questions (Titles)	Variables (Categories)	Mean/S.D	Average Mean & S.D
Use of Irrigation Methods (for Different Orchards)	Flooding	2.24/1.319	2.37/1.407
	Furrow	2.65/1.545	
	Drip	1.33/0.577	
Use of Irrigation Sources (by Different Irrigation Methods)	Canal	1.42/0.591	1.41/0.569
	Tube-well	1.45/0.572	
	Flood	1.25/0.463	
	Others*	1.29/0.469	
Sensitivity of Fruit Orchards (to Shortage of water)	Mango (*Mangifera indica* L.)	1.96/0.989	2.12/1.049
	Citrus (*Citrus mandarin*)	2.06/1.056	
	Guava (*Psidium guajava* L.)	2.21/0.875	
	Jujuba (*Zizyphus mauritiana*)	2.18/0.982	
	Mix **	2.52/1.201	

* Turbines, *Tobas*, Floods, and Rain harvested water. ** Mango, Citrus, Mango, Guava, Citrus, Guava, Mango, Citrus, Guava.

Low rainfall, soil factors and environmental factors are considered as natural or physical factors of shortage of water for irrigation and short supply of canal irrigation; ineffective water distribution system and ineffective irrigation methods can be termed as cultural or human factors of water shortage for irrigation.

The study area receives about 224 mm rainfall annually that is much below the requirement of any type of fruit orchard. Short supply of irrigation involved usually less time of irrigation per acre and reduced size of water channels (*Moga*) and can be named as shortage of water at national level. Water distribution system is also not effective; it involves unimproved water courses, from which a considerable amount of water is wasted.

3.6 Solutions to irregular availability and shortage of irrigation water

Although the shortage of irrigation is a much serious problem in nature and need to deal with equate allocation and supply of water however management and conservation strategy could also be accommodative to save, store and share water on demand basis. Therefore, the sustainable use of irrigation water is a priority for agriculture in arid areas (Chartzoulakis and Bertaki, 2015). Besides, certain water conservation and efficiency measures actually increase farm productivity and profitability, further strengthening the agricultural sector (Cooley et al., 2008).

Globally, the growing water requirements particularly for irrigation made the sound management of water resources highly important for development in sustainable way and for securing the environment as well (Chartzoulakis et al., 2001). In study area, water courses and minor canals usually were not straight and concreted and responsible for the loss of plenty of water. A recent report issued by water and power development authority (WAPDA) also indicated the problem and stated that more than 5 MAF of irrigation could be saved by lining of minor canals and additional 3.6 MAF could also be saved by improvement of water courses (Ahmed et al., 2007).

The methods of irrigation were mostly traditional and ineffective in water transmission and distribution to fields. The most widely used method was flooding method, in which the whole acre is irrigated thoroughly and is filled with water up to certain height but lot of water is wasted in this method (Fig. 6).

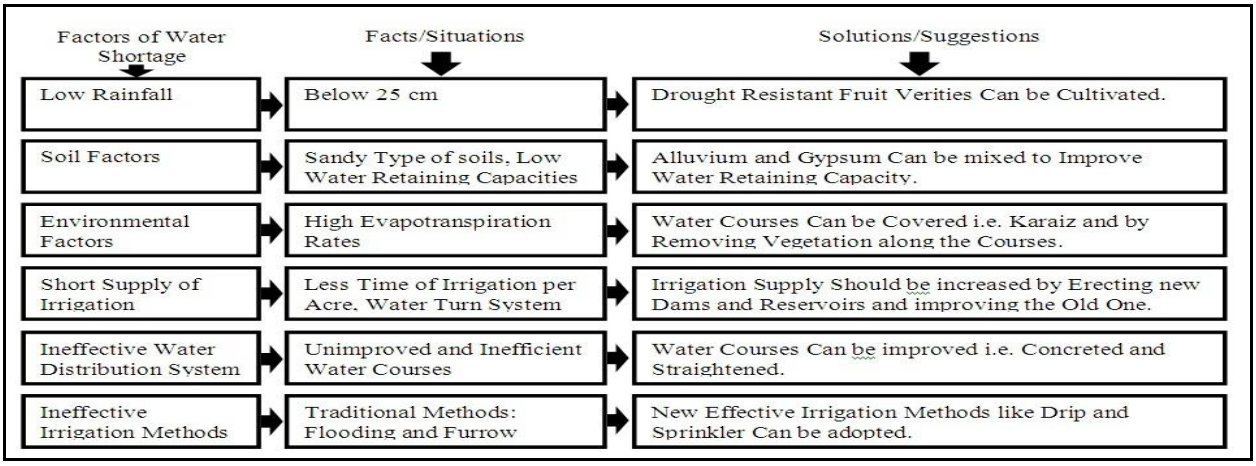

Fig. 6: Solutions to different factors causing water shortage.

The solution of this problem could be the switching of irrigation methods from traditional to modern in the directions of "Blue Revolution" to meet the challenge of water shortages and water losses to a large extent (Ahmed et al., 2007). Additionally, under low rainfall annually, survival and proper growth of fruit bearing trees becomes very hard to maintain and manage.

This problem could be minimized to some extent by cultivating drought resistant varieties those normally have relatively less water requirements than the other as there are a number of different verities of fruit trees available in the market. Short supplies of irrigation usually called less irrigation per acre in minutes (time) and size of the water channel (*Moga*) in inches. Irrigation time is mostly related to number of acres per water channel and size is related to amount of water in the canal and the area irrigated by the canal. Irrigation time per acre can be increased by decreasing the number of acres per water channel and by constructing new water channels.

Sprinkler irrigation method is most widely used in Europe for apple and vine growing. Drip and Sprinkler both methods could be very useful in the study area as the sprinkler's cooling effect in high temperature can be very advantageous to orchard bearing fruits. Besides, deficit irrigation (DI) could also prove a handy method in the context of less or deficit irrigation water in dry regions. This method involves scheme based on applying only a division of the plant water requirements during certain periods of development of plant. Deficit irrigation is frequently utilized in different fruit trees like citrus, olive, peach, pear, loquat, pomegranate etc. in countries like Australia, Spain etc (Marsal et al., 2008a; Ruiz-Sanchez et al., 2010).

The tube-well water resource is costly and carefully used by furrow and drip irrigation methods. Shortage of water can be overcome by the pavement and improvement of water courses, removing siltation from the canals and by the use of efficient methods of irrigation and thus various types of fruit trees can be planted and grown successfully. The soil factors like sandy type of soil and low water retaining capacity of such soil can be improved by mixing alluvium and gypsum into such soils. By adding manure and by deep ploughing, water retaining capacity of the soil can be increased. High evapotranspiration rates are environmental factors which are acute during the summer especially in months of June and July. Water courses in this context can be covered in the study area like the *Karaiz* in KPK and Baluchistan provinces to avoid excessive evapotranspiration. Along the long earthen water courses removal of vegetation and plants can increase the efficiency of water courses to conduct water at long distances.

4. Conclusion

The problem of water shortage now becomes a serious threat for successful fruit orchards plantation and agricultural crops in local as well as national level. After an in-depth study and research work, it is concluded that orchard farming is an important activity of tehsil Fort Abbas and a large number of people were involved in it either by producing or exporting of fruits. Major resource of water was canal while Tube-well was the 2nd most important. Flooding irrigation method was highly used and caused wastage of plenty of water while furrow and drip irrigation methods were more suitable and efficient but negligibly adopted. Jujube and guava were affected by different environmental and climatic factors severely as compare to mango orchards. Water shortage was more serious in mix orchards and impedes their proper growth. In addition, rainfall is scarce and according to farmers opinion it is insufficient and received mostly in late summer. In order to cope up the problem in an effective manner the following suggestions were laid down;

- The country needs more water storage reservoirs to properly and regularly regulate the river flows during the crop seasons to avoid water shortage.
- The Integrated Water Resources Management (IWRM) is required at all levels in water competing sectors while, improving use efficiencies and adoption of other water conservation techniques.
- Canal water supply management needs improvement to avoid wastage of water and for equitable distribution of available water for the entire canal command.
- The high efficiency irrigation systems like, bed, furrow, drip, deficit and sprinkler need to be adopted.
- Management of water resources should be done in sustainable and long term manner and siltation in water resources should be removed on regular basis.
- Groundwater should be managed under proper rules and regulations.
- Farmers of arid and semi-arid areas (Like Tehsil Fort Abbas) need to grown draught resistant varieties of fruit orchards like mango, guava etc.
- Pricing of water particularly Tube well water should be less and bearable by proving subsidies to owners.

List of Abbreviations: DI: Deficit Irrigation; ES: Eastern Sadqia; GPS: global positioning system; ha: hectare; HL: Hakra Left; HR: Hakra Right; IBIS: Indus basin irrigation system; IWRM: Integrated Water Resources Management; MAF: million acre feet; mm: mili meter; M^3: cubic meter; ML: mega liters; TAF: thousand acre feet; UC: union council; WUAs: water user associations.

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