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Consequences of Ground Water Exploitation on Farmers of Semiarid Parts of Punjab - A Case Study of Moga District, Punjab

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Abstract : Advent of tubewell technology has completely transformed the way irrigation using ground water was done earlier and has cause tremendous benefits for the farming community. But number of problems have come to fore because of excessive dependence on ground water irrigation for growing crops requiring assured water. Huge stress on ground water has caused decline of water levels and availability of annual replenishable ground water resource has been negative in 75% of blocks of Punjab. This has also resulted in increasing depths of new ground water abstraction structures for want of assured ground water based irrigation. This capital investment by the framers is taking its toll on the fragile socio-economic structure especially for small and marginal farmers of the Punjab state. A study was undertaken to analyse the impact of precarious ground water situation on small and marginal farmers of Moga district lying in the semi-arid parts of Punjab, where main crops grown are paddy and wheat. Experiments regarding artificial recharge have been conducted and have proved that possibilities do exist to improve the situation utilizing non-committed monsoon run-off.

INTRODUCTION

Despite improvements in water use efficiency over the past five decades since independence, demand for fresh water in India has increased manifold. Prevalent water crisis in India includes falling declining water table, water quality deterioration, waterlogging, and salinity etc resulting in inadequate access to safe drinking water. Ground water play plays a major role in national economy and sustenance of life and environment. The ground water irrigation received a quantum jump with the advent of high yielding variety crop technology in the second half of 1960s. It has been estimated that 70-80 percent of the value of irrigated production in India comes from ground water irrigation (sentence need revision). Around two fifth of India's agricultural output is contributed from areas irrigated by ground water. Historically, during the early 1980s, access to ground water provided fundamental key behind the spread of new agricultural technology under the green revolution. Indiscriminate use vis-à-vis over development of this precious natural resource has led to alarming decline in ground water table and increase in ground water stressed areas. This has resulted in less availability of this resource in an economically unviable manner to the farming community particularly in the state of Punjab, which has led to socio-economic problems in a big way.

DECLINING GROUND WATER RESOURCES AND ITS IMPACT ON FOOD PRODUCTION

The state of Punjab has a total area of 50360 Sq.km. spread over 20 districts. Net sown area of the state is 83% to the total area. In year 2006-07, 36770 sq. km area was sown more than once. Thus, total cropped area of the Punjab state was 78610

sq. km. It has been observed that in the state since year 1970-71 though there was marginal increase in the net area sown from 40530 to 41840 sq. km., but increase in the area sown more than once had increased around 2.5 times from 16250 to 36770 sq. km. This phenomenal increase has been made possible only because of extensive irrigation extracting water from ground water sources. Punjab has an extensive network of canals in the state. But the area irrigated by government canals dwindled from 12860 sq km in 1970-71 to 11890 sq km in year 2006-07 (Fig.-1). Thus, presently surface water resources cover only 29 % of the

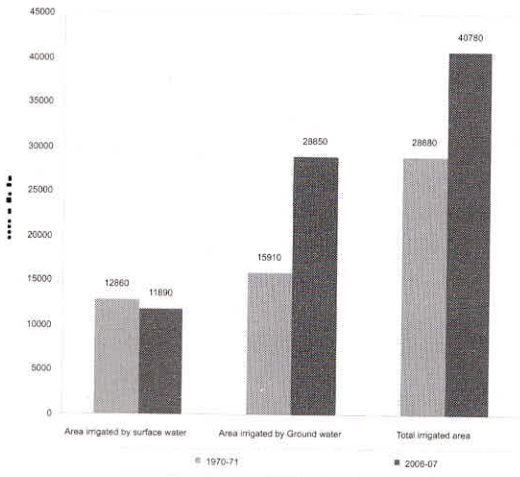

Fig. 1 : Net Irrigated Area by Source - Punjab

total irrigated area of the state. On the other hand, net area irrigated by wells and tube wells has increased tremendously from 15910 sq km in 1970-71 to 28850 sq km in the year 2006-07 covering 71 % of the total irrigated area of the state.

It is clear that huge increase in the area under crops grown more than once has been primarily due to the availability of assured ground water for irrigation. The tremendous growth in the tube well irrigation has ultimately contributed to the increase in food production of the state. The production of rice in the Punjab state has increased from 688 to 10138 thousand metric tons whereas yield has risen from 1765 to 3868 kg per hectare. Similarly, production of wheat in the Punjab state has increased from 5145 to 14596 thousand metric tons whereas yield per hectare has risen from 2238 to 4210 kg. Various parameters defining the growth in agricultural index numbers is depicted in Fig-2. Indices like cropping intensity, net area sown, yield, production and productivity have been compared for years 1970-71 and 2006-07.

One of the main reasons for this increased food production is assured irrigation from Ground ground water sources. In most of these areas, dependence on ground water resource has resulted in water level decline. Change in water levels for past one decade (May 1999-2008) has been computed. It is observed that area showing decline of water levels during this period is around 44, 000 sq km and is well spread in the Central and Southern Punjab. Entire districts of Amritsar, Taran Taran, Jalandhar, Kapurthala, Ludhiana, Sangrur, Barnala, Moga and Patiala have recorded decline of water levels. As per Ground water resource estimations (as on 31.03.2004), 103

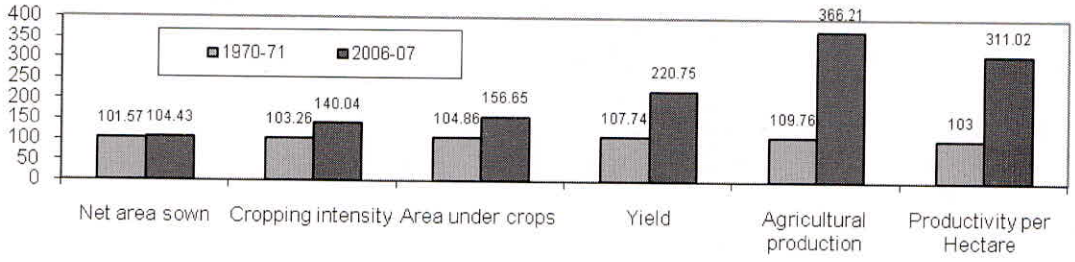

Fig. 2 : Agricultural index numbers in Punjab-Base Triennium ending 1969-70 = 100

blocks have been categorized as Over-exploited. All the blocks of Amritsar, Faridkot, Fatehgarh sahib, Kapurthala, Ludhiana, Jalandhar, Mansa, Moga, and Sangrur have been categorized as Over-exploited over-exploited. In these entire blocks, trend of water levels is declining at various rates ranging from 4 cm to more than 100 cm per year.

It has been already mentioned that 71% of the net area is at present being irrigated by ground water in the state of Punjab. District wise dependency of the farmers on Ground water is depicted in Fig-3. It is evident that in most of the districts of Punjab Ground water is primarily used for irrigation and is extracted more than annual available resource. In some of the districts Ground water draft is more than 150% of the availability of ground water resource. The districts where stage of Ground water development is higher than 150% are Amritsar, Kapurthala, Jalandhar, Ludhiana, Fatehgarh, Mansa, Moga, Patiala and Sangrur. In two districts namely Jalandhar and Kapurthala stage of Ground development is 254% and 204 % respectively.

HYDROGEOLOGICAL SET UP

AQUIFER FENCE, UPPER BARI DOAB

Punjab state of India forms a vast tract of alluvial plain formed by mighty rivers, the Ravi, the Beas and the Satluj. The area discussed is located south of "Upper Bari Doab" which is basically an inter-fluve area between the Beas and Ravi, across the Satluj river after confluence with Beas at Harike. This area is underlain by aquifers that are laterally and vertically extensive containing good quality ground water except in south western part where the thickness of fresh water aquifer is much less as compared to the other parts because area is underlain by brackish/saline water. A lithological section drawn in a north-east: south-west direction reveals the presence of 5 to 6 thick permeable granular zones down to a depth of 300-420 m below ground level. The first aquifer which forms the water table aquifer occurs up to 40-50m bgl and consists of sand with minor amount of gravels and kankar. The second and third aquifers consist mostly of sand, gravel and pebbles.

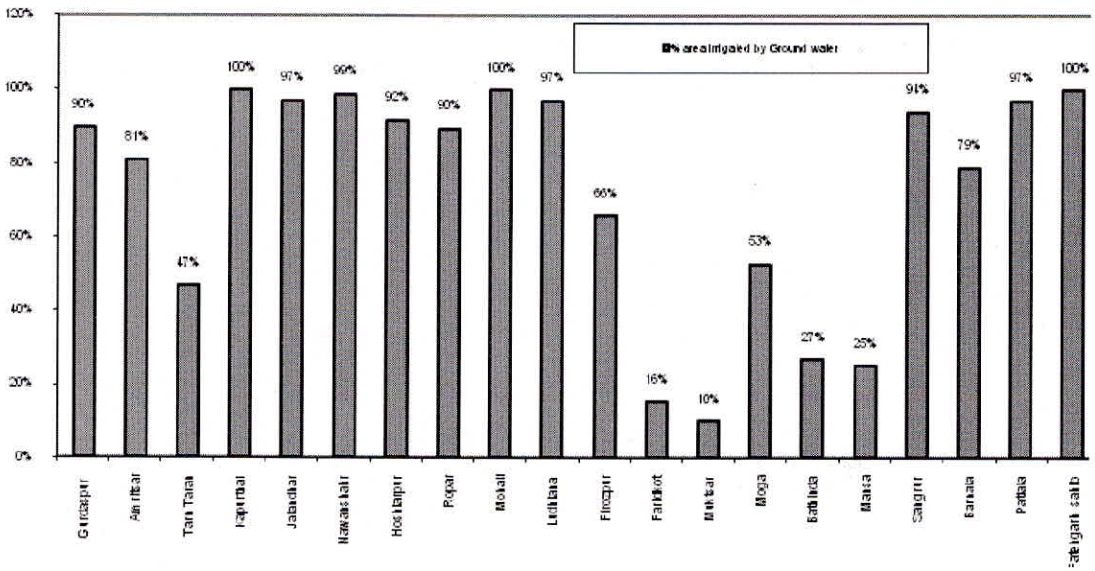

Fig. 3 : District wise area irrigated by Ground water - Punjab

A study of the disposition of the water table elevation of the p aqreveals the existence of a water divide running in NE-SW direction. Whereas the water table contours are closely spaced in the extreme NE part indicating that ground water movement is fast, in other parts these are widely spaced which show that ground water movement is slow. Rivers the Ravi, Beas and Satluj are effluent in nature. Ground water, in general, following the surface topography and flowing towards west and south-west towards the Satluj that forms the border with Pakistan. The major withdrawal of ground water in this area is through the phreatic aquifer that is being recharged locally through rainfall and other sources like canal seepage, return flow from applied irrigation etc. The 2nd and 3rd aquifers have by and large not been tapped so far and their recharge area lies in the Shivaliks in the north and north-east.

In Moga district, aquifer material comprises chiefly of fine to medium grained sand. In general shallow aquifers in the area can be grouped into two classes; one unconfined/ semi confined aquifer down to depth of 50.0 m in the district and other being in the depth range of 60.0 to 80.0m. These two aquifers are separated by a clay layer almost uniformly present in the district. The first aquifer down to depth of 50.0 m is being tapped by shallow tubewells for purpose of irrigation and drinking. However, few deeper tubewells down to depth of 125 m are also being tapped by Government agencies for drinking purpose and by some farmers for irrigation purpose.

Based on the ground water exploration by the Central Ground Water Board in Moga district up to the depth of 350.0 m, at least four aquifer groups can be identifies identified in Northern part of the district Moga as given in table 1. Tube well constructed up to the depth of 217 m has given average discharge of 3000 lpm with drawdown of 5 to 5.5 m.

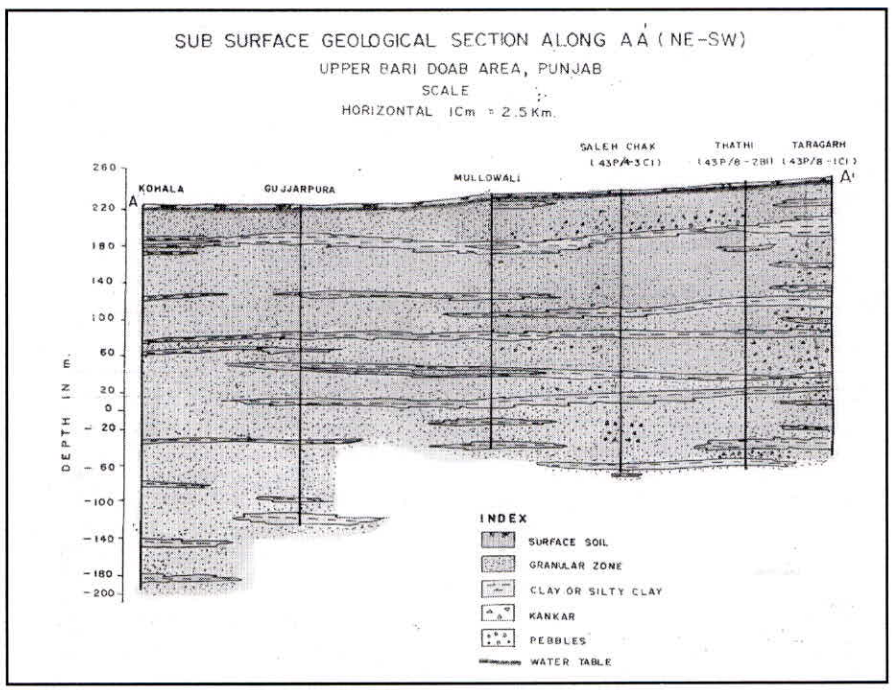

Fig. 4 : Sub Surface geological section along AA (NE-SW) Upper Bari Doab Area, Punjab

Table 1 : Aquifer disposition - Moga

Aquifer Group	Depth Range in m
First	29.00 – 47.00 60.00 – 80.00
Second	100.00 – 111.00
Third	143.00 – 160.00 182.00 – 230.00
Fourth	264.00 – 336.00

Ground water Behaviour of Moga district

Moga district, represents an area where maximum benefits due to green revolution have been observed. This area forms the part of Central Punjab belt. Other districts having similar conditions in the region are Amritsar, Tarn Taran, Kapurthala, Jalandhar, Ludhiana, Patiala, Fatehgarh Sahib, Mansa and Sangrur. Moga district has 5 blocks namely Moga–I, Moga–II, Baghapurana, Nihal Singh wala and Dharamkot. As per Ground water resource estimation, all the blocks in the distict are categorized as over exploited and stage of Ground water development is as follows :

Block Stage of Ground water development

1.	Moga – I	205%
2.	Moga – II	187%
3.	Nihal Singh Wala	218%
4.	Bagha purana	174%
5.	Dharmkot	139%

Water levels during the period 1974-1985 were shallow in most parts of the district. Generally water levels were within 5 m from ground level. Presently depths to of water levels are deep in all the blocks. In Moga-I and parts of Moga–II very deep water levels i.e. more than 25 m have been reported whereas in rest of the blocks, water levels generally rest between 20 to 25 m. Due to increasing dependence of farmers on ground water the decline of water levels started from 1985 onwards. Rate of decline of water levels had been very sharp in last 2 decades (1986-2007). During this period, the representative wells have shown high rates of decline.

Block Rate of decline (cm /year)

1.	Moga – I	75
2.	Moga – II	86
3.	Nihal Singh Wala	77
4.	Bagha purana	46
5.	Dharmkot	79

A typical hydrograph showing trend of declining water level is presented in fig- 5.

IMPACT OF DECLINING WATER LEVELS ON FARMERS

The consequences of water level decline have been severe especially for small and marginal farmers in the Punjab state, which has large population engaged in farming and related activities. The decline of water levels have resulted in increase in cost input for farmers. The inputs in which farmers are have to invest heavily are deepening of dug cum bore well, drilling of new tube well, new submersible pump sets, investments on account of new backup diesel sets etc. Farmers have to resort to non-farming activities such adopting dairy farming or even selling off their lands to big landlords having adjoining farmlands.

PROSPECTS FOR AUGMENTING GROUND WATER RESOURCES

In order to augment the dwindling ground water resources, a plan for artificial recharge has been prepared considering the hydrogeological parameters and hydrological data base. The plan has been prepared which involves the following:-

- Identification of areas suitable for artificial recharge to ground water.
- Estimation of subsurface storage space and quantity of water needed to saturate the unsaturated zone.

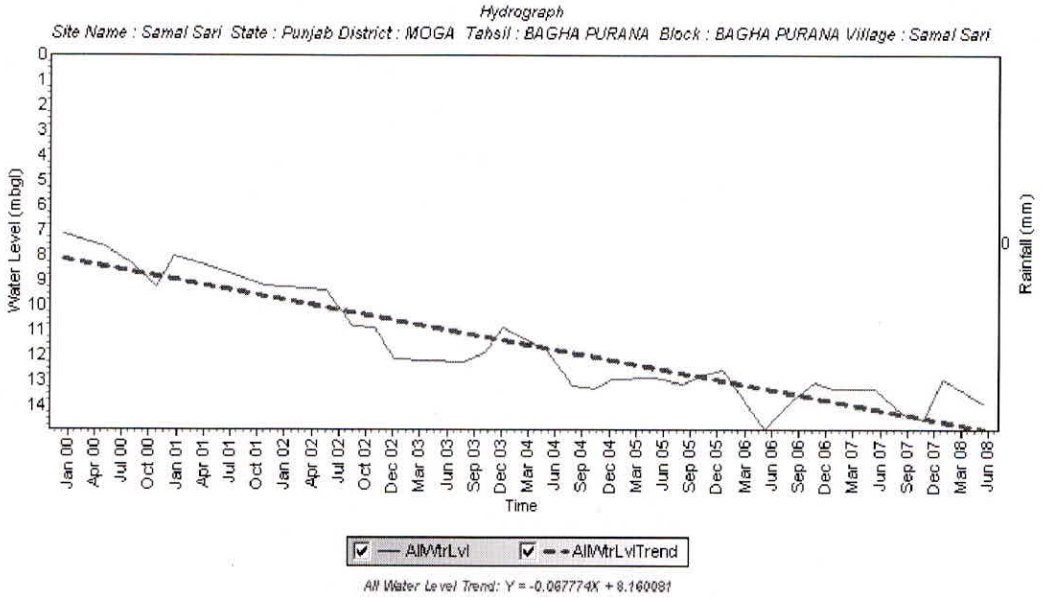

Fig –5 : Typical hydrograph of Moga district

- Quantification of surface water requirement and surplus runoff availability for artificial recharge in each district.
- Working out suitable recharge structures, their numbers, and capacity to recharge with available resources.
- Cost estimate of artificial recharge structures required to be constructed in identified area

As discussed in the preceding paragraphs, Ground Water Resources estimation of the district was done as on 31.03.2004 as per GEC-1997 for each individual block. Stage of ground water development in the district is 177%. The ground water development in all the blocks of the district has exceeded the available recharge and thus all the blocks have been categorized as "over exploited". Moga-I and Nihal Singhwala are showing more than 200% of ground water development. The ground water decline in these blocks has been observed to be in the range from 25.3 cm/yr to 74.7 cm/yr during pre monsoon and 36.7 cm/yr to 99.6 cm/yr during post monsoon (sentence needs correction).

The area identified for artificial recharge in the district is 1672 sq.km and Sub surface storage potential has been computed to be 1291 MCM and Surface water requirement has been worked out as 1717 MCM. The proportionate Non-committed water resource available in the basin is 20.76 MCM. The amount of Surface water considered for the artificial recharge is 20.76 MCM. Considering average annual intake capacity of one recharge structure to be around 0.017 MCM and the average cost for the construction of one artificial recharge structure as 1.29 lakh, the total number of structures required to recharge 20.76 MCM are 1221 with estimated total cost of 1579.974 lakhs in the moga district. Salient features of the plan are as follows:-

(These salient features are already mentioned in the paragraph given above. Keep any one and delete other)

A project was taken up for augmenting artificial recharge in Bassian Drain in Moga district and to examine the possibilities of ground water recharge. Two trenches having 170 m length each were constructed with three recharge wells in each trench and 3 piezometers on both sides of the trench. Total quantity of water recharged annually through two trenches of 170m length was 5.58 MCM. This has helped to install 18 additional shallow tubewells in the area. In the area there are

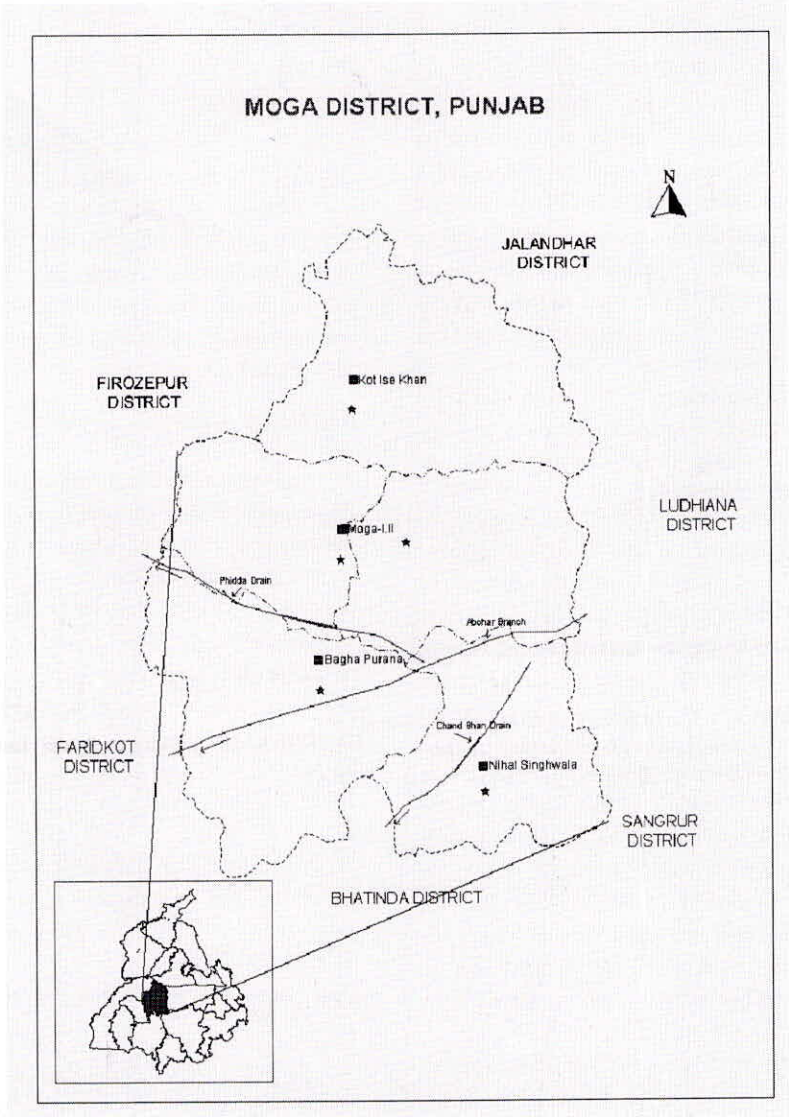

Fig. 6 : Moga District, Punjab

• Area identified for artificial recharge (Sq.km)	1672
• Estimated sub-storage potential (MCM)	1291
• Non-committed water resource available for artificial recharge (MCM)	20.76
• Average annual intake capacity of one recharge structure (MCM)	0.017
• Total number of recharge structures required	1221
• Average cost for construction of one artificial recharge structure (lakhs)	1.292
• Estimated total cost for constructing recharge structures (lakhs)	1579.974

108 shallow tubewells owned by the farmers that have been benefited due to rise in water level. Total number of beneficiaries is are 130. In an area of 11 sq km the rise in water level observed was 0.20m that can save 15 MW of energy due to reduced lift of pumps. The farmers of the area also reported that there is appreciable increase in discharge of their shallow tubewells due to artificial recharging of aquifer system of the area. Water level data reveals marginal increase in water levels around Bassian drain in spite of heavy pumping for paddy growth.

On the basis of successful experiment, artificial Recharge Schemes as pilot project is being initiated by modifying the beds of the existing drains by using the surface run-off during monsoon and using surplus water released through escapes which falls in to the drains. It is proposed to construct Artificial Recharge Schemes in the existing Phidda Drain & Chandbhan Drain in Moga–II and Nihal singh wala block respectively (Fig-6). Lateral Recharge Shafts of 100 m length of size 6x3x2m with 4 No. of 150 mm dia injection wells will be provided in the drains where the bed has sandy strata and recharge trenches 4x3x2m deep and 5 m long with one injection well each of 150 mm Ö will be provided in the drain beds where sandy strata/aquifer is not available up to 2 mtr m depth. It is proposed to construct 1 No lateral recharge Shaft of 100 M ? Length & 1 No. of 20 No of sets of recharge trenches in Phidda Drain & Chand Bhan Drain separately. Total water available for recharge in Phidda and Chandbhan drain is 81 MCM and 35.73 MCM respectively. Moreover, escape water from Abohar Branch having 400 cusec capacity is also available during cuts/breaches in Phidda drain. The structures in each drain have been designed for intake capacity of 1.123 MCM. It is anticipated that artificial recharge activity in a big way can surely ameliorate the precarious scenario.

CONCLUSIONS

Moga district has been experiencing one of the steepest water level declines in the Punjab state during last couple of decades. The magnitude of water level decline can be gauged from the fact that nearly all the dug wells have gone dry and replaced by tubewells of various depths. In order to tackle declining water levels, artificial recharge utilising monsoon runoff was experimented with the help of specifically designed lateral shafts cum injection wells so that the aquifer, which has become desaturated gets replenished. The results of the experiment have proved that proper application of artificial recharge technique suiting the local hydrogeological setting will result in additional availability of ground water resources that can be harnessed for irrigation. New projects have been taken up on the basis of successful results of the experiment. It is suggested to harness all the non-committed monsoon runoff available in the Moga district so that the dwindling ground water resources can be enriched and the problems faced by the local farmers are mitigated to some extent.