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***Irrigation sector development in Punjab (Pakistan): Case study of district
Sargodha***

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ABSTRACT

Pakistan is a densely populated country; and its population is increasing rapidly. More than fifty percent of population is living in rural areas and is related to agricultural sector. Punjab is the most populated province of Pakistan. Irrigation system of Punjab is not very developed. The present irrigation system is almost hundred year old. The management of existing irrigation system is a big challenge. With increase in population, load on existing irrigation system is also rising and situation is presenting serious problems.

This report addresses main problems related to management of irrigation system in district Sargodha of Punjab province of Pakistan. The problem with management of existing irrigation system includes social as well as technical problems. This report also discusses loss in agricultural production due to mismanagement of irrigation system. Further, report also suggests possible solutions for the management of irrigation system. These solutions take into account reforms in social sector as well as introduction of new technology.

For the assessment of report, past research related to management of irrigation system in Indus basin has been studied. This research also includes ideas of previous researchers about management of irrigation system and then we try to conclude possible solutions for better management of irrigation system in area.

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Finally, I feel honour to express especial thanks to my class fellows and my best friends for their well cooperation during study period.

ABBREVIATIONS

| | |
|------------------|---|
| <i>Abiana</i> | Water charge received by government (on each crop) |
| <i>AID</i> | Agency for international development |
| <i>Barani</i> | Rain fed land used for crop cultivation |
| <i>Bcm</i> | Billion cubic meters |
| <i>Chak</i> | Village |
| <i>MAF</i> | Million acre feet |
| <i>Mogha</i> | Outlet of water and acts as a channel to different areas from one stream |
| <i>Muzara</i> | An agricultural system, where agricultural land is given to some one by owner on fifty percent share, but that person will not be owner of land |
| <i>Pata</i> | Agriculture land given on rent |
| <i>Patwaris</i> | Data collectors/record keepers about agricultural land and seasonal and yearly crops |
| <i>Warabandi</i> | Water distribution system among farmers from outlet |

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ORGANIZATION OF THESIS

Chapter 1:

In this chapter, I discussed about introduction, methodology and goal of thesis.

Chapter 2:

This chapter discussed about background of Pakistan, detailed description about irrigation system of Punjab province, district Sargodha as well as discussed about irrigation system of Indus basin in Pakistan.

Chapter 3:

In this chapter, I compare the agricultural production of Punjab province of Pakistan with agricultural production of Punjab province of India.

Chapter 4:

This chapter discussed about social as well as technical problems for management of irrigation system in district Sargodha.

Chapter 5:

This chapter discussed about possible solutions for management of irrigation system in discussed area.

Chapter 6:

This chapter consists of summary and conclusion.

1. INTRODUCTION

This thesis is an exploration of water problems in Pakistan. For analysis, one district – a small unit for administration, named as Sargodha has been selected.

The main problem facing Sargodha, which is located in Indus basin, is the management of irrigation system. The availability of water is not a problem, but there are problems in the management of irrigation system. The irrigation development is not satisfactory in Sargodha. Consequently agricultural production is affected badly in area. Pakistan's major income sources are agricultural products. The increase/decrease in agricultural production also affects life style of farmers, because there are not other part time jobs available in area. The part time jobs available only in sugar mills, but sugar mills remain in running condition only for crushing season. So workers remain jobless for the remaining six months.

With low prices of most agricultural products, agricultural sector and particularly irrigated agriculture is not in a position to generate funds to support other sectors. It is of course, important for food security and employment, but it is industry and service sectors that generate most revenue. Irrigation sector is also a very capital intensive, i.e. it requires funds for investments rather than the other way around.

Efficient management of irrigation system is the only solution to overcome problems. Different methods can be applied for effective management of irrigation system. This thesis explains some of important social as well as technical problems faced in irrigation system in Sargodha.

The data about different crops in Indus basin has also been collected. The crops production of Punjab-a province of Pakistan and crops production of Punjab-a province of India have been compared. The main purpose of comparison is to know about agricultural production difference in between two areas, because these two areas were one part before the partition of India and Pakistan in 1947.

1.1 Goal

The main purpose of project is to highlight those points, which are the cause of ineffective management of irrigation system in Pakistan Punjab. The area selected for study is district Sargodha situated in Pakistan's Punjab. The possible reforms in this area can be implemented all over the Indus Basin in Pakistan, because cultural values are same.

1.2 Methodology

The method applied is a participant observation, and this method generally characterized as qualitative research method. In this research method, my direct observation, self analysis is also involved. I am native from research area and iam living in research area from several years, so I observed better about irrigation as well as social problems of people in their natural environment.

I analyzed data about crops production, water availability in canals, international agencies concerned about irrigation and drainage problems in developing countries, basins affected by land degradation and due to salinity and then extract the useful information and facilitating conclusion. Comparative research method also used for comparing crop production data in Pakistan Punjab and Indian Punjab.

In my thesis, I studied different books, academic research papers and did literature review (summarized and synthesized ideas of others) from Linkoping university library and by using web search engine. I compared the relevant information and then used those facts, figures which justified my thesis topic.

2. BACKGROUND

2.1 Pakistan

Pakistan is a country in South East Asia, and consists of four provinces-Punjab, Sindh, Baluchistan, North West Frontier province and one state-Kashmir. Its total area is 803,940 square kilometre. Its present population is estimated 165,803,560. Its borders are with China, India, Afghanistan, Iran and Arabian Sea (CIA World Fact book, 2006).

It is estimated that Pakistan population will be 259 million in 2030 and 316 million in 2050 (Sanderson, 1995). As the population is increasing very rapidly, the demand of food is also increasing. The demand of food was 20 million ton in 2000. It is estimated that food demand will be 40 million ton in 2025. There are two cropping seasons in Pakistan, one is called *Kharif* and other is called *Rabi*. *Kharif* is the summer cropping season, which starts from mid April to mid October. *Rabi* is the winter cropping season. The major crops of summer season are cotton and rice. The major winter crop is wheat (Tahir and Habib, 2000).

About 67.5 percent of population of Pakistan lives in rural areas and 60 percent of this population is related to agricultural sector and industries related to agricultural sector. About 70 % of river flows in Pakistan are already diverted for irrigation. Around 80 % of irrigation depends on canals and tube-wells. It is estimated that 3 percent of canal water is used for saline water zones. The average supplies of canal water for 1993-94 varied from 280 mm/ha (for 720 thousands ha) to 1600 mm/ha (for 210 thousands ha). Rain fall also varies from 700 mm (in 0.5 million ha) to 75 mm (in 1.1 million ha). Ground water pumping varies from zero mm (in 30 percent of Indus command) to more than 1000 mm (in 10 percent of the Indus command). The water from these sources varies from 900 mm/ha to 2000 mm/ha among various canals commands (Habib, 2000).

In 1994, average yields for major crops were rice 2,300 kg/ha, wheat 2,100 kg/ha, cotton 1,700 kg/ha and the sugarcane 42 tons/ha. In Pakistan as a whole farms are very small. Around 47 percent of farms are less than 2 ha in size, and average annual income generation from these farms is US\$ 500. Around 50 percent of populations own less than 1 ha, and they do labour work on other farms. The farms in between the size of 2 ha to 5 ha are 34 percent.

The farms between 5 ha to 10 ha are 12 percent. Owners with own more than 20 ha are only 7 percent. Generally this group is in the category of landlords and have facilities for food security and for a good life (Habib, 2000).

The canal network was developed in Pakistan during British occupation the subcontinent. At that time of British occupation, water rights were allocated for 70 percent of cultivation every year, but water promised upon the availability of water in rivers. During last 50 years, extension in irrigation sector was about 15 percent more area. In most of the areas, existing canals were developed and extended. Two big water reservoirs were added for the storage of water (Habib, 2000).

2.2 Indus Basin System

Pakistan is an agricultural country, its total area is 803,940 square kilometres (79.6 million hectares) and area available for farming is 20 million hectares. Out of 20 million hectares, irrigated agriculture is practiced on 16 million hectares and 4 million hectare is dependent on rain and is called *barani* farming. Land irrigated through canals is 14.23 million hectares, land irrigated through tube-wells is 3.75 million hectares and land irrigated by other sources is 0.2 million hectares.

The agricultural sector is playing a vital role in Pakistan. It contributes 25 % of GDP. The surface water source in Pakistan is Indus River and its tributaries are *Chenab*, *Jhelum*, *Kabul*, *Sutlej* and *Ravi*. The Eastern Rivers are *Sutlej* and *Ravi*, and Western rivers are *Jhelum*, *Chenab*, *Kabul* and Indus River. These rivers are the main source of water in Pakistan and water flow reaches up to 151.58 MAF. Water flow from western rivers is nearly 143.18 MAF and from eastern rivers is nearly equal to 8.40 MAF. The ground water abstracted for urban, rural and for agriculture purposes is estimated to be 41.6 MAF. According to province-wise distribution, in Punjab it is estimated to be 34 MAF, in Sindh 3.5 MAF, in NWFP 2 MAF and 0.5 MAF in Baluchistan. In Punjab province fresh water is available for 79 % of area, and in Sindh province fresh water available for 28 % of area.

It is estimated that 41.6 MAF of ground water abstracted for irrigation use and for rural and urban drinking water supplies. Therefore ground water table is declining in most of fresh water areas and the potential of further exploitation of ground water is very limited.

In some areas, ground water is salty. So by using tube-wells and throwing this water in canals also make fresh water saltiest, consequently there are more chances of saline land. In 1950, government started Salinity Control and Reclamation projects (Unitar, 2004).

Pakistan and India signed water treaty in 1960. According to treaty, Pakistan will use water of western rivers (*Indus, Jhelum and Chenab*) and India will use water of eastern rivers (*Sutlej, Ravi and Beas*). So to supply water to that areas, which were fed by eastern rivers, Pakistan started to build water reservoirs .The first reservoir was built in 1967 named “*Mangla Dam*” with total capacity 5.8 MAF, height of 115.8 meters and 3,353 meters long. The second reservoir named as “*Tarbela Dam*” completed in 1974 with total capacity 11.1 MAF, height of 147.8 meters and 2,743 meters long (Fukuda, 1976).

The annual average water flow by this system is 145.9 MAF and command area is 14.3 million hectares. Before the present Indus basin system, there was inundation canals existed on all rivers of Indus basin. They were constructed and managed by local tribes. Water diverted from rivers to canals by weirs (Tahir and Habib, 2000).

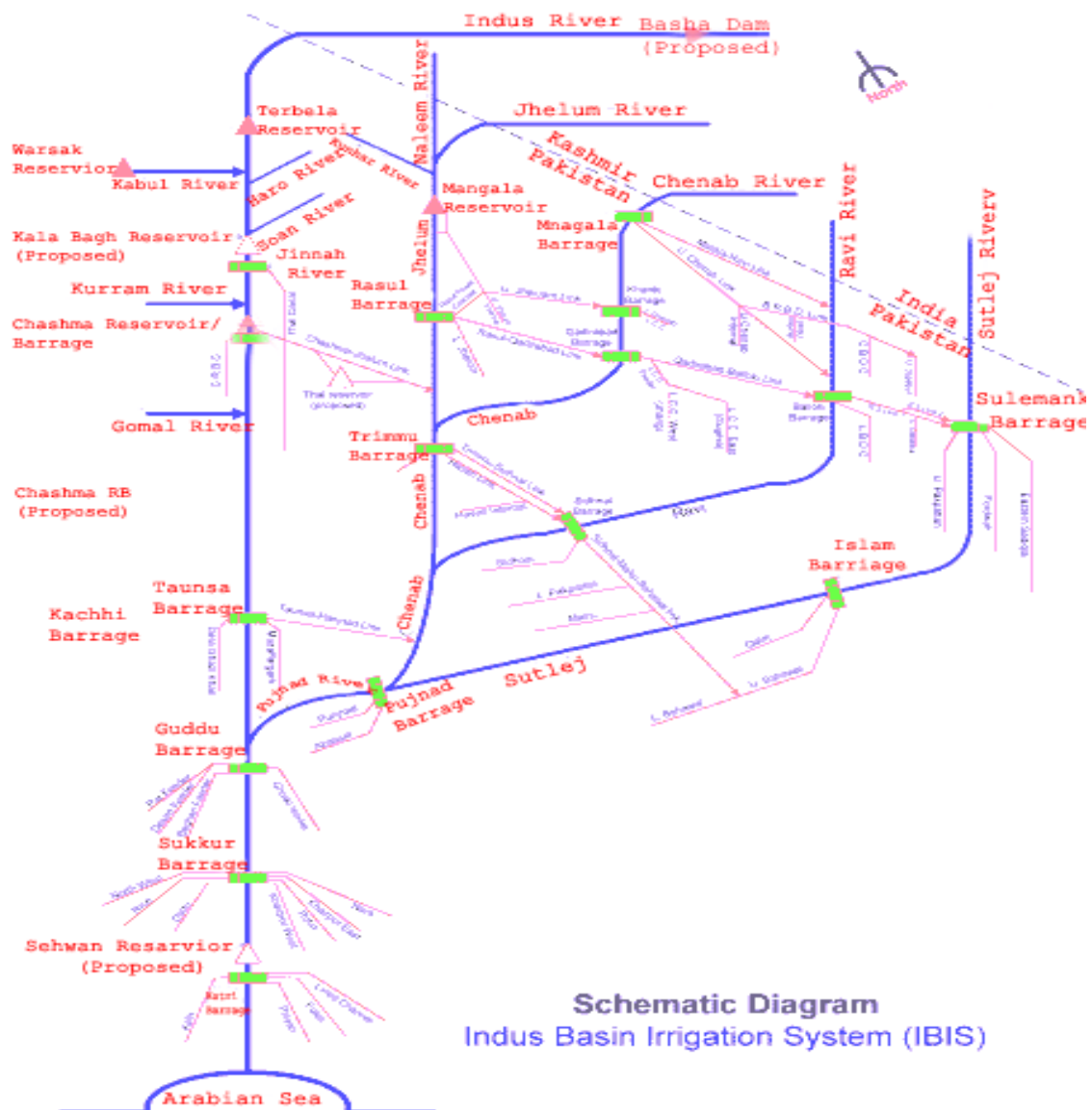


Figure 2.1: Indus Basin System. <http://www.inbo-news.org/ag2000/pakistan.htm>.

2.3 Punjab

There are 23 canals in Punjab province out of total 45 canals in Indus basin system and consist of 12 interlinked channels. Punjab has 56.5 % of total population of Pakistan and the area is 25.8 % of total area of Pakistan. Table 2.1 (Appendix- A) shows statistics of canal area in Punjab province. It shows CCA (cultivable command area), GCA (gross command area) and about percentage area perennial. Further elaboration is also available in Table 2.2 (Appendix- A), which explains availability of water in Punjab canal commands. Table 2.3 (Appendix- A) shows crops production in two seasons. Production of crops in Punjab province depends on irrigation system. Irrigation plays main role in the development of food

production, but other factors also include in production of crops like environment, infrastructure (Tahir and Habib, 2000).

The discharge of untreated effluent into water bodies and soils is the main source of pollution. Liquid effluents from dyeing, washing and bleaching operation contain organic and inorganic chemicals as well as solids (grease and fibre). These effluents lower dissolved oxygen level in water bodies and affect the environment of local production process (Banuri, 1998).

Infrastructure (communication, transportation etc) not related directly to food production, but good infrastructure is also among the main elements of increase food production.

Punjab is most densely populated province of Pakistan. Its population is 89,464,595 (Iqbal, 2007). More than 50 % population of Punjab lives in rural areas, where they are doing job related to agricultural sector and industry related to agricultural sector. Farmers living in Punjab are not well educated. They do not know proper methods of farming. They are using old techniques of farming. The knowledge about farming is transferred from generation to generation. Due to lack of education and increasing poverty, most of them are unable to adopt new methods of farming.

The situation with respect to poverty level in rural areas of Punjab is not good. The poverty level is increasing day by day in rural areas of Punjab province. The people are migrating from rural areas towards urban areas. The reason for this migration is the unsatisfactory condition in rural areas. Government is also not giving required attention to rural areas of Punjab province. The agriculture sector is going towards the worst condition. People living in rural areas are not interested in field of agriculture due to low availability of water. The profit in agricultural field is not enough to meet the daily requirement of farmers.

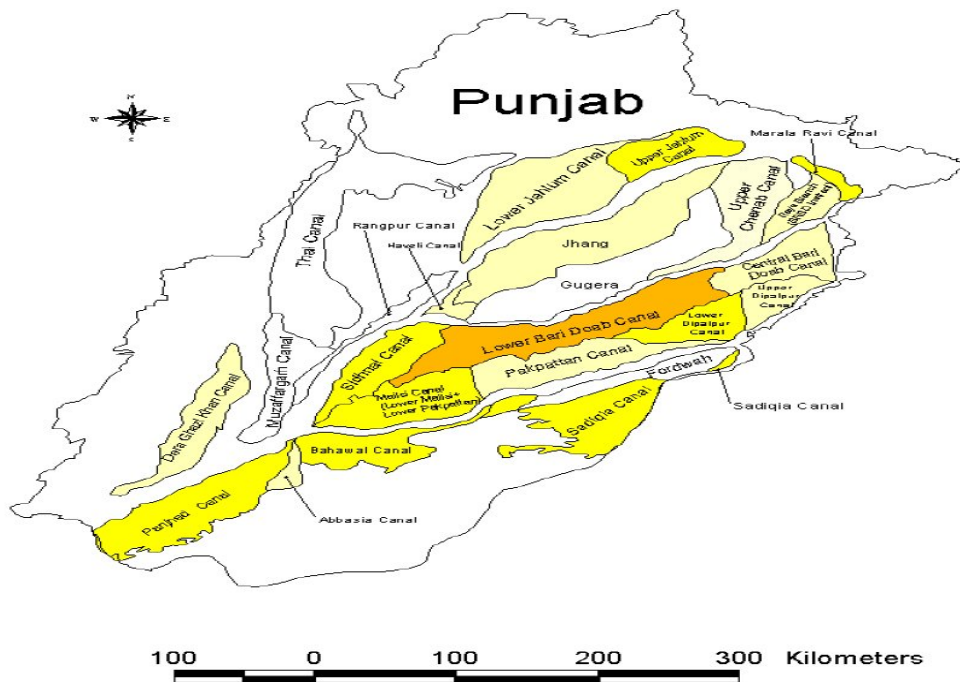


Figure 2.2: Punjab Canal Command from (Tahir and Habib, 2000).

2.4: Study Area

2.4.1 Sargodha

Introduction

Sargodha is the division of Punjab province. For better administration, Punjab province is divided into many divisions and each division is divided into several districts and then each district is divided into several tehsils. Division Sargodha has four districts named as *Mianwali*, *Bhakar*, *Khushab* and itself Sargodha, then district Sargodha has six tehsils named as, *Sahiwal*, *Bhalwal*, *Kotmomin*, *Shahpur Sadar*, *Sillanwal* and itself *Sargodha*. Population of district Sargodha is 2,665,979 and people living in urban areas are 27.96 % (Sargodha district, 2007). District Sargodha has a plane land and some hills. Its geographical position is very important from defensive point of view. There are not enough industries in district Sargodha, except few sugar mills and textile factory. The presence of sugar mills is due to cultivation of sugarcane in area. Sugar industry is a profitable business in that area. Sugar

industry remains in running condition only in sugar cane season. So it is in running condition only for six months in year. The people working in industry remain jobless or searching for other jobs for the remaining six months of year. So it is not the permanent source of job.

2.4.2 Location

District Sargodha is located at Latitude 32.10 N and Longitude 72.30 E (Sargodha district, 2007). It is located in between two big cities, Islamabad (Capital of Pakistan) and Lahore (Capital of Punjab) and connected by motor way (highway infrastructure in Pakistan). Area of district Sargodha is 5856 square kilometre and total divisional area is 26360 square kilometres (Area of Pakistan, 2001). Sargodha is the third largest division of Punjab province. Climate of district Sargodha varies according to seasons. It has winter season starts from November to March. Summer season starts from April to October. Maximum and minimum temperatures in summer may up to 47 centigrade and 25 centigrade and in winter it may be up to 20 centigrade and -5 centigrade.

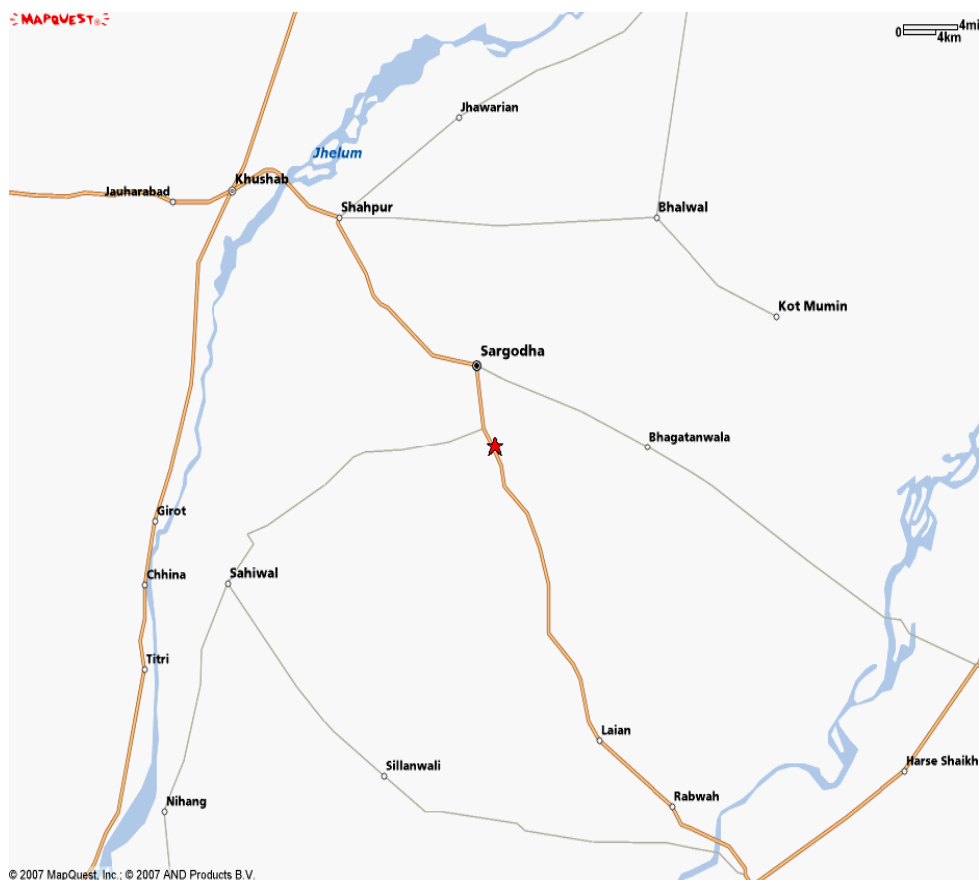


Figure 2.3: Map of Sargodha from (Map Quest, <http://www.mapquest.com/maps/map.adp?city=sargodha&state=&country=PK&zoom=5&id=findlocalweather.com>).

2.4.3 Rivers

There are two main rivers passes near district Sargodha. One river name is *Jhelum* and other river is *Chenab*. Both rivers are the main source of water supply in Indus Basin irrigation system.

2.4.4 Agriculture and Related Sectors

Land in Sargodha is irrigated by canals and tube-wells. Canal work established at time of British period in subcontinent. Underground water in district Sargodha is very suitable for agriculture. Farmers in Sargodha use underground water for agricultural purposes, at the time of deficiency of water in rivers. Agricultural products from the markets of Sargodha can be easily transported to other cities due to motorways. Sargodha is famous for crops like wheat, rice, cotton and sugarcane, but it is particularly famous for oranges. Oranges from Sargodha are not only being supplied in the country, but also exports to international markets. Some small factories for polishing and packing of oranges have been established in Sargodha by the coordination of local farmers.

2.4.5 Population, Literacy and Poverty

Literacy rate in Sargodha is only 46.3 percent (Waqar, 2006). In Sargodha, large population of farmer is uneducated. It impacts very badly upon the improvement of agricultural sector. Farmers mostly got knowledge about farming from their forefathers. Their forefathers were also illiterate and they could not tell them about latest techniques used for irrigation. Farmers give more importance to the saying of their forefathers. Some time it also happens that government try to give some information about new development in irrigation sector, but farmers refused to adopt this new system and they insist to follow the same old system, which they were following from generation to generation. The small farms do not possess to purchase the fertilizers, better seed, new agricultural technology (Maddison, 1971).

Sometime religious centres in villages can become the source of education for farmers. Farming organizations deliver their lectures in the religious centres of villages. People in villages listen very carefully to in charges of religious centres. Whenever any farming organization came in village, they contact with head of religious centre and then head of

religious centre announce in village about the arrival of that organization and also request to villagers to listen their lecture. Mostly at evening time, people gathered at that palace and farming organization can deliver lecture.

2.4.6 Landlord System

In Sargodha, some farmers have vast areas of agricultural land. At the time of British India, vast areas of agricultural were distributed among a few people, who become landlords in Indian continent. At the time of partition of Indian continent in two countries Pakistan and India, some landlords held vast area of agricultural land. After partition in 1947, Pakistan could not do more effort to take back the agricultural land from these landlords due to their hold in all political institutes of Pakistan. So all efforts to take the land back from these landlords and distribute among poor farmers become meaningless.

In period of president Ayub Khan in Pakistan (1958-1969), he described the situation of land ownership as follows: In Punjab province 50 % of available land, in Sindh province over 80 % of available land, in North West Frontier province little less than 50% of land was possessed by a few thousand landlords. President Ayub Khan managed to brake up some of bigger holdings with some compensation. Six thousands landlords surrendered 2.3 million acres. The ceiling for unirrigated land was 1000 acres (as compared with India, 50 acres or less) and for irrigated land was 500 acres. By this process, only 6 percent of cultivated land surrendered. Landlords split land in their family members (Maddison, 1971).

In 1959, 1972, 1976 and 1977, reforms legislations were enacted, to break the large landholdings of land and distribute land among landless farmers of Pakistan. But reforms could not reach the desired objectives and hence failed (Rahman, 1981).

Landlords mostly take less interest in agriculture. They give land to “*Pata*” (lease) and then move to other cities for some other professions. In *pata* system, farmer gives rent of land to landlord. The landlords come to their agricultural field, may be once or twice a year. They think that agricultural land does not give too many benefits as compared to their other businesses in cities. The landlords think that this agricultural land is the symbol of their status in society. So this thinking of status symbol transfers from generation to generation. Some landlords give their land to “*muzara*” (labours). In this “*muzara*” system landlords give their

land to farmers by fifty percent share. In *muzara* system, all expenses of cultivation crops divided among farmer and landlord. The main costs are for seeds, pesticides, water (in case of water shortage in canals and deficiency of water is fulfilled by underground tube-wells). In this system, landlord does not do any effort for farming, farmer does all efforts. So it impacts negative on agricultural production.

3. PRODUCTION COMPARISON

3.1 Production Loss

The detail data about different crops production in Pakistan Punjab as well as Indian Punjab during different years is available in tables 3.1 – 3.6 (Appendix- A).

3.2 Production Comparison of Two Punjab

Table 3.7 describes the comparative estimated production of main crops in Pakistan Punjab and Indian Punjab 2003-2004.

Table 3.7 Production Country wise

| Crops | Production (Country wise) | |
|--------|----------------------------|--------------------------|
| | Pakistan Punjab (Ton/Hect) | Indian Punjab (Ton/Hect) |
| Rice | 1.70 | 3.69 |
| Wheat | 2.49 | 4.20 |
| Maize | 1.78 | 2.98 |
| Cotton | 3.22 Bales/Hectare | 3.26 Bales/Hectare |

Above mentioned table about crop production in Pakistan Punjab and Indian Punjab, clearly shows the difference of crops production per hectare. The crop production in Indian Punjab is almost double than the crop production in Pakistan Punjab. There are various reasons of the loss of production in Punjab side of Pakistan.

Punjab was Indian first state that uses agricultural technology to engineer a green revolution. The road infrastructure in Indian Punjab is among the best road infrastructure in India. Punjab is connected with rail to all main cities of India. Literacy rate is 70 percent, private sector is participating in educational sector. It has 5 leading biotechnical institutes, which produce 100 postgraduates and doctorates and 200 graduates every year and per capita income is 25 percent higher than national per capita (Public,2006).

4. PROBLEMS IN MANAGING THE EXISTING IRRIGATION SECTOR

The problems in managing the existing irrigation sector in district Sargodha are same all over the Indus Basin of Punjab in Pakistan. The major problems in managing of irrigation sector in district Sargodha are following.

4.1 Water Tax

In district Sargodha, water distribution depends upon the size of farmland. Water supply to farms adjusted by time. As farms size increased, time duration of water supply to farms increased, if farm size decreased then time duration of water supply decreased, so time duration varies according to size of farm land. This system was introduced at the time of British Rule in Indian continent nearly before 100 years. This system is called “*Warabandi*” (term-wise). This system is managed by agricultural landowners. Whenever any problem comes in this system, then irrigation department gets involved and solve the matter. Often the irrigation department also fails to solve the problem among agricultural landowners. Because the system is very old and distribution of water is becoming more complex day by day due to population growth. *Warabandi* system introduced many conflicts among farmers living at the head and tail between biraderis (descent groups), between families, caste groups.

Water tax charged is neither according to water supplied to farmers, nor the traditional water rates increased with the increase cost of storage and supply of water. Instead the farmers charged with seasonal crops and it did not provide any kind of incentives to irrigation department. Low water charges show power of landlords in the political system of Pakistan (Shepperdson, 1981).

There are three kinds of farmers: (1) Farmers getting more water than their share, (2) Farmers getting less water than their share, (3) Farmers getting no water. It is estimated that 10 % of farmers are in 3rd category. Farmer pays water tax to revenue department. Water tax is called “*abiana*”. Irrigation department assess crops four times in year, crop assessment two times in summer and winter and two times crop assessment for vegetables and then the irrigation department gives report to revenue department for the collection of water tax. If crop

condition not good in area then Revenue department did not charge any water tax from those particular farmers. To get the final tax report from Revenue department, some times farmers wait for at least six months. Water tax was Rs 100 per acre in 1993 until 1998, water tax become 2.5 times than the water tax in 1998 (Nakashima, 2005). Powerful farmers did not pay water tax to the revenue department. By this action, bad image goes to those farmers, who are paying water tax, then these farmers feel hesitate to pay water tax.

Financial problem is main reasons of improper maintenance of irrigation system .Authorities have not enough of funds for the proper maintenance of irrigation system. The operational and maintenance cost is too high as compared to water tax collected. The operational and maintenance cost increased due to start of public project like Salinity Control and Reclamation project programme. In salinity control project, many tube-wells have been installed in different areas. The gap between water tax and the operation and maintenance cost was 44 % in 1992 and it is increasing (Nakashima, 2005).

There are twenty main organizations in world helping developing countries to improve irrigation and drainage systems. These organizations are providing technical assistance and financial help. Only five of twenty organizations are providing financial help for irrigation development. While the remaining other organizations are only providing technical assistance as shown in table 4.1 (Appendix- A) (Phillip Z. Kirpich). The numbers of organizations providing financial help are not enough to overcome the problems of irrigation system.

World Bank described a new Country Assistance Strategy (CAS) for Pakistan. This document covers a period of 2006 – 2009 and envisages flexible lending program upto US \$ 6.5 billion. For Punjab irrigation sector development, loan will be US \$ 100 million. The project is designed for main pillars (The World Bank, 2006).

- Institutional and policy reforms (Improvement of management and maintenance of Punjab irrigation system)
- Water resource management reforms (Intra province water allocation and distribution more transparent)
- Irrigation service delivery reforms (Improve the quality, efficiency and accountability)

- Reforms to encourage introduction of new technologies (Improve water use efficiency and on – farm productivity)

4.2 Gap between Government and Water Users

Farmer's distrust of authorities is gradually rising. People in authorities take bribes from landlords and then give them permission to use more water as compared to their share. There are many cases reported against irrigation department officers, like bribes extracted regularly for increase of illegally water intake (Nakashima, 2005).

Poor farmers can not go to courts with accusation against authorities, because they are not the owner of water. But irrigation department can take action against the misuse of water. After 1971 election, mostly landlords become politically active and started to use their power in various government institutions directly and more actively, because landlords become in charge of most of institutions.

These politicians also forced irrigation department for their personal benefits. Those officers, who give decisions against those corrupted landlords politicians, transferred to another places by orders of these politicians. The gap among farmers and irrigation department is increasing. The farmers think that all people in irrigation department are corrupt. On other side, irrigation department assumes the farmers ignorant and incapable of participating in management of department activities. If this system continues for a long time then there can be a social disaster (Nakashima, 2005).

Indus basin irrigation system suffered badly due to improper management. Indus basin irrigation system is very inefficient. Reservoirs already filled with sedimentation. Capacity of reservoirs is decreasing. From canal head to root level, 60 % of water waste. Government of Pakistan is failed to distribute irrigated land to inhabitants. Newly irrigated land again distributed among military personnel and to rich land owners by authorities. Landlords control 66 % of agricultural land in Pakistan, but on other side half of rural households are not the owner of land. According to one survey by Transparency Institute in 2003 reports that Pakistan water and power development Institute is the 2nd corrupt institute of country. Also anticorruption institute reports in 2002 states that they received complaints related to Water

and Power development Institute are close to half of total 31,000 complaints. According to World Bank report, powerful people used water sector for their own benefits and reward bureaucracy for their service (Bosshard, 2006).

Pakistan water development sector is not a transparent sector. Water allocations are not disclosed to public. Like other cities of Pakistan, Sargodha is also badly affected by corruption in management sections of water and power development authority. Authorities give priorities to the problems of landlords of area and neglect the complaints of poor farmers. This action by authorities is creating the hopelessness among farmers of area and they are thinking that may be their problems will never be solved. Due to lack of resources, poor farmers of area can not go to higher authorities of department and to courts for justice. Roots of corruption are not only in irrigation sector, but also in all other sectors of agricultural department. This corruption is affecting whole agricultural sector.

4.3 Canal System

In Sargodha, canals are of two types, in some canals water flows whole year, while in some canals flow is restricted to six months in year. The area along canals, flow during whole year has enough water and farmers in those areas do not require tube-wells for irrigation purposes. While on other side, farmers living along those canals, which flow six months in year, use tube-wells for irrigation purposes. So these farmers face burden in the form of over water charge. These farmers mostly use private tube-wells for irrigation purposes. They use diesel or petrol for running of tube-wells and that is very costly. This is one kind of overburden to poor farmers.

The seepage of canals is also a big issue. In main canals and in sub canals, mostly seepage happens. Water is wasted in form of evaporation and sometimes goes towards underground water. Seepage mostly happens due to bad condition of boundaries of canals and sometimes water flows outside towards agricultural fields. Canals lose their original depth due to mud and sand settles down in the bottom and it happen whenever water flow more than a capacity of canals. So as a result water comes out from boundaries of canals and damages agricultural fields and due to continuous seepage from canals, underground water level increased and damages the agricultural land.

Indus basin irrigation system withdraws about 130 billion cubic metres of river water flows annually. Portion of it evaporates and seeps to ground annually. In 1993-94, Water and Power Development Authority computed canal withdrawals. The methodology includes soil texture, variability of flows, canal lengths. Loss computed every 10 daily period and also it accumulated for season. The volume of 95.6 Bcm was available at water course head out of total canal head withdrawal 124.7 Bcm. The minimum loss at particular canal command was 13 % and maximum loss was 30 % (Khan et al).

There are two causes of water loss, direct cause and indirect cause .Direct water loss includes poorly sealed *Kacha* (uncemented, earthen) outlets, junctions of water courses and canals. Seepage from the beds of all channels and unlined canals has probably been exaggerated and most of loss of water occurs with in farmers own water course. The other kind of loss occurs in those channels, which are not properly designed as well as not properly maintained vegetation and silt available in channels and the loss arise from dead water in that channels. Johnson, et al (1979) mentions about the study in district Sargodha that 90 percent of irrigated plots were not levelled. Indirect water loss occurs, due to not proper designed of canal outlets. The canal outlets (*mogha*) provide a constant outlets flow, even sometime crops do not require same amount of water due to rainfall and some other factors (Shepperdson, 1981).

4.4 Tube-well System

Tube-wells machinery is not in well condition in the rural areas of district Sargodha. Tube-wells operators do not care about the protection of machinery and also they do not care to perform their duties well. The officers of irrigation department also do not care about the loss of costly machinery. These tube-wells are a burden on irrigation department. Every year, irrigation department spends huge amount for repair of these tube-wells. The decision making system is the centralized system in government sector, and sometimes at federal level. This centralized system also creates so many problems for the development of irrigation sector. After several months final decision (about repair or replacement of existed damaged tube wells) comes and delay in decision puts bad impact upon irrigation development.

4.5 Water Logging and Salinity

It is estimated that 8 % of gross irrigated area is badly affected by salinity and 6 % is moderately affected. To cover the deficiency of water in canals, groundwater is overexploited and groundwater table is lowered. Intrusion of saline water in freshwater becomes a problem that makes fresh water unusable (Nakashima, 2005).

The drainage is very difficult due to limited slope of land (McPherson and Johnston, 1967).

In last 40 years, irrigated area has been increased rapidly in world, but drainage facilities have been neglected. As a result, vast areas of irrigated land become salinized and water logged. The reason of salinity and water logging is the increase of water table and accumulation of salt. In India water logging affects 5 million ha and due to this two million ton grain lost every year. World wide, half of existing soil is affected by salinization to some degree. The major food producing areas of world are affected by this problem like the Punjab and Indus valley (World Bank Report, 2005). Table 4.2 (Appendix- A) explains major production basins affected by land degradation due to salinity.

4.6 Water Stealing

In rural areas of Sargodha, water stealing is also a contributing factor in irrigation mismanagement. Landlords mostly involve in water stealing, sometime they theft water by tempering *Mogha* near their agricultural land. So in this way some farmers use more water than their proper share. Poor farmers do not complain to authorities about this problem, because they are always afraid from landlords. These landlords have power in the political system of area and they use this power for their personal benefits. Water stealing mostly happens due to the absence of any water monitoring instrument on canals.

4.7 Floods

River *Jhelum* flows in district Sargodha. Floods came in River *Jhelum* every year. Due to floods, only villages along river are affected, but sometimes due to floods, vast area affected. Floods mostly affect main canals, sub canals and underground tube-wells in area. Whenever

flood water remains in agricultural fields for a long time, then tube-wells badly damaged. The tube-wells are unable to suck water and farmers have to reinstall these tube-wells because in rural areas there is no system of boring tube wells with bricks boundary wall, so whenever water remains there then bore changes its angle due to muddy bore and pump fail to suck water. In rural areas of district Sargodha, farmers dig small canals which originate from main canals to their agricultural fields. These small ways flow with flood water. If flood water remains in agricultural fields for a long time, it damages crops badly in fields.

4.8 Sedimentation in Reservoirs

There are two main reservoirs in Indus basin irrigation system, *Mangla* dam and *Tarbela* dam. *Mangla* dam was built in 1967. It is 453 feet high and 10,300 feet wide. It irrigates 3,000,000 acres. Both reservoirs are the main source of water supply in whole Indus basin. There are two main canals originates from river *Jhelum* named as Upper *Jhelum* and Lower *Jhelum* canal. Lower *Jhelum* canal originates at Rasul (Britannica, 2007). As time passed, reservoir capacity of *Mangla* dam has reduced due to sedimentation. The silt already deposited in *Mangla* Dam is 2 billion ton and it is increasing at average rate of 57 million ton per year (*Mangla*). Due to rising of silt in *Mangla* dam, whole cultivated area irrigated by *Mangla* dam is affected. Rural areas surrounded by city are irrigated by Lower *Jhelum* Canal. There are also many sub canals originates from main Lower *Jhelum* Canal for irrigation purposes in district Sargodha. But due to increasing silt in reservoirs, annual flow of water in canals has been reduced. So the whole irrigated area is affecting by deficiency of water.

5. TOOLS FOR THE MANAGEMENT OF IRRIGATION SYSTEM

According to Lowdermilk (1986), irrigation water management is the process in which water is controlled and used for crops. It is not water resources, reservoirs or dams to store water, nor laws, nor institutions to allocate water, nor soils or cropping system, nor farmer organization. It is the way, these skills and physical, chemical, biological, and social resources utilized to provide water for improvement of food production.

The performance of irrigation system depends upon the management of irrigation system as a whole, including management of information and control, of people (work in irrigation organization and farmers), also other inputs besides water. The management revolves around water and its control. The management without control and objectives is not possible (Mohan, 1986).

5.1 World Bank Proposal

In 1994, World Bank presented a proposal for possible reforms in irrigation management system. The main features of that report are (Nakashima, 2005).

1- Four provincial irrigation departments should be divided among 43 autonomous public utilities, each public utility should be for 43 canal commands and also to create farmers organizations (one farmer organization for each distributaries).

2- Water is treated as a tradable commodity not as private good.

3- Water property rights be given to farmers to create water market, and it should be disconnected from land.

4- Management of public utilities should be company style, and they should also be registered with the Corporate Law Authority under the companies act.

According to World Bank report, water should not be treated as public good instead being used as a private good in Pakistan. In case of water treated as private good, then water users have water rights to ensure free water market. According to report, water rights have several advantages e.g. to improve the distribution of water, better efficiency, to promote long term investment and to reduce conflicts.

5.1.1 Reactions to Proposal of World Bank

A- Media Response

Media argue that utility company can disconnect their water supply, because water charges were not paid properly. So farmers were not ready to sacrifice their crops on the ground as a result of such action. Farmers protested about this proposal and respond, that water rates can go up in future and landlords can exploit them.

Media role was very important and it performed its role very well. Whenever irrigation sector or whole agricultural sector faced financial crisis due to corruption in institutions, then bureaucracy try to recover the budget loss by increase tax. So in future such kind of utility companies can be the cause of overburden on poor farmers.

B- Water Market

In Pakistan 77 % of farmers are cultivating only 28 % of land. People think that in water market, poor farmers can sell their water rights to rich farmers at the time of money need, and then the rich farmers can exploit them and poor farmers can be in more trouble. Water market can also create water monopolies. In monopoly, prices of water can be very high, whenever water is in short and then there is a danger for the disturbance of rural society. In Pakistan there are various examples, whenever the utility prices go up and the private companies gained over profit. There can be also technical faults, because canals are designed for 60 % crop intensity. It is also not possible to carry less or more water than design capacity. The hydraulic regime in canals can be disturbed in case of change in depth and velocity.

Water markets can be possible, if the following specific conditions are satisfied. First, there should be sub irrigation system, from where the hydraulic regime can also accommodate the

flow demands. Second, there should be an institutional frame to stop water monopoly. Third, there should be a safety net to save poor farmers to lose their livelihood.

C- Imposition of reform by an outsider

People rejected the proposal of World Bank, due to fear that the proposals are imposed by outsider organization. If reforms fail then the agricultural sector will collapse and no foreign organization will compensate loss. The World Bank proposal did not represent farmer's views. Farmers Associates of Pakistan (FAP) therefore rejected these proposals (Nakashima, 2005).

5.2 Farmers Participation

If farmers are invited in meeting of canal authorities then farmers can play an effective role in decision making, particularly implementing, operating, maintaining, planning, evaluating projects and programmes designed to improve equity, productivity and effectiveness of irrigation projects, because they know their problems well and can give better suggestions about the solution of their problems. The canal authorities always confused over farmer participation. Canal authorities administrate water network rather than manage water system. In history, farmers always planned, built and operated their own private system and also participate in public system. If irrigation development means agricultural production, then farmers are the central actors in development of irrigation system. Today in India, there are tanks, used for irrigation purposes of significant area. The farmers own and operate (Lowdermilk, 1986).

In some countries, farmer's involvement is about complete ownership of irrigation system, active involvement in the management of public system and little involvement in operation. In countries like Japan, Korea, Taiwan, water user association plays effective role. In water user associations, farmers are responsible for the improvement, construction, operation and maintenance of irrigation facilities, prevention and relief of irrigation system and drainage facilities as well as financing the association staff, coordination with government policies on land, industry, agriculture and rural development. The government responsibility is to provide loans, policies, technical assistance and incentives for strengthening associations. In 1945,

mainland China also decentralized the irrigation system. This decentralized irrigation system is in charge of the construction, operation, management, improvement, maintenance and drainage facilities. These organizations also have the responsibility to settle water disputes, collect fees, take and repay loans, engineering costs, and also conduct study for improvement (Lowdermilk, 1986).

5.2.1 Farmer Involvement

Farmer labour amounted to about \$ 7.6 M in one project for the rehabilitation of *Chaks* (small villages) in Pakistan with total estimated cost of \$ 42 M. In recent World Bank project, farmers provide estimating 30 % of project cost in labour and cost recoveries for improvement activities. Farmer's organizations provide man power for work in any project in their area. Because their interests are related with that project and these farmers organizations are ready to provide sufficient help (without any wages) for the completion of project. In this way, financial burden upon donor agencies can be decreased to some extent. Because to import man power from other areas for any project in specified area is highly paid. The organized farmers have a sense of ownership and can maintain the system. In planning stage, farmers experience about soil type, depth of soil, location of outlets, topography, and information about social problems can be very helpful in management of irrigation system (Lowdermilk, 1986). Government should give farmers technical assistance in designing, planning and policy making. In Pakistan a recent study shows that about 70 % of farmers reported that they do not know about the closure of system for maintenance, and also they do not know about opening dates of system. Farmers have seldom chance to meet irrigation officials, only they meet the local *Patwari*, and they are mostly not at their stations (Lowdermilk, 1986).

In one report of water management improvement project in small villages of Pakistan states that farmers in villages agreed to (Lowdermilk, 1986).

- Provide masons
- Supervise the local improvements
- Provide the labour for lining and earthwork
- Provide some cash for the small water course structure
- Settle the disputes about water ,land and other small significant problems

- Resolve the conflicts
- Set up method for maintenance, regular operation of the system
- Create organization for the project activities

Government can not bear the complete cost of the irrigation system with out the help of farmers. Without the participation of farmers, irrigation efficiency can never be increased. The worldwide development experience indicates that on farm improvement, operation and maintenance, field channel construction and general management of irrigation below outlet can be best accomplished only with direct involvement of farmers (Lowdermilk, 1986).

Farmers are the authorities, who will run system in real way. The responsibility of government should be to complete any irrigation project and then handover the system to local authorities and only evaluate final report on the efficiency of project. It will create sense of confidence among farmers and they will run the system with care, otherwise they will think that it is the government property and they have no care about it and ultimately the system will loss its efficiency with time.

5.3 Introduction of New Technology

There are new irrigation technologies available that reduce salinity. The new technologies include, change in irrigation system, land grading, placement of seed, increased frequency of irrigation and artificial drainage.

Sprinkler irrigation with short interval between applications maintains the high soil moisture. The soil moisture dilutes salts in soil. Another technology for irrigation is drip irrigation, drip irrigation successful observed for vegetable crops. Drip irrigation is high moisture regime in a limited area of soil volume, in which salts are diluted, but salts are highly concentrated at edge of wetted zone. The other technique is the tissue culture technique; this technique is about selection and separation of salt resistant plants. This technique is useful for study of physiological aspects of salinity resistant plants (Yaron, 1986).

The performance of irrigation system can be increased by investing in modernization and rehabilitation of existing projects. The loans can be given to improve organizations and management of sectors (World Bank, 2005).

5.4 Technology Transfer

Technology transfer is the art of transmitting information and ideas from one person to another person. In underdeveloped countries, resources are not available for basic research. So it is necessary for underdeveloped countries to use ideas of other people and to advance rapidly. Technology transfer and technology change are related with each other. As technology transfer often brings the technology change that can increase the economic production (Lattimore, 1986).

In process of technology transfer, it has high number of interrelated elements. If one element is missing, then other elements also become useless. So to establish the modern technology in underdeveloped countries, change in the following area is very necessary.

- Knowledge and the human skill
- Social system and the human attitudes
- Physical implementation in which the modern technology is embodied

The main problem in the modernization of agriculture is social structure and the resulting behaviour. Modernization will never occur even if the irrigation, fertilizers and equipments are available, because social structure resist. In the West formal education was main instrument for technology change. But that process took centuries to reach the present stage. The developing countries can not wait for a long time for change. To meet pressure of developing society and to increase the speed of development, a teamwork approach is required. To achieve targets, there is a need of collaboration among host countries and scientist from developed countries in an interdisciplinary setting. In order to accelerate the technology transfer, irrigation problems must be approached with discipline complementing and by filling gaps that exist in system (Lattimore, 1986).

There are various micro techniques to improve irrigation system. Drip irrigation method is efficient method, and it requires 30-50 percent less water than surface irrigation and it also reduces water logging and salinization and can achieve efficiency upto 95 percent. But it requires clean water to prevent the clogging. Currently in world only 1 percent of total irrigated land is irrigated by micro techniques and it is only 3.2 million hectares. Only four percent of irrigated area is covered by sprinkle irrigation method. The new surface irrigation techniques like precise land levelling, surge irrigation, gated pipes also improve the surface irrigation (World Bank Report, 2005).

5.5 On Farm Research

To improve the management of farm irrigation water, social sciences and biological aspects are required. These interventions can improve irrigation management, but it should not coincide with other high priority goal of farmers. While conducting on farm research, field team should consider the following points (Schmehl, 1986).

- Farmer, field, hydraulic unit selection
- Farmer/ Researcher relationship
- Incentives and agreements
- Monitoring seasonal progress
- Field test design
- Methods to measure and evaluate the results

The selected farmers for on farm research should represent the project goals and objectives and be willing to cooperate during research and in test proposed. The relationship between researcher and farmer is very important. In field testing, researcher observes the response of farmer about the introduction of a new technology and researcher may ask farmer about the practice of new technology to improve production or the researcher can also try by himself. The incentives should be given to farmers at that time, if the yield reduced due to intervention of new technology, or due to more biological samples be taken for experiments. The progress on farm experiments also is monitored, input cost of proposed technology, requirement of labour and socio-cultural conditions. To evaluate result, resource accessibility, biological

feasibility, sociocultural acceptability, and economic/financial feasibility is to be considered (Schmehl, 1986).

5.6 Water Scheduling and Delivery

Water scheduling and delivery is a very important aspect of management of irrigation system. Water scheduling and delivery is defined as the deliveries of water in time in command area. There are three essential components in policy or schedule: 1) frequency of time of delivery to the field, 2) duration of delivery, 3) delivery flow rate to field. Water scheduling and delivery is to be present in most of job description responsible for irrigation management. The attention requires for providing the framework for water scheduling particularly in large irrigation system (Lenton, 1986).

The schedule policies are selected for a specific project for a certain period of time due to certain reasons, but these policies exist for several decades. There is a need to revise these policies, because these policies may not valid for present time. In some areas, schedule designs in order to meet peak crop requirement of water in season. In some areas water schedule intentionally design in order to under deliver, because of the reliability of rainfall.

To meet crop water requirement, knowledge about plant, water, soil and atmosphere relationship is required. The schedule can be considered either rigid or flexible. The flexible system permits farm operator participation that allows more delivery of water at time of requirement at field. The farm operator can open or close water supply valve at request of local farmers. But this system also required good communication between farm operator and water authority. On other side in rigid system, water delivered according to a fixed flow rate and frequency. The rigid system causes more problems and complexities, because requirement of water varies at fields. There can be various factors for change in requirement of water at field like rain or crops type (required less or more water). The flexible system is the better option in water scheduling (Replogle, 1986).

In present situation, current water tax in Sindh (Pakistan) and Haryana (India) is less than 3 % of net revenue from irrigated crops. In Morocco, farmers are willing to pay 17 percent of their net income for reliable surface water supply (FAO, 2007). If policy makers in Pakistan and

Haryana consider water pricing to deter farmers from using water, then they required to raise the current water taxes to twenty to thirty percent to reach at level of 15 percent of their net income. It is not an easy task to increase water price at this level in short term. Prices can be increased over's with improvement of service delivery. The study from Nepal and Pakistan demonstrate that system of collection of water taxes should be improved, because present system did not achieve target of the collection of water tax (not more than 30-60 percent of the very low water taxes) (FAO, 2007).

The collection of water tax also depends upon the services supplied to farmers. The good and better service can only be achieved by giving the financial autonomy. Without the autonomy, there is no guarantee that services supplied to users can be better, because in most of cases funds do not go to project, but go towards central treasury. The transparency of system also encourages users to pay tax (World Bank Report, 2005).

5.7 Measurement of Water Control

5.7.1 Planning

Planning is the first step either designing of new project as well as improving of existed project. Planning can be started by basic information about climate conditions, information about soil, topography, soil structure, about hydrology, lay out of main canals and distributaries, irrigation deliver schedule, and mode of operation (automatic or manual) etc.

In the unit command area, planning refers to irrigation delivery schedule, decisions regarding size of command, layout of water courses and drains, farmers concerns should also be considered, type of crops to be grown, irrigation type (deficit or full irrigation), frequency of irrigation (low or high). The points at layout of system are also considered at planning stage at farm level (Mohan, 1986).

5.7.2 Design

To control water, irrigation system must be designed, planned, operated and maintained properly. If any one of above points is lacking then it is not easy to control water. In design of

irrigation system, following parameters should be considered: depth of flow, flow rate, location and size of regulating size of outlets and turnouts on distribution network both above and below outlet structures, controlling and measuring structures, channel cross section and slope. In design system, it should also specify the frequency and flow rate at every point of distribution system. If irrigation system does not deliver water according to requirement of plan, it can be due to the following reasons: location of control structures is inappropriate, slopes are erosive, no erosion protection structure provided. The design at field level specifies *bund* height, field size (border size etc), appropriate flow rate and time of irrigation and irrigation required per season also estimated. The common method of irrigation is wild flooding and that is the inefficient method of surface irrigation. Often the flow rates do not match with size of field, soil type, topography is uneven, that are main reasons of non uniform distribution (Mohan, 1986).

5.7.3 Operation & Maintenance

Operation refers to manipulate structure that convey, distribute irrigated water according to design. The flow rate is very important factor in operation plan. In case of change in flow rate or delivery schedule, it must be communicated to personnel operating irrigation system and farmer. To supply right quantity of water at right time is the important part of operation. Sometimes original system operation does not achieve the required flow rate due to deficiencies in design or deficiencies in construction, then there is a need for change in design of irrigation system and it requires more money. But sometimes original irrigation system constraints any change in design of irrigation system.

Regular maintenance of irrigation system is very important to maintain the efficient performance of irrigation system. The regular maintenance of structures, canal cross sections, drains and fields must be proper maintained. To achieve good water control, regular maintenance of system is important. The good results can not be taken, if irrigated system condition is not close to original system condition. However in many projects around world, sufficient funds not available for regular maintenance of project. As a result several irrigation projects deteriorated, resulting in system performance not close to original system.

The resources and funding must be identified for operation and maintenance. The public, private and semi-public agencies are responsible for main and distributaries system. The

expenditures funded by fees charged from farmers and paid from their own resources. Subsidies given from government budget, may also supplement this funding.

The responsibility of Government is to maintain the national important water bodies and major structures like dams. These expenditures meet by national budget. Water and user associations are usually responsible for field system. Operation and maintenance cost is funded by farmers with their own money and labour. Sometime financial help also funded by private bank in form of loans (World Bank Report, 2005).

5.8 Monitoring and Evaluation

The process of checking those parameters that indicates performance of system is the monitoring of a system. The monitoring indicates that how the best project is working. Monitoring provides (Mohan, 1986).

- Post evaluation of projects to improve planning of projects
- The database facilitates the evaluation of ongoing project operation and performance
- To ensure that schedule tasks are going correctly and with appropriate frequency

Monitoring provides good management, and it must be considered at planning stage. The parameters that influence the performance of a system must be identified. To measure the performance, right information must be collected. The quality of data is more important than quantity of data. The following points also to be considered during decision making.

- The staff required
- The frequency of data collection (season,month,day,hour)
- The data communication (receiver ,frequency)
- The recording and processing data (equipment, automatic or manual)
- Distribution of monitoring stations (head/middle/tail)

5.9 Educational System

Educational system is the backbone of any nation. The progress of nations depends upon progress of educational system. The educational system in Sargodha is not satisfactory. The development of agriculture sector depends upon progress of educational centre in that area. The education about irrigation development should be given to children at primary level. This education should be taught to children as a compulsory subject. Then they can become a good farmer in future. The education about development of irrigation to adults is also very necessary element. The government or private organizations can arrange seminars about development of irrigation sector. To make valuable and more participation of farmers, prominent people of rural areas should be invited (e.g. religious leaders, political leaders and landlords of area). The farmers of rural areas listen carefully their own people instead of speakers from outside. In these seminars, those farmers should also be invited, who already adopted new techniques about irrigation and as result, better crop production come. The farmers in rural areas of district Sargodha are illiterate and they hesitate to adopt new irrigation techniques.

There is a need of regular seminars in rural areas of district Sargodha. New and modern techniques in irrigation system can be introduced among rural community. If specialists from other countries invited in these seminars, then it can also be helpful to share the experiences of other countries in field of irrigation development. The experts from developed countries should be invited for surveys in rural areas of Sargodha. The media can also play a very effective role in promotion of education among villagers of rural areas of district Sargodha. District Sargodha has one radio station and radio channels can start programmes about irrigation development in area. Farmers in rural areas of Sargodha listen to programmes of radio channel with keen interest.

There is a need of training engineers and farmers. In one analysis of 63 projects since 1970 by World Bank and Agency for International development indicates that training of farmers and engineer includes only 5 projects. The cost data of 40 projects indicates that less than 1 percent of total budget allocated for training purposes (Lowdermilk, 1986).

To save and reuse of water and then recycle water for agricultural purposes is important. Students should be taught about the use of water for agricultural purposes by involving them in local projects, also case studies should be taught about interaction of society and science (Rao, 1987).

By providing knowledge and skill to farmers, governmental bodies, service providers, and farmers associations, irrigation system can be better managed and wastage of water can be stopped as well as water productivity can be increased. The problem is not only the scarcity of water, but management of water is also a problem (World Bank Report, 2005).

The above mention programme can be financed by help of World Bank. World Bank approved a package of US \$ 451million in 2007 for government of Pakistan to improve education in Sindh and Punjab, to develop irrigation sector in Punjab and for health care in NWFP province (The World Bank, 2007).

5.10 Modification of Canals

The boundaries of canals and sub-canals should be established in a way that water should not come out through boundaries of canals and sub canals. The boundaries of canals and sub canals should be made of bricks or stones. The height of boundaries should be at such level that if flow of water increases in canals due to any reason, then water should not come out from boundaries. The early warning system should be installed at canals, so water level can be monitored. The monitoring system should be installed at different points of canals. The irrigation department should also inform farmers in case of any emergency. So farmers can take preventive measures against any harm to their crops as well as irrigation system. The information to farmers can be given from local radio channel.

The sidewalls of water channels can be *pakka* (concrete walls) for preventing water wastage. As 20 percent or 40 percent of water entering in water course lost before it reaches root zone and assume that full or subsidised cost of cement can be used for construction (Shepperdson, 1981).

5.11 Construction of New Reservoirs

There is a need for construction of new reservoirs. The big reservoirs are required for Indus Basin System and small reservoirs are required in rural areas for the supply of water for irrigation at time of water shortage in canals. In rural areas of district Sargodha, there is a need of many small reservoirs instead of one big reservoir. The reservoir can be constructed for two or three villages together. The irrigation department should be responsible for filling of reservoir and local villagers should be responsible for the maintenance of reservoirs. The minor maintenance should be done at local level, at farmer union level, but for major maintenance, irrigation department should take responsibility.

5.12 Tube-well System

Tube-well is the main source of irrigation in that areas, where underground water is available less than 20 metres from surface. Tube-well is the main source of water supply and it is the important source of poverty reduction. The technology of tube-well is not complicated and use of this technology is increasing rapidly. Tube-well is not expensive way of supply water for drinking as well as for irrigation purposes. In Pakistan tube-well owners (private sector) are active water seller to neighbours (World Bank Report, 2005).

There is a need of privatization of tube-well system. The private companies can manage this tube-well system in a better way. There are many private companies already working in rural areas of Sargodha. Private companies can better monitor the tube-well system. The system of private companies is decentralized. The decision making authorities are available at city level. The farmers of rural areas can easily meet authorities of private companies and explain their problems well; also authorities can take decisions with out waiting for decisions coming from head office. In this way, lot of time can be saved as well as irrigation sector developed.

The investment by different companies in irrigation sector development creates atmosphere of competition. Whenever new sectors opened for investment, foreign companies also participate in competition with local companies. Then quality products came in market as well as prices of products also fall down in markets due to competition.

Tube-wells can be installed to overcome the problems of drainage. Tube-wells also provide supplementary irrigation at time of water insufficient in rivers. During time of water deficiency in canals in planting time and then at growing season, crops in that area badly effected. Only tube-wells in that area can overcome this deficiency and make it possible economic benefit for farmers in area. The other benefit of tube-well installation is that it lowers water table. Thus it relieves water logging and reduces salinity (McPherson and Johnston, 1967). Table 5.1 explains ground water importance in irrigation (Appendix- A).

6. SUMMARY AND CONCLUSION

The thesis discussed social as well as technical problems about management of irrigation system in Punjab of Pakistan and suggested possible solutions about management of irrigation system. To solve management problems of irrigation sector, first thing is to know about root causes of problem. To suggest and impose any solutions without knowledge of root causes of problem may always not be successful. In this thesis, we discussed about basic infrastructure of Indus Basin System in Pakistan, and then we put light on irrigation system of Sargodha. The management of irrigation system in district Sargodha has social as well as technical problems. The social as well as technical problems mentioned in thesis are identified through literature study as well as through participatory observation living in area. Before implementation of any solution for irrigation management, first preference should be given to solve social problems in area, and second priority should be given to solve technical problems.

The area selected for possible reforms is district Sargodha of Punjab province of Indus Basin of Pakistan. Pakistan is a developing country and social problems are at peak for management of irrigation system in Indus basin. In district Sargodha, water management authorities have not succeeded in terms of introducing new techniques due to social problems. Similarly foreign and national NGOs can not be successful in introducing new projects for better management of irrigation system in any part of Indus basin, until they know about social problems in area. Pakistan is a developing country and people living in rural areas are facing many social problems and there is a need to solve these social problems, then there can be hope to solve other problems like irrigation related problem. Otherwise there is a chance that gap between local people and investors may increase which might result in overall negative effects. Some problems like landlord problem will be solved automatically as time passed, because ownership of land is reducing from generation to generation and there is a hope that in near future there will be no big landlords in area. The Children of landlords are become educated and there thinking is no more feudal as like their forefathers and there is a better hope that irrigation sector will be progressed in near future in district Sargodha.

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APPENDIX - A

Table 2.1 Command Area Statistics of Punjab Canals

| Canals | Year of Operation | GCA | CCA | % Area Perennial |
|---------------------------|-------------------|--------|--------|------------------|
| Upper Chenab | 1912 | 618836 | 580147 | 60% |
| M.R.Link | 1956 | 71002 | 63616 | 0% |
| C.B.D.C. | 1859 | 284639 | 265700 | 100% |
| Depalpur (Upper) | 1928 | 152223 | 141711 | 0% |
| Depalpur (Lower) | 1928 | 263620 | 247718 | 0% |
| B.R.B.D. | | | | 0% |
| Lower Chenab (East) | 1892 | 773321 | 647502 | 95% |
| Lower Chenab (West) | 1892 | 724140 | 588614 | 95% |
| Upper Jehlum | 1915 | 236625 | 220094 | 69% |
| Lower Jehlum | 1901 | 662982 | 614488 | 86% |
| Thal | 1947 | 950802 | 773843 | 100% |
| L.B.D.C. | 1913 | 740374 | 675667 | 97% |
| Haveli | 1939 | 457382 | 411711 | 36% |
| Mailsi | 1928 | 303916 | 277956 | 32% |
| Pakpattan (Upper & Lower) | 1927 | 570971 | 516233 | 60% |
| Fordwah | 1927 | 188118 | 173111 | 15% |
| East Sadiqia | 1926 | 497749 | 424850 | 98% |
| Abbasia | 1929 | 120739 | 96139 | 48% |
| Bahawal | 1927 | 365681 | 299776 | 47% |
| Qaim | 1927 | 18320 | 17121 | 0% |
| Panjnad | 1929 | 613172 | 551926 | 33% |
| D.G.Khan | 1958 | 388706 | 368546 | 0% |
| Muzaffargarh | 1958 | 383473 | 331764 | 0% |
| Rangpur | 1939 | 144831 | 139769 | 0% |

Source: (Tahir and Habib, 2000).

Table 2.2 Water availability in Punjab canal commands (figures in mm)

| Canal Command | Kharif Season | | | | Rabi Season | | | |
|-------------------|---------------|----------------|------|-------------|-------------|----------------|------|-------------|
| | Canal water | Tubewell water | Rain | Total water | Canal water | Tubewell water | Rain | Total water |
| UCC | 208 | 335 | 410 | 953 | 41 | 335 | 26 | 402 |
| CBDC | 327 | 294 | 295 | 916 | 249 | 294 | 36 | 580 |
| Upper Dipalpur | 349 | 311 | 255 | 915 | 71 | 311 | 25 | 407 |
| Lower Dipalpur | 464 | 280 | 250 | 994 | 64 | 280 | 25 | 369 |
| LCC East (Gugera) | 372 | 242 | 270 | 883 | 244 | 242 | 25 | 510 |
| LCC West (Jhang) | 273 | 316 | 284 | 872 | 179 | 316 | 25 | 520 |
| Upper Jehlam | 429 | 294 | 480 | 1203 | 309 | 294 | 25 | 627 |
| Lower Jehlam | 252 | 304 | 305 | 861 | 159 | 304 | 25 | 488 |
| Thal | 324 | 107 | 310 | 742 | 230 | 107 | 44 | 380 |
| LBDC | 426 | 292 | 250 | 968 | 262 | 292 | 25 | 579 |
| Haveli | 370 | 307 | 250 | 926 | 194 | 307 | 25 | 526 |
| Mailsi | 389 | 422 | 183 | 993 | 83 | 422 | 25 | 530 |
| Pakpattan | 402 | 222 | 250 | 874 | 205 | 222 | 25 | 451 |
| Fordwah | 444 | 82 | 250 | 776 | 38 | 82 | 25 | 145 |
| Eastern Sadiqia | 508 | 83 | 240 | 831 | 357 | 83 | 25 | 465 |
| Abbasia | 375 | 89 | 145 | 609 | 411 | 89 | 25 | 525 |
| Bahawal | 520 | 167 | 150 | 837 | 243 | 167 | 25 | 436 |
| Qaim | 718 | 0 | 224 | 942 | 199 | 0 | 25 | 224 |
| Panjand | 536 | 163 | 65 | 764 | 168 | 163 | 25 | 357 |
| DG Khan | 727 | 48 | 138 | 913 | 233 | 48 | 25 | 306 |
| Muzaffargarh | 609 | 133 | 206 | 949 | 134 | 133 | 25 | 292 |
| Rangpur | 238 | 205 | 237 | 680 | 33 | 205 | 25 | 263 |

Source: (Tahir and Habib, 2000).

Table 2.3 Crops in Two Seasons

| No. | Kharif Crops | Rabi Crops |
|------------|---------------------|-------------------|
| 1 | Sugarcane | Wheat |
| 2 | Rice | Barley |
| 3 | Cotton | Grain |
| 4 | Maize | Grams |
| 5 | Jowar & Chari | Rabi Oilseeds |
| 6 | Bajra | Rabi Fodder |
| 7 | Kharif Oilseeds | Rabi Others |
| 8 | Kharif Fodder | Rabi Orchards |
| 9 | Kharif Others | |
| 10 | Kharif Orchards | |

Source: (Tahir and Habib, 2000).

Data about Agricultural Production of Different Crops in Punjab (Pakistan):

Below are tables explaining, about different crops production in Pakistan Punjab.

Table 3.1: Rice Production

Area, Production and Average yield of Rice in Punjab province in different years

| Crop/Unit | 1997-98 | 1998-99 | 1999-00 | 2000-01 | 2001-02 | 2002-03 | 2003-04 | 2004-05 | % age Inc/Dec Over Last Year |
|------------------------|---------|---------|---------|---------|---------|---------|---------|---------|------------------------------|
| Area “000” Hect | 1409.9 | 1492.86 | 1609.4 | 1627.21 | 1475.86 | 1512.28 | 1687.91 | 1737 | 2.9 |
| Prod “000” Tonnes | 1948 | 2176 | 2481 | 2577 | 2266.08 | 2579.65 | 2871.5 | 2947 | |
| Average: Yield Kg/Hect | 1382 | 1457 | 1541 | 1584 | 1535 | 1705 | 1701 | 1696 | |

Source: <http://www.agripunjab.gov.pk/Target1.asp>.

Table 3.2: Wheat Production

Area, Production and Average yield of Wheat in Punjab province in different years

| Crop/Unit | 1997-98 | 1998-99 | 1999-00 | 2000-01 | 2001-02 | 2002-03 | 2003-04 | 2004-05 | % age Inc/Dec Over Last Year |
|------------------------|---------|---------|---------|---------|----------|---------|---------|---------|------------------------------|
| Area “000” Hect | 5934.63 | 5934.63 | 6180.27 | 6255.51 | 6101.74 | 6097.28 | 6256 | | 2.6 |
| Prod “000” Tonnes | 13807 | 13212 | 16480 | 15419 | 14594.43 | 15355 | 15639 | | 1.85 |
| Average: Yield Kg/Hect | 2326 | 2226 | 2666 | 2465 | 2392 | 2518 | 2500 | | |

Source: <http://www.agripunjab.gov.pk/Target1.asp>.

Table 3.3: Cotton Production

Area, Production and Average yield of Cotton in Punjab province in different years

| Crop/Unit | 1997-98 | 1998-99 | 1999-00 | 2000-01 | 2001-02 | 2002-03 | 2003-04 | 2004-05 | % age Inc/Dec Over Last Year |
|------------------------|---------|---------|---------|---------|---------|---------|---------|---------|------------------------------|
| Area "000" Hect | 2348.35 | 2282.79 | 2329.33 | 2386.39 | 2526.41 | 2208.33 | 2386.79 | 2547 | 6.7 |
| Prod "000" Tonnes | 6817 | 6628 | 8804 | 8540 | 8046 | 7664 | 7702 | 9592 | |
| Average: Yield Kg/Hect | 1481 | 1481 | 1929 | 1826 | 1625 | 1771 | 1646 | 1921 | |

Source: <http://www.agripunjab.gov.pk/Target1.asp>.

Table 3.4: Maize Production

Area, Production and Average yield of Maize in Punjab province in different years

| Crop/Unit | 1997-98 | 1998-99 | 1999-00 | 2000-01 | 2001-02 | 2002-03 | 2003-04 | 2004-05 | % age Inc/Dec Over Last Year |
|------------------------|---------|---------|---------|---------|---------|---------|---------|---------|------------------------------|
| Area "000" Hect | 321.7 | 335.8 | 343.6 | 352.7 | 345 | 371.53 | 371.5 | 901.4 | |
| Prod "000" Tonnes | 427.9 | 465.1 | 516.3 | 535.7 | 529.6 | 653.5 | 663.9 | | 1.6 |
| Average: Yield Kg/Hect | 1330 | 1385 | 1503 | 1519 | 1535 | 1759 | 1787 | | 0 |

Source: <http://www.agripunjab.gov.pk/Target1.asp>.

Indian Punjab Agricultural Production Data:

Below are table explaining about total cultivation area and crop production in Punjab province, part of India.

Table 3.5: Area under crops “000” Hect

This table shows about total cultivation area of different crops in different years

| Item | 1990-91 | 2000-01(R) | 2001-02(P) | 2002-03(P) | 2003-04(P) | 2004-05(T) |
|--------------------------|---------|------------|------------|------------|------------|------------|
| Rice | 2015 | 2612 | 2489 | 2530 | 2614 | 2400 |
| Bajra | 12 | 6 | 7 | 7 | 8 | 10 |
| Maize | 188 | 165 | 165 | 153 | 154 | 220 |
| Wheat | 3273 | 3408 | 3422 | 3375 | 3444 | 3250 |
| Barley | 37 | 32 | 23 | 26 | 23 | 30 |
| Jowar | (a) | - | (a) | - | - | - |
| Other Cereals | (a) | - | - | - | - | - |
| Total Cereals | 5525 | 6223 | 6106 | 6091 | 6243 | 5910 |
| Gram | 60 | 8 | 7 | 7 | 6 | 20 |
| Other Pulses | 83 | 46 | 42 | 34 | 38 | 65 |
| Total Pulses | 143 | 54 | 49 | 41 | 44 | 85 |
| Total Food grains | 5668 | 6277 | 6155 | 6132 | 6287 | 5995 |
| Groundnut | 11 | 4 | 4 | 5 | 4 | 6 |
| Other Oilseeds | 93 | 82 | 79 | 94 | 82 | 164 |
| Total Oilseeds | 104 | 86 | 83 | 99 | 86 | 170 |
| Sugarcane | 101 | 121 | 143 | 154 | 123 | 150 |
| Cotton | 701 | 474 | 607 | 450 | 452 | 550 |
| American | 637 | 358 | 507 | 374 | 386 | .. |
| Desi | 64 | 116 | 100 | 76 | 66 | .. |
| All Other Crops | 927 | 983 | 954 | 991 | 957 | .. |
| Gross Area Shown | 7501 | 7941 | 7941 | 7826 | 7905 | .. |

Source: <http://punjabgovt.nic.in/agriculture/statistics.HTM#Production>.

Table 3.6: Agricultural Production “000” Tonnes

This table shows about production of different crops in different years

| Item | 1990-1991 | 2000-2001 (R) | 2001-2002 (P) | 2002-2003 (P) | 2003-2004 (P) | 2004-2005 (T) |
|-------------------------|-----------|---------------|---------------|---------------|---------------|---------------|
| Rice | 6506 | 9157 | 8824 | 8880 | 9656 | 8800 |
| Bajra | 13 | 5 | 7 | 6 | 8 | 10 |
| Maize | 333 | 461 | 449 | 312 | 459 | 605 |
| Wheat | 12159 | 15551 | 15509 | 14175 | 14489 | 14788 |
| Barely | 101 | 109 | 78 | 85 | 77 | 102 |
| Jowar | (b) | - | (b) | - | - | - |
| Other Cereals | (b) | - | - | - | - | - |
| Total Cereals | 19113 | 25283 | 24867 | 23458 | 24689 | 24305 |
| Gram | 45 | 8 | 6 | 7 | 5 | 20 |
| Other Pulses | 60 | 31 | 25 | 24 | 30 | 49 |
| Total Pulses | 105 | 39 | 31 | 31 | 35 | 69 |
| Total Foodgrains | 19218 | 25322 | 24898 | 23489 | 24724 | 24374 |
| Groundnut | 9 | 4 | 4 | 4 | 4 | 5 |
| Other Oilseeds | 84 | 84 | 80 | 82 | 99 | 160 |
| Total Oilseeds | 93 | 88 | 84 | 86 | 103 | 165 |
| Sugarcane | 601 | 777 | 925 | 908 | 662 | 960 |
| Cotton | 1909 | 1199 | 1307 | 1085 | 1478 | 1450 |
| American | 1802 | 921 | 1139 | 955 | 1306 | .. |
| Desi | 107 | 278 | 168 | 130 | 172 | .. |

Source: <http://punjabgovt.nic.in/agriculture/statistics.HTM#Production>.

Table 4.1: International Agencies Concerned for Irrigation and Drainage in Developing Countries

| Agency | Finance | Technical Assistance | Technical Publications |
|---|----------------|-----------------------------|-------------------------------|
| ADB–Asian Development Bank | Yes | Yes | No |
| AGU–American Geophysical Union | No | Yes | Yes |
| AWRA–American Water Resources Assn. | No | No | Yes |
| EWRI–Environmental and Water Resources Institute of the Am. Soc. of Civil Engineers | No | No | Yes |
| FAO–Food & Agriculture Organisation, UN | No | Yes | Yes |
| IADB–Interamerican Development Bank | Yes | Yes | Yes |
| IBRD–Int. Bank for Reconstruction and Development (World Bank) | Yes | Yes | Yes |
| ICID–Intl. Commission on Irrig. & Drainage | No | No | Yes |
| IDRC–Int. Devt. Research Centre, Ottawa | No | Yes | Yes |
| IFAD–Intl. Fund for Agric. Devt., Rome | Yes | No | No |
| IFPRI–Intl. Food Policy Research Institute, Washington | No | Yes | Yes |
| ILRI–Intl. Institute For Land Reclamation, Netherlands | No | Yes | Yes |
| IPTRID–Intl. Program for Technical Research in Irrig. and Drainage, Washington | No | No | Yes |
| IWMI–Intl. Water Management Inst., Sri Lanka | No | Yes | Yes |
| IWRA–Intl. Water Resources | No | No | Yes |

| | | | |
|---|-----|-----|-----|
| Association | | | |
| OAS–Organization of American States | No | Yes | No |
| SIWI–Stockholm Intl. Water Institute | No | No | Yes |
| UNDP–United Nations Development Programme | No | Yes | Yes |
| USAID–U.S. Agency for Intl. Development | Yes | Yes | Yes |
| USCID–U.S. Committee on Irrigation and Drainage | No | No | Yes |

Source: (Phillip Z. Kirpich, <http://www.waterencyclopedia.com/Hy-La/Irrigation-Management.html>).

Table 4.2 Major Production Basins Affected by Land Degradation Due to Salinity

| Region | Production basin |
|---------------------------------|---|
| East Asia and Pacific | Mekong River Basin (Thailand and Vietnam) Yellow river basin (Ningxia and Shandon province of China) |
| Middle East and North Africa | Tigris and Euphrates river basin, Jordan River Basin, Nile Delta. |
| Sub-Saharan Africa | Limpopo River Basin, Volta River basin |
| South Asia | Indus River basin |
| Europe and Central Asia | Amu Darya and Sir Darya basins |
| Latin America and the Caribbean | Northern Mexico, Andean Highlands |

Source: (World Bank Report, 2005).

Table 5.1 Ground Water Importance in Irrigation

| Country | Period | Irrigation Water Use (million m³/year) | Ground Water % |
|----------------|---------------|--|-----------------------|
| China | 1993-5 | 407,770 | 18 |
| Pakistan | 1990-1 | 150,600 | 34 |
| India | 1990-3 | 460,600 | 53 |
| Bangladesh | 1990-5 | 12,600 | 69 |
| Mexico | 1995-7 | 61,200 | 27 |

Source: (World Bank Report, 2005).