DRIVERS OF IRRIGATION INEFFICIENCIES AND GROUNDWATER SITUATION AT JOYANWALA CATCHMENT, SHEIKHUPURA, PUNJAB

WATER PRODUCTIVITY (WAPRO PROJECT)

Date: October, 2018

HELVETAS Swiss Intercooperation | PAKISTAN

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RICE PARTNERS

DRIVERS OF IRRIGATION INEFFICIENCIES AND GROUNDWATER SITUATION AT JOYANWALA CATCHEMENT, SHEIKHUPURA, PUNJAB

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List of Abbreviations

CCA	Culturable Command Area
EC	Electric Conductivity
FSL	Full Supply Level
GPFS	Global Program Food Security
Helvetas	HELVETAS Swiss Intercooperation
IBIS	Indus Basin Irrigation System
MAF	Million Acre Feet
NSL	Natural Land Surface
O&M	Operation & Maintenance
PID	Punjab Irrigation Department
RPL	Rice Partnership Limited
RSC	Residual Sodium Carbonate
SAR	Sodium Absorption Ratio
SDC	Swiss Agency for Development and Cooperation
UCC	Upper Chenab Canal
USD	United States Dollar
WAPRO	Water Productivity Project

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EXECUTIVE SUMMARY

This document summarizes a study conducted in Joyanwala area in Muridke *tehsil* of district Sheikhupura Punjab province on irrigation system and status of groundwater. The study is part of the Water Productivity (WAPRO) Project currently being implemented in Muridke by HELVETAS Swiss Intercooperation (Helvetas) and Rice Partners Limited (RPL), a local partner of MARS Foods. WAPRO is funded by the Global Program Food Security of the Swiss Agency for Development and Cooperation (GPFS). Main objective of the WAPRO project is to improve irrigation efficiency in rice cultivation.

The Punjab province has one of the largest contiguous gravity flow network in the world irrigating nearly 21 million acres Culturable Command Area (CCA). The total length of canal systems is 23,184 miles. Irrigation water is delivered through 58,000 outlets off-taking from canals. To maintain the irrigation system, the Punjab Irrigation Department has nearly 40,000 personnel with an approximate annual budget allocation of Rs.60 billion. In addition to 104 Million Acre Feet (MAF) of surface water diverted for irrigation, the system also avails an estimated 40-50 MAF of groundwater through about more than 1 million tube wells installed by farmers. Cropping intensity in the province has increased from 60-70 to more than 150% from 1947 due to ever increasing population and accordingly tremendous increase in water demand which has led to more thrust on groundwater.

Water management has acquired new dimensions in Pakistan due to the challenges posed by an expanding population, deterioration of irrigation infrastructure, increasing environmental issues, global climatic changes, poor water use efficiency and system losses etc. In this context, more efficient and sustainable irrigation operational management and equitable distribution of irrigation water have gained added significance. The irrigation infrastructure being more than 100 years old, has deteriorated and need significant investment to improve/rehabilitate. The World Bank has estimated the remodelling/rehabilitation cost of irrigation infrastructure to be around USD 60 billion. The major challenges associated with irrigation management include diminishing capacity of the reservoirs, lack of additional storages, excessive conveyance losses (nearly 50%), deteriorating infrastructure, high operation cost, deterioration of water quality and excessive groundwater use.

The Joyanwala distributary lies within the area of Upper Chenab Canal (UCC) command. It off takes from Sikhanwala Feeder with authorized discharge of 23 cusecs and a length of 4.5 miles. Joyanwala distributary is a non-perennial channel with CCA of 4884 acres. This study identified a number of issues with the Joyanwala distributary. These include deteriorated head regulating structures leading to fluctuating water supply in the channel, poor maintenance of canal banks and water theft. In order to assess the entitlement vs delivery of water to Joyanwala distributary, data for the last seven years (2010-2017) was analysed. This data revealed that Joyanwala distributary has largely been provided with its authorized supply of water from the main canal.

Groundwater analysis for water table and quality was studied on the basis of data available for the last 10-15 years. The data indicated that average position of water table in the area is 20ft below

ground level. The most likely reason for availability of water at a shallower depth is that the area is engulfed between Upper Chenab Canal and Joyanwala distributary. Hence, seepage from main canal is a continuous source of recharge of groundwater. However, quality of this groundwater is questionable as local farmers have their tube wells installed at more than 100ft depth. Groundwater analysis shows higher Sodium Absorption Ratio (SAR) in nearby villages compared to Joyanwala which has a reduced SAR value. According to the classification of groundwater on the basis of SAR value groundwater near Joyanwala can be rated as excellent (SAR <10) while groundwater quality of Chak Sanata can be rated as good (SAR in the range of 10-18).

Feedback was collected from the farmers from entire length of the distributary to analyze the behavior of water channel from head to tail and any difficulties being faced related to canal irrigation. It was found that currently total number of tube wells in the area of Joyanwala distributary ranges from 130-150. It is worth mentioning that 40% of these tube wells are installed within head to middle reach of the canal while the rest 60% are within lower middle to tail reach indicating water shortage towards the tail. During the past 20-30 years, installation of tube wells and trend towards groundwater pumping has increased. The time of tube well operation has increased during the last decade due to shortage of water. The farmers said that water availability can improve if either the channel is lined or at least properly maintained in its existing condition. Farmers of the middle reach said that they have to deal with the fluctuating supplies due to poor condition of the channel, vegetation growth in the channel prism and water theft in the upper reach of the distributary. They get good quality water at a depth of 200ft. though a decade ago water quality was good at a depth of 100ft. Farmers of the tail reach said that water availability is very limited. The main reasons are lack of proper maintenance and lack of control over water theft in the upper reaches of the distributary canal. Therefore, they have to rely on groundwater pumping more than the farmers of head and middle reach. They also said that good water quality is available at a depth of 250-300ft. and that more tube wells have been installed during the last decade. Excessive pumping has to be done during peak demand to meet crop water requirement.

1 INTRODUCTION

1.1 General

Punjab province has one of the largest contiguous gravity flow network in the World. Pakistan's irrigation system commonly known as Indus Basin Irrigation System (IBIS) is one of the largest integrated irrigation systems, mostly in Punjab. The system was mainly established during 1960s after the emergence of water issues with India. In 1960, through the mediation of World Bank, Indus Water Treaty was signed and water rights of three western rivers (Chenab, Jhelum and Indus) were allocated to Pakistan. Two large dams (Mangla and Tarbela) and 12 link canals were constructed to account for eastern rivers loss (SJBSPP, 2016). The system is serving nearly 21 million acres (8.4 million hectares) Culturable Command Area (CCA). Currently, Punjab irrigation system is consisted of 24 main canal systems. The total length of these canal systems (main canals, branch canals, distributaries, minors and sub minors) is 23,184 miles. Irrigation water is delivered through 58,000 outlets off-taking from canals having total water conveying capacity of 120,000 cusecs(GoP, 2018).To maintain such a large network of canals, Punjab Irrigation Department has manpower of nearly 40,000 personnel including both professionals and support staff with an approximate annual budget allocation of Pakistani Rupees 60 billion including both overheads and development cost (GoPA, 2018).The irrigation system serves as lifeline for sustaining agriculture in the province.

A well-maintained irrigation infrastructure is the fundamental requirement for proper functioning of irrigation system. Irrigation/water management is such a necessity that it affects the lives of every single individual. Lack of proper irrigation infrastructure causes hindrances in agricultural growth. It also causes bottlenecks in the smooth functioning of the economy.

Water management has acquired new dimensions in Pakistan due to the challenges posed by an expanding population, deterioration of irrigation infrastructure and increasing environmental issues. The sustainability of agriculture appears to be jeopardized due to rapidly increasing demands for irrigation on one hand and limited prospects for development of water resources on the other. In this context, more efficient and transparent irrigation operational management and equitable distribution of irrigation water have gained an immense importance.

1.2 Challenges in Irrigation Management

The irrigation infrastructure built in the 1960s need significant investment to improve. The funds available for maintenance and rehabilitation are inadequate. The World Bank has estimated that the replacement cost of irrigation infrastructure in Pakistan to be around US$60billion. Replacement of irrigation infrastructure in a broader sense includes remodelling/ rehabilitation of existing system/infrastructure to withstand the changing behaviour of rivers and canals over the years. It may include up-gradation of existing infrastructure or construction of an entirely new structure. In addition to 104 Million Acre Feet (MAF) of surface water diverted for irrigation, the system also avails an estimated 41.60 MAF of groundwater through over 600,000 tube wells, mostly installed by private entities (SJBSPP, 2016). The major challenges associated with irrigation management include but are not limited to:

1.2.1 Diminishing Capacity of Reservoirs

The reduced capacity of reservoirs is a major concern in Pakistan. Main reason is sedimentation. Tarbela and Mangla are the major reservoirs used for irrigation and power generation purposes. According to statistics storage capacity of Tarbela reservoir has reduced to 30-40% of its initial capacity (Roca and Wallingford, 2012). The storage capacity of Mangla Dam was also reduced due to sedimentation. Its capacity has been raised in recent years to cater for the water demand. Main reason of sedimentation is that the Source Rivers carry a high sediment load from glacier water (Roca and Wallingford, 2012).

1.2.2 Excessive Conveyance Losses (nearly 50%)

Conveyance losses in irrigation channels is an area of concern for the last many years. Studies have shown that excessive conveyance losses occur in secondary and tertiary channels. According to the available statistics 40-50% of the water is lost in lined water courses while around 60% water is lost in unlined water courses (Sultan et al., 2014). Main reasons of these conveyance losses are leakages from turnouts, high weed/vegetation growth, turns in the channels/watercourses, un-compacted and weak banks, silting and lack of maintenance.

1.2.3 Deteriorating Infrastructure

Irrigation system in the province has deteriorated and large deficits in O&M maintenance have led to sub-optimal service delivery levels characterized by low water conveyance efficiencies and inequitable water deliveries.

1.2.4 High Operation Cost

The irrigation infrastructure is very old and operating well beyond its designed life. Government agencies in Pakistan neither have adequate funding nor reliable estimates for replacement or maintenance of this infrastructure (SJBSPP, 2016).

1.2.5 Excessive Groundwater Use

The sustainability of agricultural growth has been greatly influenced by the excessive use of groundwater in Pakistan. Continuous pumping of groundwater through uncontrolled expansion of tube wells has led to many negative impacts on sustainability of irrigated culture in Pakistan (Watto and Mugera, 2016). Unpredictable /unreliable canal water supplies have also enticed the farmers for use of groundwater. Inadequate maintenance of irrigation infrastructure, inequitable distribution of canal water (water theft), and changes in climatic conditions in recent times are other factors resulting in massive extraction of groundwater.

2 DESCRIPTION OF STUDY AREA

2.1 General

Sheikhupura city is situated at a distance of about 36 Km from Lahore, the provincial headquarters and lies at 31°42'51.16"N latitude and 73°59'3.49"E longitude. The city is well connected with its surrounding big urban centers like Faisalabad 94 Km, Sargodha 143 Km and Gujranwala 54 Km. Sheikhupura is also a railway junction and trains coming from Lahore take these routes for Faisalabad and Shorkot. Sheikhupura City is connected with Faisalabad through newly constructed road Lahore-Faisalabad road project and also connected to Faisalabad by M2 and M3 Motorway. The fauna and flora of the area include: Kikar, Piple, Bohar, Eucalyptus, Popular and Sharin There is very little of wild life in the area. Wild boar is met within the riverine track. Jackals and hares play havoc with crops. Waterfowls are found everywhere in the Degh valley. Particularly after good rains. Black partridges are found along the Ravi and grey ones all over the district. The demographical profile of city shows that it became city in 1619, became tehsil in 1851, there are 14 UCs, and total area of the City is 38 Sq. Km, total Population of the City (Population reported by Urban Unit) was 389.768. Hiran Minar, a place of archaeological and historical growth, is situated about 5 kilometres from city. Shisham, Kikar Piple, Bohar, Eucalyptus, Popular and Sharin are the major trees in the area.

The area has been characterized with extreme climate; the summer season starts from April and continues till October. During the summer season, temperature ranges from 30 to 45 °C the winter season starts from November and continues till March. December and January are the coldest

months with a mean minimum temperature of 5 0C. The dust storms occur occasionally during the hot season, during June, July and August. Rainy weather alternates with oppressive weather. The average rainfall is 500 mm per year. The mean minimum and maximum humidity during winter is 37% and 84%. Major crops in the area are rice, wheat, sugarcane and fodder. Some industries are also present in the area.

2.2 Basic Data of Joyanwala Distributary

Basic data of the channel is as under as accessed from the website of Punjab Irrigation department.

		IMIS Code	30721000013100		
Parent Channel	Sihkanwala Feed	**Channel Type**	Distributry	**Flow Type**	Non Perennial
Zone	Lahore	**Circle**	UCC	**Division**	Sheikhupura
Sub Division	Sikhanwala	**Section**	DDC	**FO**	
Reduced Distance	22700.00	**Length (Miles)**	4.54		
Remarks					

Authorized Head Discharge	23.00
Authorized Tail Discharge	6.93
Authorized Tail Gauge	1.00
Gross Command Area	5141.00
Culturable Command Area	4884.00

≤	September 2018					≥
S	M	T	W	T	F	S
26	27	28	29	30	31	1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	1	2	3	4	5	6

Source: **PID (2018)**

2.3 Canal Irrigation Network

Joyanwala distributary lies within the area of Upper Chenab Canal (UCC) Command. It off takes from Sikhanwala feeder with authorized discharge of 23 cusecs and a length of 4.5 miles. Joyanwala distributary is a non-perennial channel with Culturable Command Area of4884 acres (GoP, 2018). It mainly irrigates Sheikhupura District. Joyanwala Distributary runs through the

villages of Joyanwala, Pindi Rattan Singh, Sheikhan, Chak Sanata, Khushalpura, Leel, Kathianwala and Dauke Mallian. Line diagram of Joyawala distributary shown in **Figure1.**

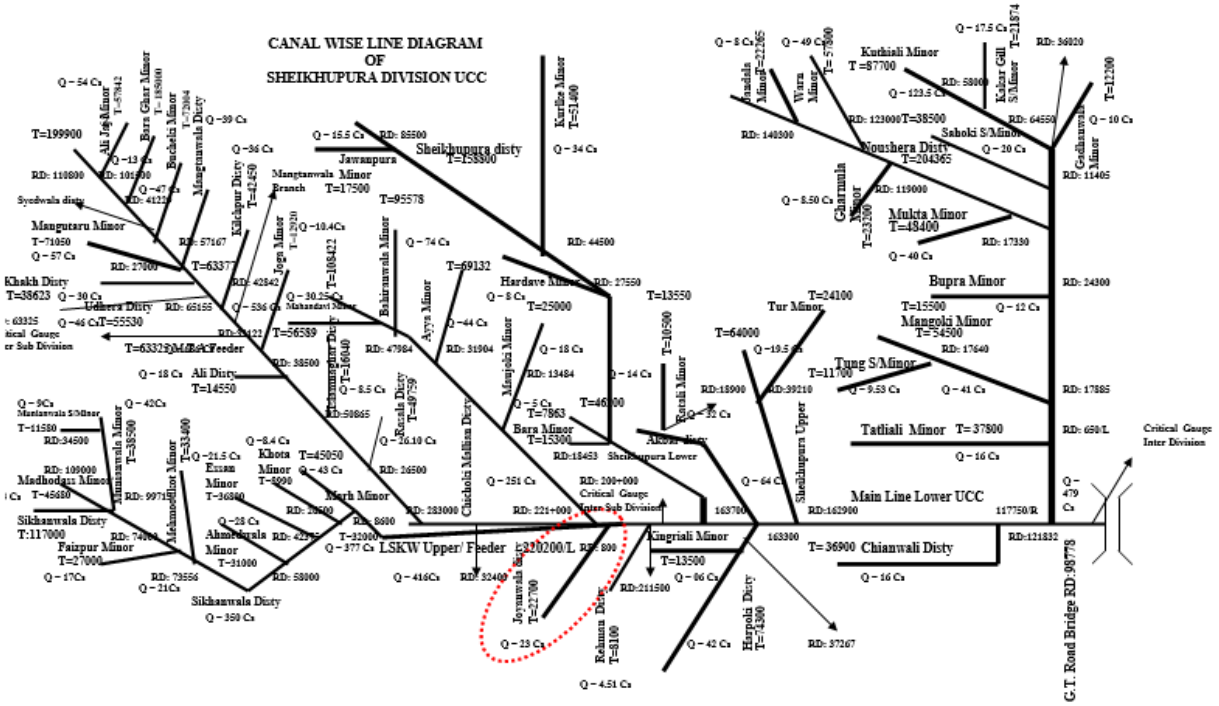

Figure 1. Line diagram of Joyanwala distributary

2.4 Challenges/Issues

2.4.1 Deteriorated Head Regulating Structure

A regulating structure is provided to regulate the flow across the channel. It can be either cross regulator (across the channel) or head regulator (off-taking point of a channel).Regulating structure is of utmost importance for proper regulation of water to the conveyance channel. In the subject study, head regulator of Joyanwala minor was found damaged/non-operational. This leads to the fluctuating supply in the channel and may lead to water shortage along the channel. Head regulator of Joyanwala distributary is shown in **Figure2**.

Figure 2. Head regulator of Joyanwala distributary

2.4.2 Inadequate Bank Maintenance

Canal banks play a vital role in carrying water to the entire length of the channel. Inadequate maintenance and poor/weak banks result in frequent breaches and are vulnerable to water theft activities. The banks of the channel were found eroded in several reaches throughout especially in the first half. Excessive bank erosions have also caused excessive water losses and less efficiency of canal system due to channel breaches. Inadequate bank maintenance of Joyanwala distributary shown in **Figure3**.

Figure 3. Inadequate bank maintenance on Joyanwala distributary

2.4.3 Inadequate Free Board

'Free board' is described as the difference between Full Supply Level (FSL) from the top of channel bank level. During site visit, the water marks on the banks confirmed that recommended freeboard of 1ft was not available along the channel because of bank erosion, weather action, less maintenance and widened sections. It resulted in poor canal operation and inequitable distribution of canal water. The freeboard was also found short at the upstream of some hydraulic structures. Inadequate free board on Joyanwala distributary shown in **Figure4.**

Figure 4. Inadequate free board on Joyanwala distributary

2.4.4 Poor Condition of the Channel Prism

Side embayment was found at Joyanwala minor resulting in poor condition of channel prism and damaged protection walls (Figure 5).The undulating flow pattern of Joyanwala minor has caused channel instability and side embayment. Trespassing of domestic animals from the nearby areas into the channel is also a major source of deterioration of the channel prism.

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Figure 5. Poor condition of Joyanwala distributary prism

2.4.5 Weed/Vegetation Growth

Excessive vegetative growth was observed through the entire length of the channel resulting in obstruction to a smooth flow of the canal water and shortage at tail of the distributary.

Figure 6. Weeds/vegetation on Joyanwala distributary

2.4.6 Water Theft

Water theft has been a major concern for Joyanwala distributary. Farmers do have the tendency to apply unauthorized means (cuts, pipes, illegal obstruction in the flow of water) to irrigation whenever there is supply available in the channel. This also contributes towards shortage of supply at tail. Water theft sites on Joyanwala distributary shown in **Figure7**.

Figure 7. Water theft sites on Joyanwala distributary

2.4.7 Improper De-silting of Channel

During the visit of Joyanwala Distributary, it was observed that bed and banks of some reaches especially middle to tail was deepened by using excavator. All this was done in an attempt to carry the water at tail. This resulted in disturbance of channel prism and resultantly all the outlets in the reach were not getting their full share of water. Improper desilting of channels on Joyanwala distributary is shown in **Figure 8.**

Figure 8. Improper desilting of channels on Joyanwala distributary

2.4.8 Encroachment along the Channel

Encroachments along the channel were observed in the form of cattle sheds, and houses. All such encroachments result in deterioration of channel banks and widening of channel prism.

Figure 9. Encroachment on Joyanwala distributary.

2.4.9 Poor Tail Maintenance

Tail structure of Joyanwala distributary was found in poor condition as deposits of debris were seen around tail structure creating obstruction in the flow of water. Condition of water courses at tail cluster were also found poor due to lack of maintenance by local irrigators. Tail measuring gauge was also in deteriorated condition and the true picture of water supply at tail could not be assessed.

Figure 10. Poor tail maintenance

3 CANAL WATER AVAILABILITY TO JOYANWALA DISTRIBUTARY

In order to assess the entitlement Vs delivery of water to Joyanwala minor, data for the last seven years (2010-2017) was analysed. Figure 12 shows the average water supply to Joyanwala distributary. The graphical representation reflects that during the last seven years, Joyanwala distributary has largely been provided with its authorized supply of water (>95%) except for Kharif 2011 where it was provided with 78% of the authorized discharge.

Similarly, supply of water at tails was also analysed and it was observed that supply of water at tail has generally been satisfactory except for the year 2011 when the channel got less supply from the head despite which, the graphical presentation shows better delivery of water at tails. Some farmers complained about shortage of water at tails which is because that channel gets its volumetric entitlement by the end of the season and there are fluctuating supplies in mid-season. As the authorized tail gauge (depth of water over the tail cluster outlets) is 1.0ft, the delivery at tail is usually approximately 0.90ft (**Figure 12).**

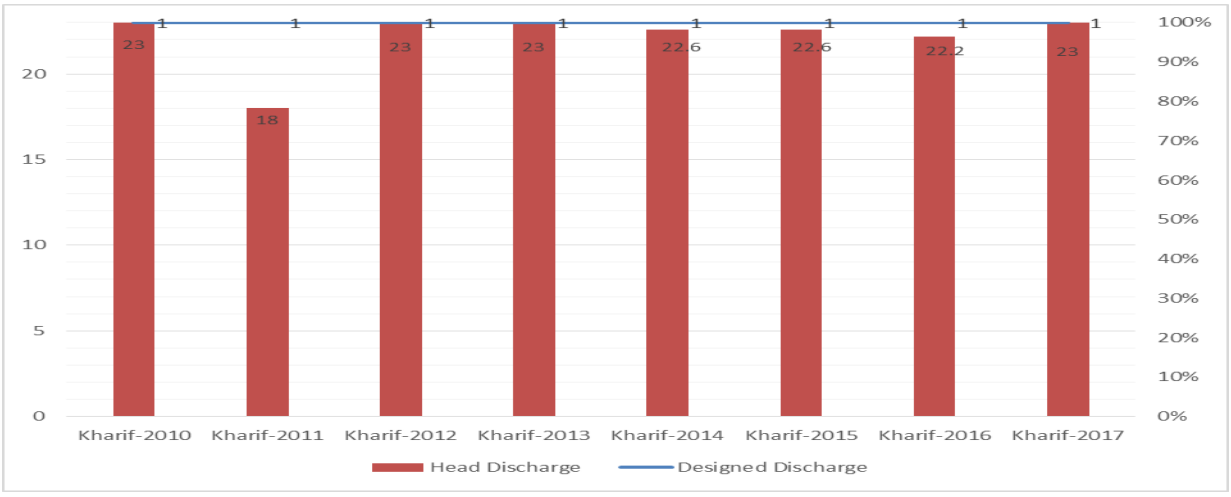

Figure 11. Water availability at head of Joyanwala distributary;
Source: Irrigation Department, Govt. of Punjab.

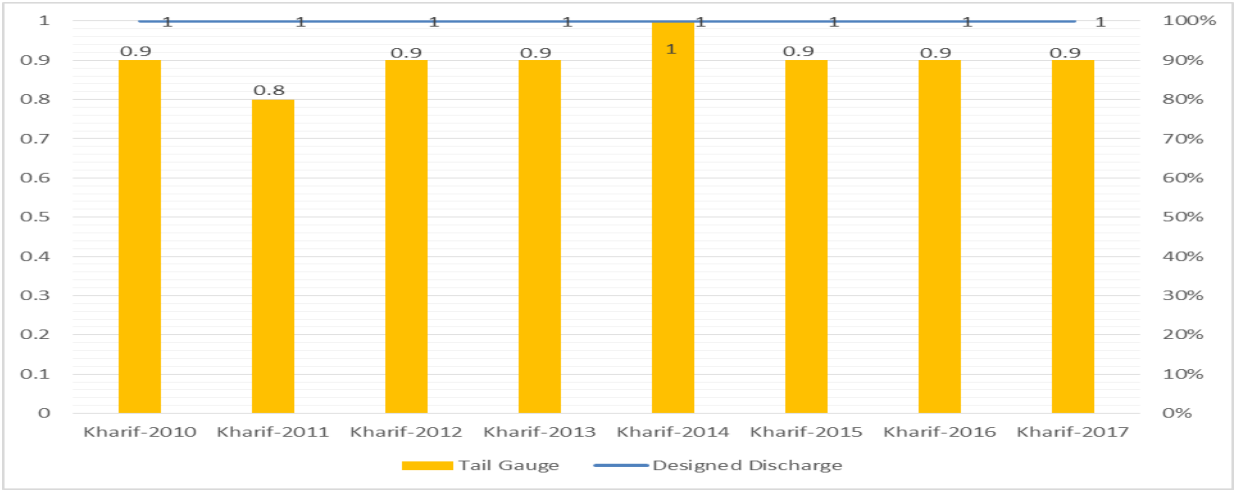

Figure 12. Water availability at tail of Joyanwala distributary;
Source: Irrigation Department, Govt. of Punjab

4 GROUNDWATER POSITION AND QUALITY

4.1 Groundwater Levels

Groundwater analysis for water table and quality has been done on the basis of available data for the last 10-15 years **(Figure 13).** The data includes groundwater table position for both pre and post monsoon/flood season. The figure shows that average position of water table in the area is 20ft below ground level. Joyanwala village covers the head reach (first 1/3rd portion) of the channel. The most likely reason for availability of water at a shallower depth is that the area is engulfed between Upper Chenab Canal and Joyanwala distributary. Hence seepage from main canal is a continuous source of groundwater recharge. However, quality of this groundwater is questionable as local farmers have their tube wells installed at more than 100ft depth.

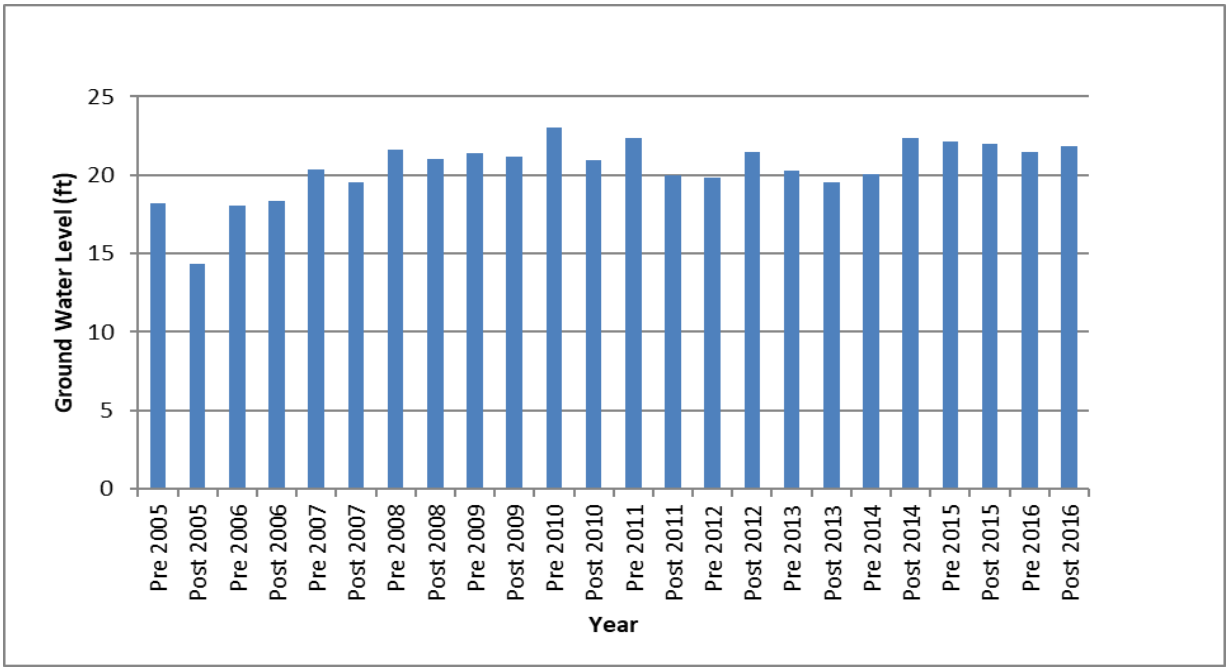

Figure 13. Position of groundwater level near Joyanwala village;
Source: Irrigation Department, Govt. of Punjab.

Spatial distribution/pattern of depth to water table in the area is depicted in the **Figures 14 and 15** which show that the groundwater becomes deeper as we move from head to tail reach of the channel, which can be attributed to the more pumping in the command area falling at the tail.

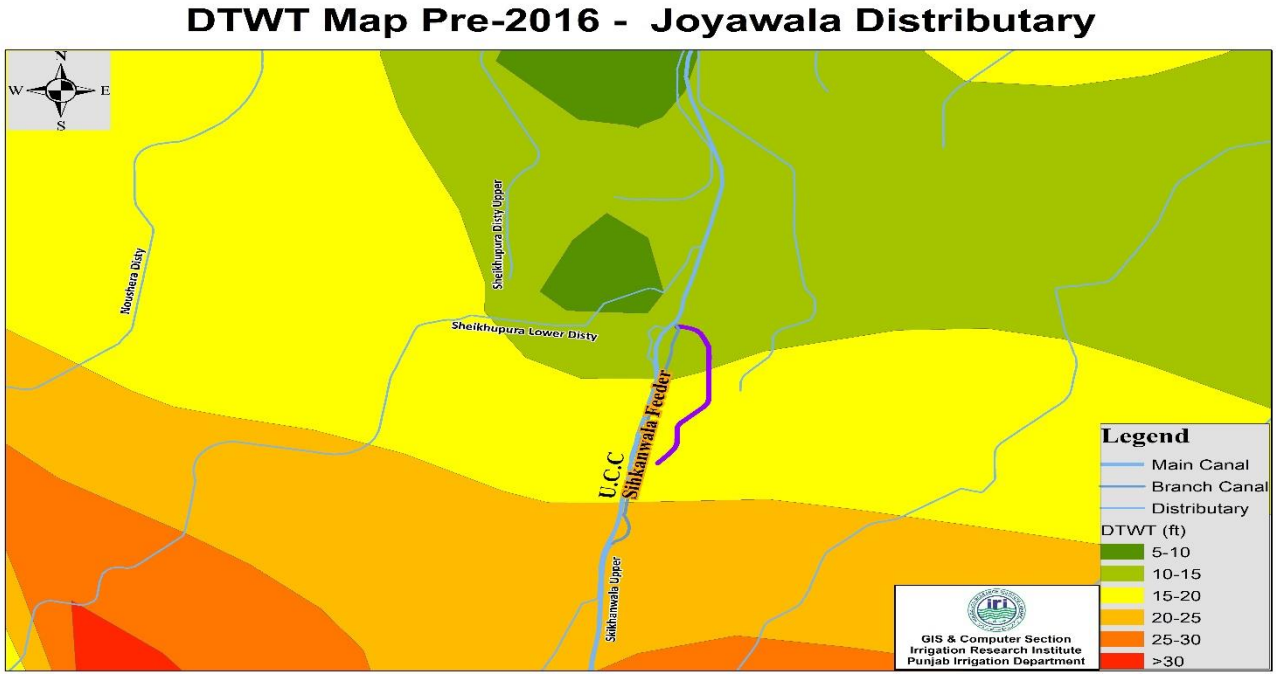

Figure 14. Depth to water table map for pre monsoon 2016

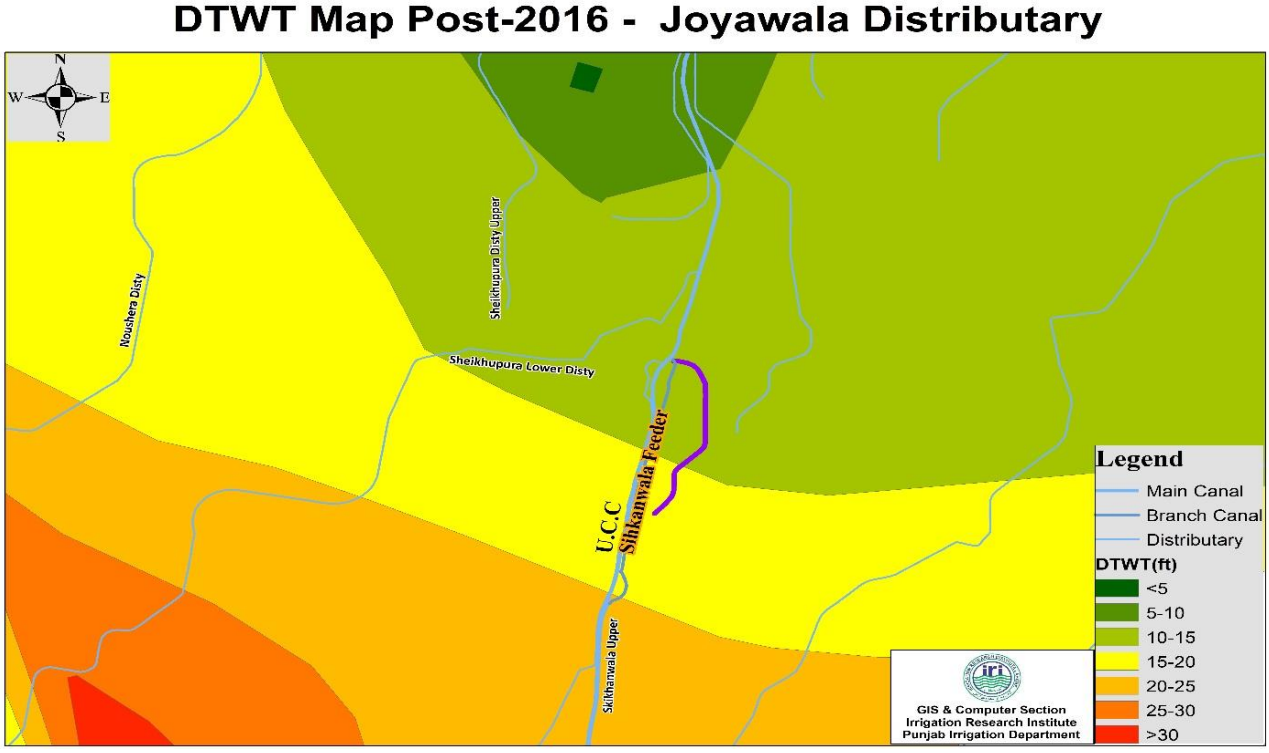

Figure 15. Depth to water table map for post monsoon 2016

Contour plot of depth to water table is shown in **Figure 16** which indicates that water table in the vicinity of Joyanwala distributary falls in the range of 12 to 18 ft. below the natural land surface (NSL). It can further be observed that as we move from head to tail reach the groundwater level becomes deeper and also the groundwater flow pattern is almost parallel to the channel. Groundwater becomes deeper towards the Sheikhupura city which might be due to excessive pumping in the city area.

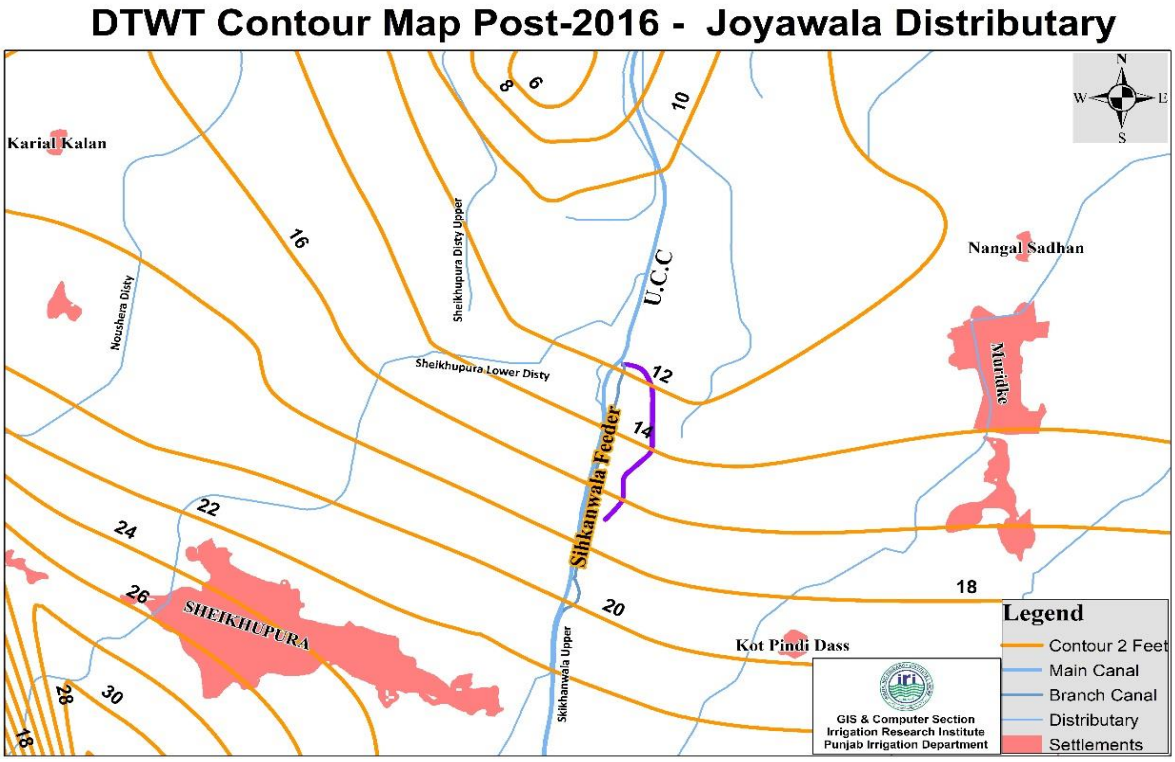

Figure 16. Contours of depth to water table post 2015 (ft below NSL)

4.2 Groundwater Quality

Figures 14 and 15 below describe that water quality of villages Joyanwala and Chak Sanata drops under the Culturable Command Area (CCA) of Joyanwala distributary. The quality of irrigation water mainly depends on the presence of dissolved salts and their concentrations. Sodium Absorption Ratio (SAR) and Residual Sodium Carbonate (RSC) are the most important quality criteria which influence the water quality and its suitability for irrigation (Shah and Mistry, 2013). Apart from the dissolved salts, Electrical Conductivity (EC) is a good indicator to assess groundwater quality.

Electrical Conductivity is an indication of the concentration of total dissolved solids and major ions in a water body[6]. SAR is used as an index for evaluation of sodium risk associated with an irrigation water supply. Excessive SAR levels may cause soil crusting, poor/weak emergence of seedling and poor aeration. Soil infiltration and percolation rates are also affected due to high SAR level resulting in soil dispersion (Shah and Mistry, 2013).

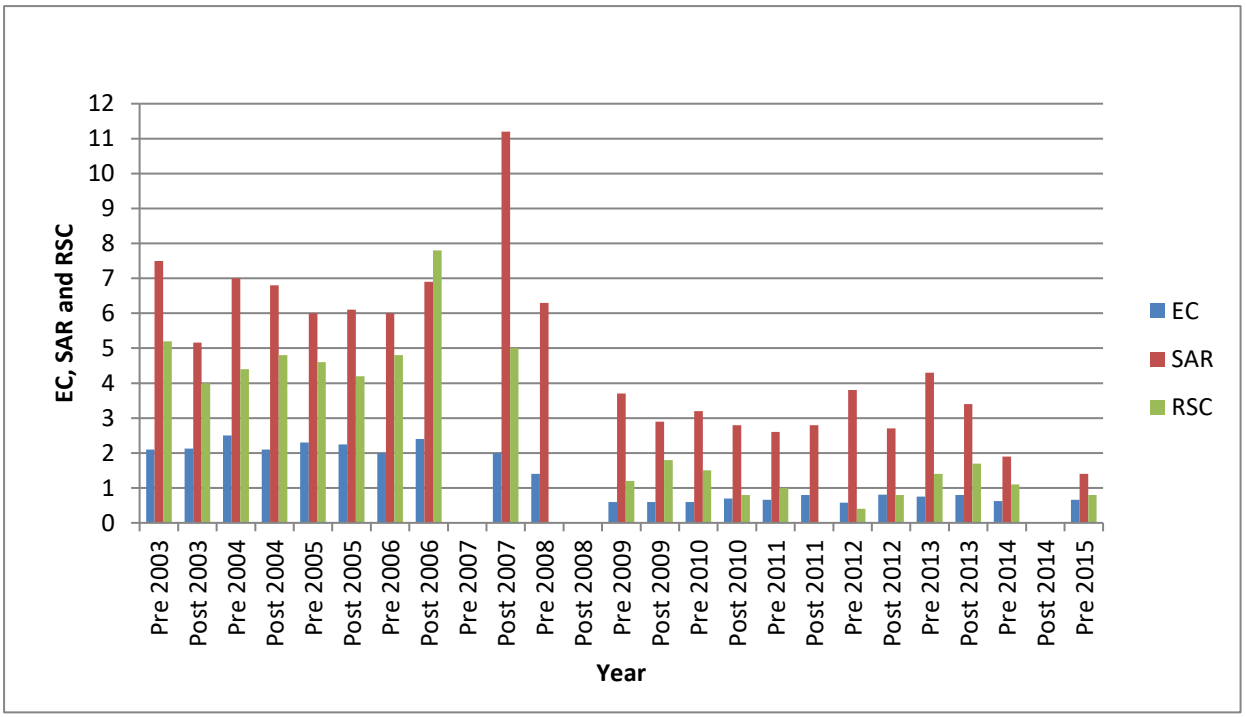

Figure 17. Pre and post monsoon ground water quality analysis near Joyanwala village; Source: Irrigation Department, Govt. of Punjab.

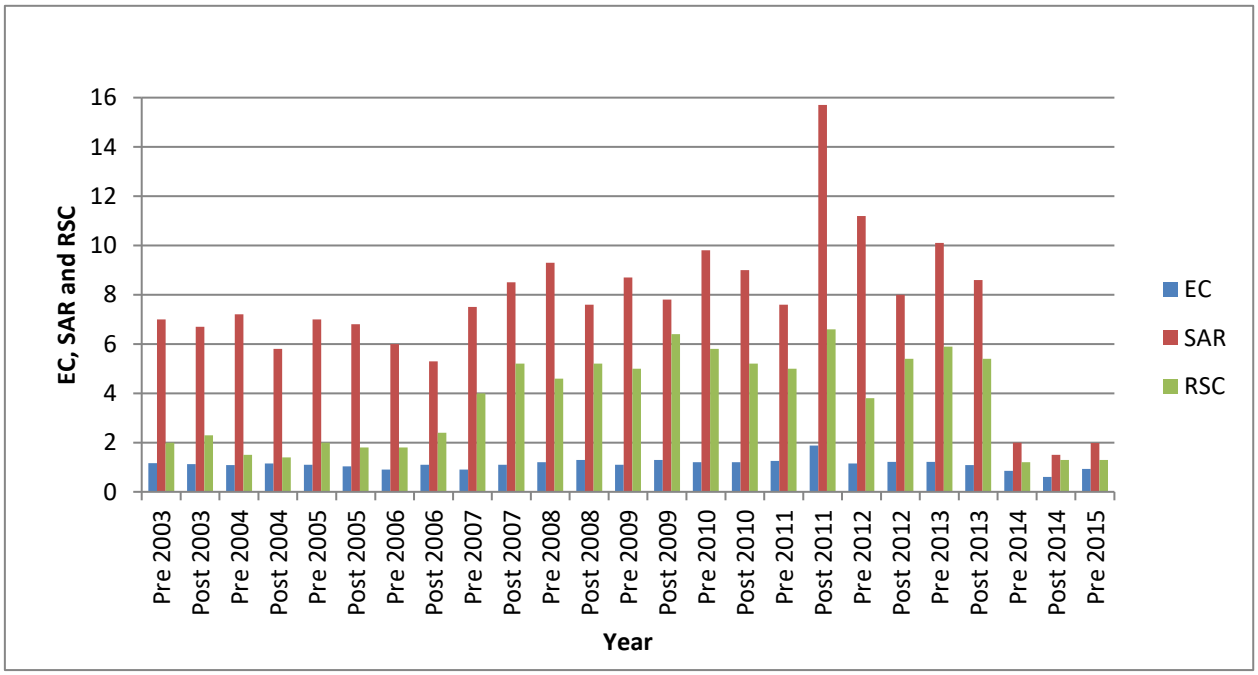

Figure 18. Pre and post monsoon groundwater quality analysis near village Chak Sanata; Source: Irrigation Department, Govt. of Punjab

Figure 15 and 16 show varying trends in SAR values for both Joyanwala and Chak Sanata villages. Groundwater analysis of Chak Sanata shows higher SAR values after 2011 which indicates build-up of sodium level as compared to Joyanwala which has a reduced SAR value. According to the classification of groundwater on the basis of SAR value, the groundwater near

Joyanwala can be rated as excellent (SAR <10) while groundwater quality of Chak Sanata can be rated as good (SAR in the range of 10-18)[6] as shown in Table 1.

TABLE 1: Classification of Groundwater on the Basis of SAR[6]

Parameter	Range	Water Class
SAR	<10	Excellent
	10-18	Good
	18-26	Doubtful
	>26	Unsuitable

Spatial patterns of Ec, RSC and SAR for the study area as shown in **Figure19** respectively which indicate that groundwater quality is better in the vicinity of the Joyanwala Distributary and deteriorates as we move towards the Sheikhupura city. This is due to more pollution due the effluents from city and contamination the drainage network in the area.

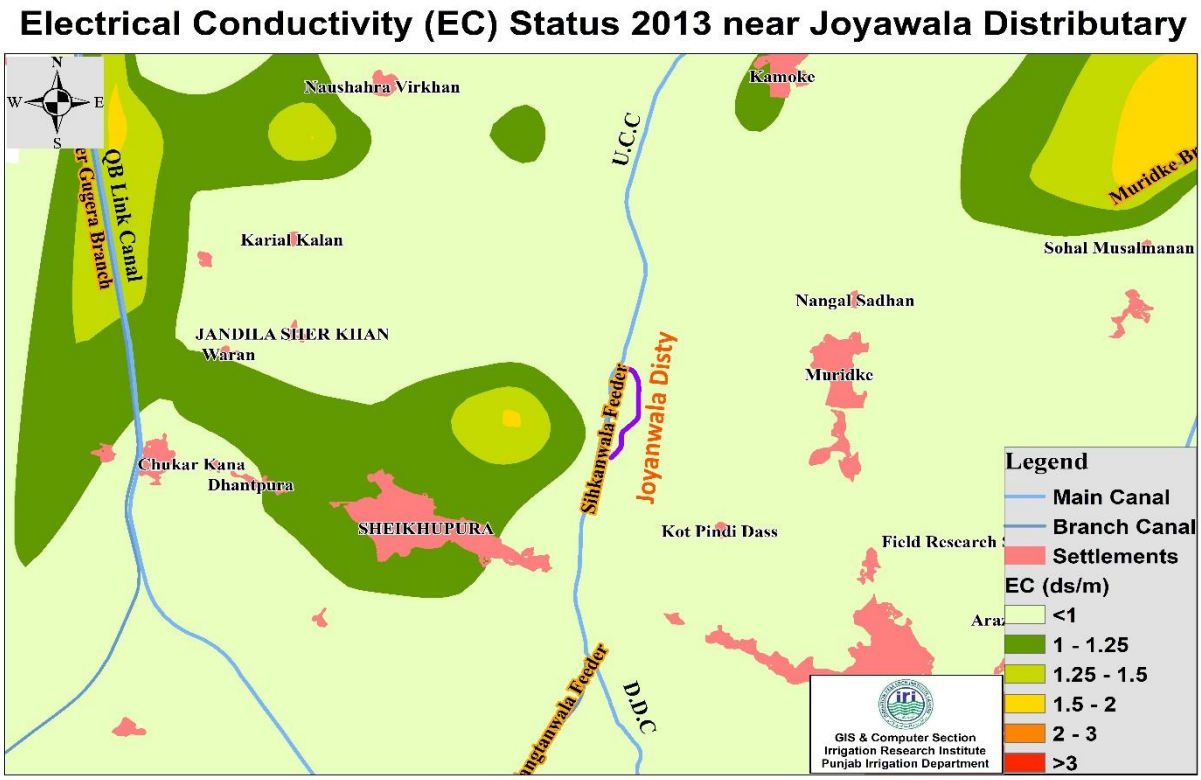

Figure 19. Ec map of groundwater in the study area for 2013

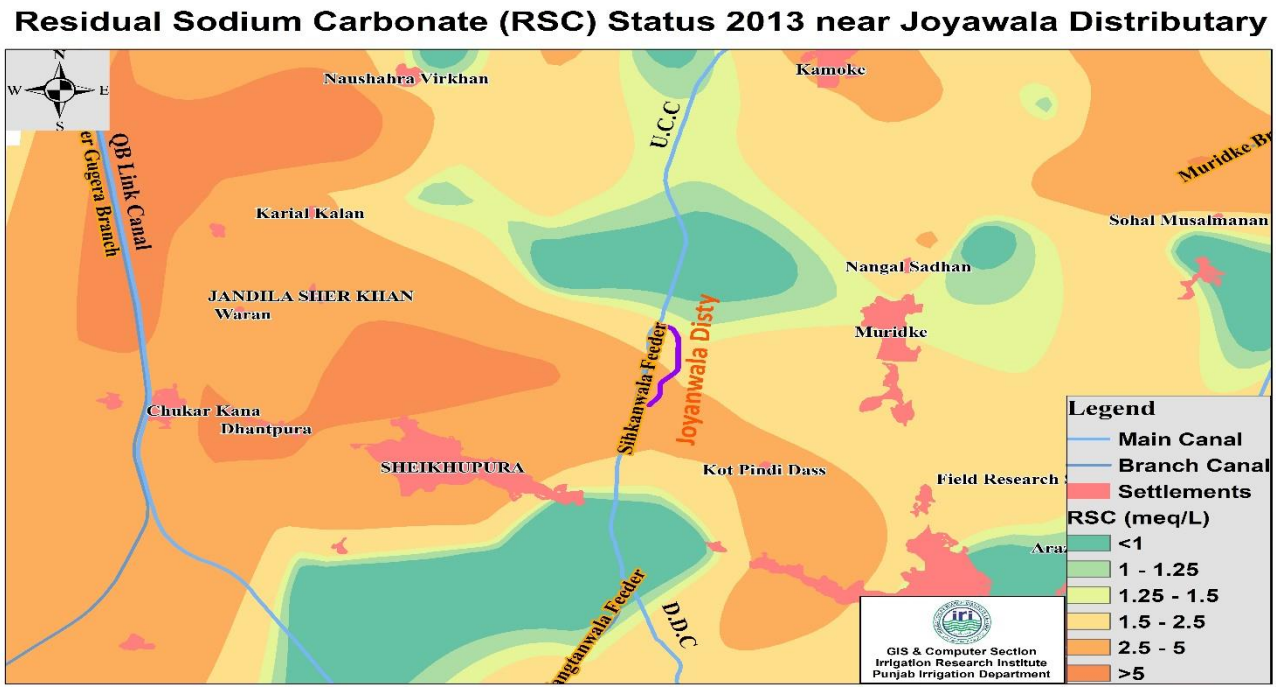

Figure 21. Map of RSC in study area druing 2013

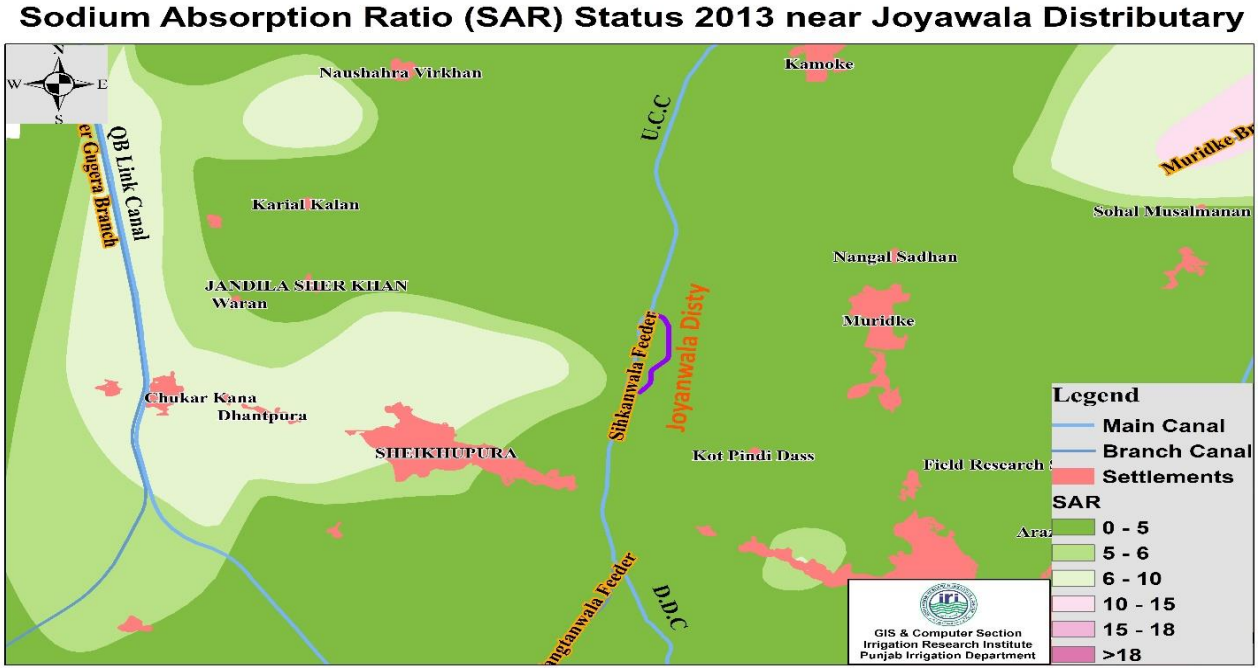

Figure 20. Map of SAR in study area during 2013

4.3 Drainage Network

A number of surface drains are passing through the area carrying the domestic, industrial and agricultural effluents which are a source of degradation of land and groundwater resources due to leaching down of hazardous pollutants. List of drains is given in the box and location is shown in **Figure22.**

List of Drains in the study Area

i. Nikki Drain
ii. Khoth Nala
iii. Bharianwala Drain
iv. Chichoki Drain
v. Drajke Drain
vi. Degh Nadi
vii. Sheikhupura Drain
viii. Mangoki Drain
ix. Sheikhupura Bund Drain

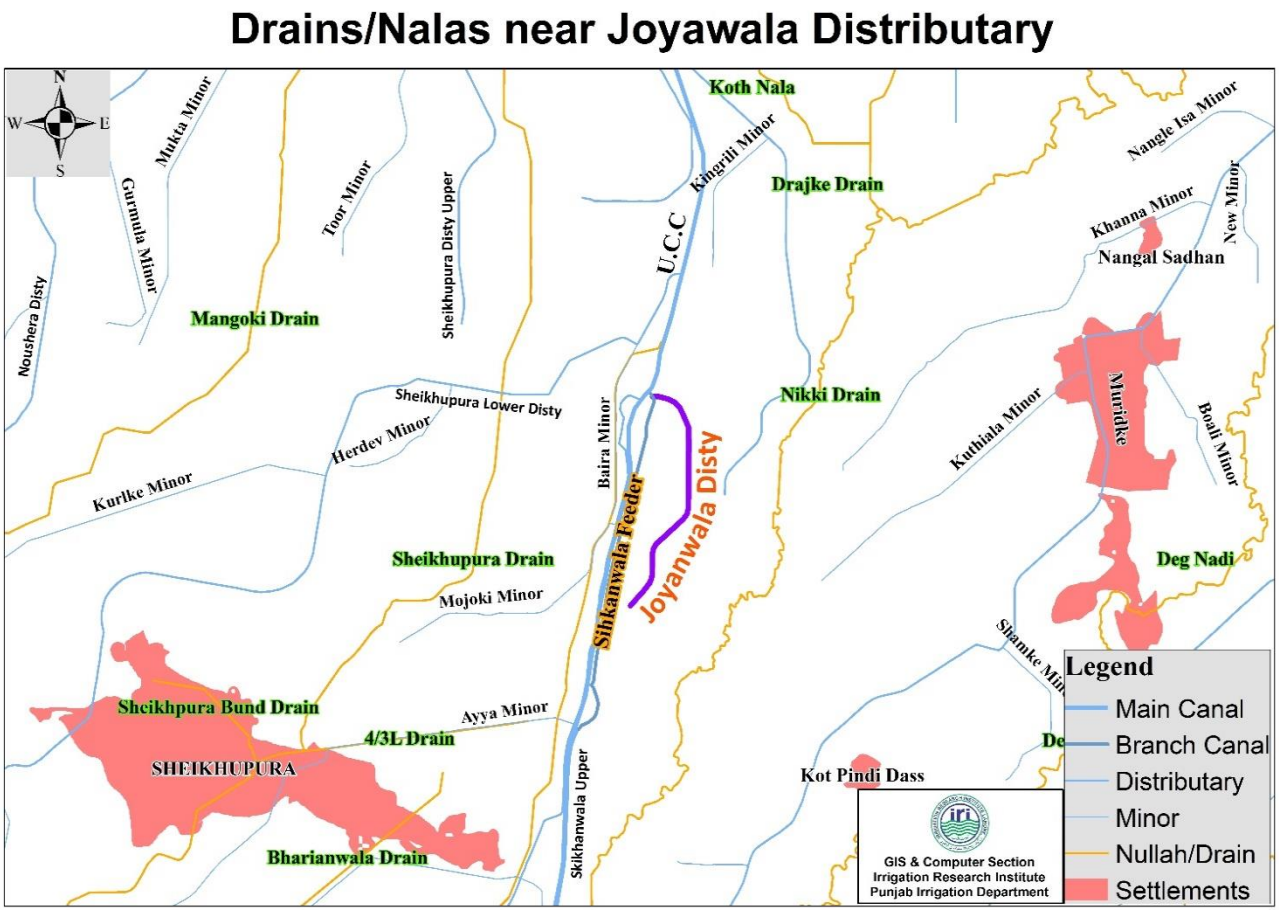

Figure 22. Location of surface drains in the study area

5 FARMER'S RESPONSE ON CANAL WATER AVAILABILITY AND GROUND WATER PUMPING

In order to get a clear picture on availability of canal water and the use of groundwater, stakeholders/irrigators of Joyanwala distributary were approached. Responses of farmers from the entire length of the distributary were collected to analyse the behaviour of channel from head to tail and any difficulties farmers are facing related to canal watering. During the field data collection it was said that currently total number of tube wells in the entire culturable area of Joyanwala distributary ranges from 130-150. It is worth mentioning that 40% of these tube wells lie within head to middle reach while the rest are within lower middle to tail reach.

During the past 20-30 years, installation of tube wells and trend towards groundwater pumping has been on higher side. Farmers of Joyanwala distributary reiterated that time of tube well operation has increased during the last decade due to fluctuating water supply and water theft along the channel. However, this pumping of groundwater is limited for cultivation/irrigation purposes and no commercial element has been observed while installing the tube wells.

5.1 Head Reach

Farmers of head reach of Joyanwala distributary were of the opinion that they generally do not face water shortage as long as the channel is running. However, during peak demand periods they need to run tube wells in order to ensure un-interrupted supply to their lands. They also said that the groundwater condition and quality is satisfactory and is available at a depth of 100ft. According to the farmers this could get even better if either the channel gets lined or at least properly maintained to its existing condition. One of the farmers said that the average expenditure of tube well for six months of Kharif season is nearly Rs. 0.5 million. Meeting with the farmers of head reach of Joyanwala distributary shown in **Figure23.**

Figure 23. Meeting with the farmers of head reach of Joyanwala distributary.

5.2 Middle Reach

Farmers of the middle reach responded that they have to deal with the fluctuating supplies mostly due to poor condition of the channel, frequent breaches due to inadequate bank maintenance, vegetative growth in the channel prism and water theft in the upper reach of the distributary. They also said that they get good quality groundwater at a depth of 200ft. Almost a decade ago water quality was good at a depth of 100ft but now it is unfit for irrigation. When asked if any study has been in their area on groundwater, their reply was 'no' but their own experience is that current groundwater available at a shallow depth is not suitable for irrigation. This was apparent to them when during the last many years shallow groundwater damaged their crop and ultimately, they had to go deeper for boring. They strongly recommended that the channel needs to get lined by the authorities or restored to its original condition by silt removal and berm cutting. According to the middle reach farmers, the groundwater pumping trend has generally increased due to uncertainty about availability of canal water.

5.3 Tail Reach

Farmers of the tail reach considered themselves to be the most deprived in terms of availability of canal water. The main reasons for the inadequate supply are lack of proper maintenance and little prevention of water theft in the upper reaches of the distributary. Added to that ample supply of channel is being wasted due to frequent cuts, breaches along the channel and cattle trespassing etc. The farmers have to rely on groundwater pumping more than the farmers of head and middle reach. Tail reach farmers also added that good water quality is available at a depth of 250-300ft.Data collected from the farmers also suggests that during the last decade more tube wells have been installed in lower middle to tail reach resulting in rapid draw down of the water table in the area. Excessive pumping is done during peak demand season to meet with the crop water requirements.

6 Conclusions

After analysis of secondary data and farmer's feedback, it has been concluded that Joyanwala distributary is subjected to a number of administrative and maintenance problems including but not limited to lack of proper maintenance of the channel due to financial constraints, old and deteriorated regulating structures, frequent breaches and water theft incidents etc. Farmers of Joyanwala distributary iterated that the channel must be maintained and restored to its design section to avoid wastage of the canal water. A strong consensus among farmers along entire length of the distributary was observed regarding lining of Joyanwala distributary. Groundwater pumping is an integral part of cultivation in the command area of Joyanwala. However, good quality groundwater is available at varying depths from head to tail reach of the distributary. Effluents from drains and urban localities are the threats for contamination of the sweet water in the aquifer.

7 Recommendations/ Way Forward

Based on the data analysis, field visits, interaction with farming communities and conclusions drawn, it is recommended that some works of emergent nature are required at Joyanwala distributary to cope with the problems of maintenance of the channel prism including desilting, rehabilitation of structures, strengthening of the banks. Administrative authorities must devise some policy to address these issues. Ample maintenance funds should be allocated to restore the distributary to its original shape for minimum wastage of water and better water use efficiency. Legislation must be done to cope with water theft issues. Similarly, stakeholders of the channels must be trained / educated to discourage indulgence in water theft and other detrimental practices. Awareness raising campaigns regarding the diminishing water resources need to be launched at local, regional and national level. Farming community must be taken into confidence to give them more ownership of the channels and must be enticed to participate in self-help basis activities to maintain their channels as they are the ultimate user/beneficiary of the canal water. Excessive groundwater pumping should be discouraged by improving canal water availability and its efficient use. Steps need to be taken to improve the water productivity for overall contribution to the national economic growth. Detailed investigation for assessment of groundwater potential, potential threats, sustainable use and aquifer protective measure should be carried out.

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