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WATER RESOURCES OF PUNJAB

Status of Environment & Related Issues

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EDITORIAL

Water is vital for all life forms on earth. Though it is an abundant and renewable natural resource, yet only 2.7 percent of global water is available as fresh water, and of this, only 30 percent is available to meet the water demand of mankind and livestock. Water resources in Punjab consist of both surface water and ground water resources. The per capita water availability is decreasing due to ever increasing population. Punjab utilizes nearly 80 percent of available water resources. The anthropogenic activities namely, agriculture, industrial growth, and uncontrolled urbanization put tremendous pressure on its water resources both in terms of quantity and quality. Though the state has well developed canal system but most of them are located in south-western districts such as Bathinda, Ferozepur, Mansa, Faridkot, Muktsar, etc The ground water resources are also being utilized indiscrimi-nately. This has caused water table decline in certain parts (central districts) of Punjab and water table rise causing water-logging and salinity problems in other parts(south-western districts). Further, long dry spells and low precipitations have aggravated the problem in the semi-arid region of the state. Thus, over-exploitation of the resource and discharge of untreated municipal and industrial effluents in rivers, canals and drainage system have created multiple environmental problems and social challenges. It has further, posed a threat to degrade the quality of soil and reduce crop yields and also deteriorating the quality of both surface and ground water.

The present issue of Newsletter discusses the status and quality of water resource in Punjab. It is hoped that within the state, more studies may be taken up to address the emerging issues related to water and also various organizations engaged in water management take more remedial actions to protect the resource by taking up problem specific and area specific programmes.

- Editors

ENVIS Centre, PSCST is a partner of Regional Centre of Expertise (RCE) Chandigarh. RCE Network is an initiative of United Nations University – Institute of Advanced Studies, Japan, which focuses on Education for Sustainable Development (ESD). This article on "Water Resource of Punjab" in the region reinstate PSCST's endeavour for creating awareness and capacity building for conservation of water resource within the region.

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Introduction

Punjab is a small state. It occupies only 1.57 percent of the country's total geographical spread and is a part of Indo- Gangetic plains formed due to alluvial deposits by rivers and tributaries. Two major rivers, the Sutlej and the Beas, traverse the state and Ravi and Ghaggar touch its Northern and Southern borders, respectively. This river pattern divides the state into three geographical area popularly known as 'Majha' (North West of Beas), 'Malwa' (South of Sutlej) and 'Doaba' (between Sutlej & Beas).

On the basis of geomorphology, the state can be divided into hills, table lands, intermontane valleys, piedmont plains, alluvial plains, sand dunes, paleochannels, flood plains, wetlands and salt affected areas. Some of these areas like paleochannels, sand dunes, salt affected, wet/water logged areas and alluvial plains have experienced drastic changes in the past couple of decades due to human interventions. The state supports 2.29 percent of the country's population with a population density of 550 persons per sq. Km. Land use in the state is shared by agriculture, forests, water bodies, built up areas, barren & uncultured land, etc. Ecologically, the area under the present state of Punjab comprises of grassland and cropland ecosystems interspersed with natural forest areas and orchards with abundant lotic and lentic water bodies.

The state, which has done remarkably well in the field of agriculture, is also on its way to rapid industrialization. Presently, the Punjab state contributes nearly 39 percent wheat and 22 percent rice to the central pool.

Green Fields in Punjab

Administratively, the state is divided into 22 districts including Ajitgarh (formerly Mohali or SAS Nagar), Amritsar, Barnala, Bathinda, Faridkot, Fatehgarh Sahib, Fazilka, Ferozpur, Gurdaspur, Hoshiarpur, Jalandhar, Kapurthala, Ludhiana, Mansa, Moga, Pathankot, Patiala, Ropar, Sahid Bhagat Singh Nagar(formerly Nawanshahar), Sangrur, Sri Muktsar Sahib (earlier Muktsar) and Tarn Taran. The districts are further divided into 81 tehsils, 86 sub-tehsils, 145 blocks and 12,581 inhabited villages. The state is having a good network of roads.

Climatically, the State is typically sub-tropical with hot summers and cold winters. The minimum temperature in winter falls to 0°C and the summer maximum temperature touches 47°C. Frost is common during the winter months, which affects vegetation to a large extent. The onset of monsoon in July brings down the temperature, but high humidity during July-August causes uncomfortable conditions. The temperature falls appreciably by the end of October. Cold waves occasionally cause temperature to fall below freezing point at some places. The day temperature rises rapidly during March and thereafter slows down from May to June when it reaches the maximum. The westerly winds (locally known as Loo) blow in the month of June.

The average annual rainfall received in the State is around 560 mm in the plants and 960mm in the mountainous region. The rainfall decreases from north and north-east to the south. About 70 percentof the annual rainfall is received during the monsoon months between the middle of July to the middle of September and rest is received during the winter in the months of December and January. The mean relative humidity varies between 50 to 95 percent.

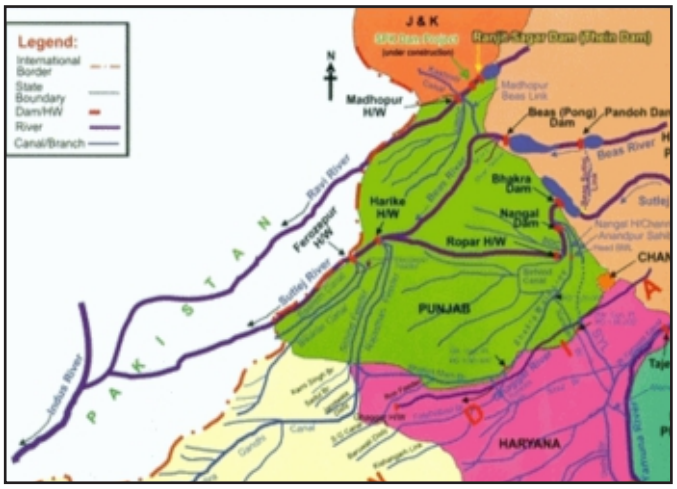
Water Resources of Punjab

In Punjab, the vast Indo - Gangetic alluvial plain forms an excellent repository of ground water resources. Ground water in Punjab occurs under both confined and unconfined conditions. The

aquifers are laterally and vertically extensive and persistent in nature. In south-western parts, the thickness of fresh water aquifer is much less as compared to the other parts because area is underlain by brackish/saline water. At places, the thickness of fresh water bearing aquifer is even less than 10 m **(CGWB, 2014)**.

Satluj Beas and Ravi are the perennial rivers of the Indus system, which flows through Punjab that together carry 40.5 x 10^9 m^3 of water **(Jain and Rajkumar, 2007)**. Ghaggar is the seasonal river. Himalayan glaciers melt account for about 58 percent of the source water supply of these rivers. All these rivers are tapped by using dams at different levels in the catchment areas **(Map 1)** and stored water is utilized for irrigation through a strong network of canals in the command areas. **(Singh & Bangoo, 2013)** The origin and extent of major rivers of Punjab are given in **Box 1**. The details of surface water and ground water resources is discussed in the succeeding text.

Map 1 Water Resources in Punjab



Source : *Department of Irrigation, Punjab*

Surface Water Resources

The water potential of state is about 14.54 Million Acre Feet (MAF) or 1.79 million hectare metre (mham). The state has well developed network of canals with about 1,00,000 km water courses with total Culturalable Command Area (CCA) of 30.88 Lacs hectares. **(Map 2)** The main canals from River Satluj are Anandpur Hydel Channel and Bhakhra

Box 1. Major Rivers in Punjab: Origin & Extent

River Sutlej is the longest of all the rivers that flow through the region of Punjab. The Satluj enters Punjab near Nangal, moves on to plains at Ropar, passes through district Ludhiana and joins Beas at Harike before crossing over to Pakistan. Its total length is 440 km in the state

Beas river enters Punjab near Talwara and enters the plains to meet the Satluj at Harike. Its total length is 470 km.

Ravi river enters Punjab plains near Madhopur and passes on to Pakistan 26 km below Amritsar.

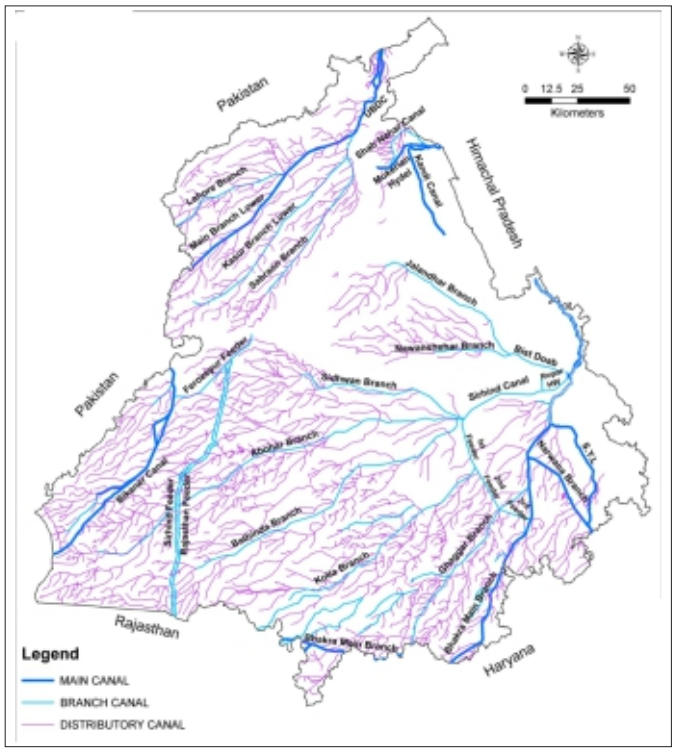
River Ghaggar enters Punjab ne ar Mubarkpur traversing through district Patiala, Sangrur and Mansa and then it re-enters Haryana.

Source : *Punjab Pollution Control Board*

Main Line (BML). BML further bifurcates into Narwana branch and Bhakhra main branch. At Ropar again two main canals, Sirhind canal and Bist Doab canal originate. At Harike, Satluj feeds water to Rajasthan feeder canal and Ferozepur feeder canal. The Bikaner canal (Gang Canal) originates at Hussainiwala, one main canal from Beas originates at Shah Nehar Barrage called Shah Nehar or MukerianHydel Channel. The major irrigation canal originating from Ravi at Madhopur is Upper Bari Doab Canal (UBDC). The total stretch of canals & distributaries (including minor distributaries) is approx. 14,500 km. The Rajasthan feeder canal has the maximum capacity of 18,500 Cusecs. Sirhind canal system has the maximum Culturable

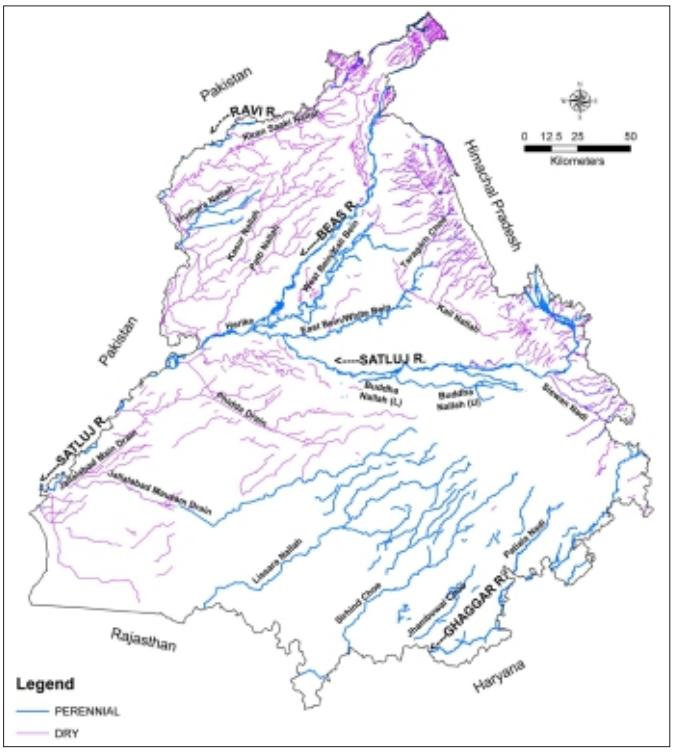
Abohar Canal at Sudhar, District Ludhiana

Map 2 Canal Network of Punjab



Source : *Punjab Remote Sensing Center*

Map 3. Drainage Network of Punjab

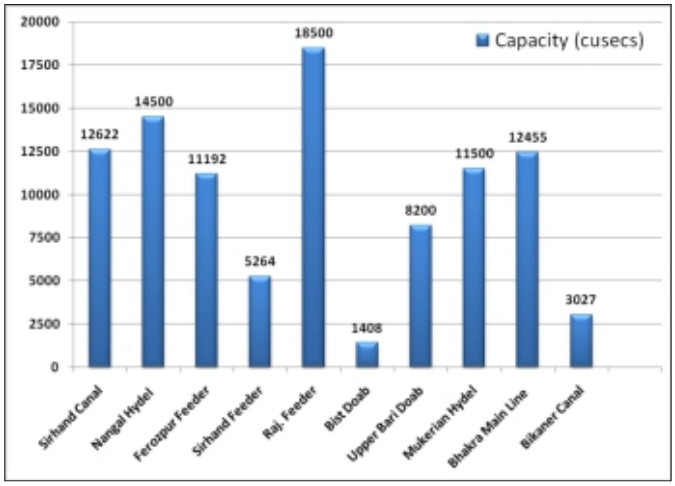


Source : *Punjab Remote Sensing Center*

Command Area of 1.36 million ha. The capacity of main canals in Punjab is presented in **Fig 1**.

An 8000 km long drainage exists in the state which helps in quickly dealing with heavy runoff and in preventing water logging. It plays an important role in shaping the landscape of an area due to its erosional and depositional nature. The Satluj Beas and Ravi rivers form the main drainage system in the state of Punjab. The other main drainage channels in Punjab are Ghaggar river, White Bein or East Bein, Kali Bein or West Bein (Holy bein), Chakki River, Sakki Nala, Kiran Nallah, Buddha Nallah, Siswan Nadi, Patiala Nadi and Jallalabad drain **(Map 3)**. Numerous seasonal choes are found in Shiwalik or Kandi Area. These are mainly responsible for soil erosion in Hoshiarpur, Nawanshar & Ropar districts. The natural gradient of the drainage channels is generally from north-east to south-west direction. In areas, where natural drainage is lacking, artificial drains have been dug up for the disposal of storm water and seepage from waterlogged areas in the state. The state has two large dams, Bhakhra on river Sutlej and Ranjit Sagar on river Ravi. The major barrages are at Madhopur, Hussainiwala, Shahpur Kandi, Tajewala, Shah Nehar, etc., in addition to Harike, Kanjli & Ropar which have been constructed to facilitate hydro power production and irrigation in the state. The total state reservoir area amounts to 157 sq km. The state also has rich wetland eco-systems **(Box 2)** which play important role in recharging the ground water levels.

Fig. 1 Major Canals of Punjab



Source: *Department of Irrigation, Punjab, 2014*

Box 2 : Wetlands in Punjab

Wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres. Punjab has 12 natural and 9 manmade wetlands **(Table 1 & Map 4)** covering an area of 8.39 sq.km. and 147.39 sq.km, respectively. Harike, Kanjli and Ropar are three major wetlands and recognized as wetlands of International significance under Ramsar Convention. Ranjit Sagar and Nangal Lake have been declared as National wetlands. These wetlands are important aquatic ecosystems in nature and are the important habitats for waterfowl, fish and other flora & fauna.

Table 1. Wetlands of Punjab

S.N.	Name of Wetland	Nearest town	District	Area (km^2)	Status
A.	**Natural Wetlands**				
1	Jastarwal Jheel	Jastarwal / Ajnala	Amritsar	0.55	Permanent
2	AliwalKotli	Aliwal / Ajnala	Amritsar	0.10	Permanent
3	Bareta	Bareta	Mansa	0.20	Seasonal
4	Kahnuwan Chhamb	Kahnuwan / Man Chopa / Chhawarian Banghar	Gurdaspur	1.28	Permanent
5	Keshopur - MianiJheel	Keshopur MianiJhamela	Gurdaspur	4.08	Permanent
6	Mand Bharthala	Bharthala	Nawanshahr	0.61	Permanent
7	Narayangarh - Terkiana	Terkiana/ Dasuya	Hoshiarpur	0.82	Permanent
8	SitalSagar	Mansar	Hoshiarpur	*	Permanent
9	Rababsar	Bharowana	Kapurthala	0.41	Temporary
10	Lobana	Patiala	Patiala	0.11	Temporary
11	Lahail Kalan	Lehail	Sangrur	0.20	Temporary
12	Gobindgarh Khokhar	Gobindgarh Khokhar	Sangrur	0.08	Temporary
B.	**Manmade Wetlands**				
1	Harike Lake	Harike, Tarn Taran, Kapurthala	Ferozepur	41.0	Ramsar Site
2	Kanjli Lake	Kanjli	Kapurthala	0.44	Ramsar Site
3	Ropar Lake	Ropar	Ropar	13.65	Ramsar Site
4	Hussainiwala Reservoir	Ferozepur	Ferozepur	6.88	Nominated for recognition as National Wetland
5	Ranjit Sagar	ShahpurKandi	Gurdaspur	32.64	National Wetland
6	Dholbaha Dam	Dholbaba	Hoshiarpur	13.2	Earth filled dam
7	Maili Dam	Maili	Hoshiarpur	0.72	-
8	Mangrowal Dam	Mangrowal	Hoshiarpur	0.70	-
9	Nangal Lake	Nangal	Ropar	4.0	National Wetland

Source: *Jerath et al., 2014*

Map 4. Location Map of Wetlands in Punjab

Source : *Punjab Remote Sensing Center*

Harike Wetland (Ramsar Site), Punjab

Nangal Wetland (a National Wetland), Punjab

Surface Water Quality

Water quality in the aquatic ecosystems of Punjab is being monitored by the Punjab Pollution Control Board (PPCB) at 37 locations on Sutlej, Beas, Ravi and Ghagger rivers. The monitoring is being carried out under the Monitoring of Indian National Aquatic Resources System (MINARS) scheme of Central Pollution Control Board. At each monitoring location, samples are collected every quarter (in the months of January, April, July and October) and analysed for physico-chemical parameters **(Box 3)**. During 2013-14, PPCB collected and analyzed 995 samples of surface water from various rivers, drains, canals, ponds and lakes **(PPCB, 2013)**. The river-wise water quality is as under:

River Satluj

The quality of river sutlej water at upstream of Nangal generally conforms to Class 'B' of water quality index- (fit for drinking without conventional treatment but after dis-infection).But as the river progresses slowly and receives sewage from Nangal township and the water quality gets impaired. At downstream of Kiratpur Sahib, the water quality conforms to Class 'B' till it reaches at Ropar Head Works. The water quality is worst at the confluence point of the river Sutlej with Budha Nallah which carries the industrial effluents and the sewage of Ludhiana City. After the confluence point, the water quality deteriorates down to Class 'D' (Propagation of Wild Life and Fisheries). As the river progresses further, East Bein joins it which brings along with it the sewage and industrial effluents from

Box 3. Major Physico-Chemical Parameters for Water Quality Measurement

Dissolved oxyen (D): Dissolved oxygen is an important parameter to determine the water quality for various purposes. Dissolve oxygen concentration in a water body indicates its ability to support aquatic life and feflect physical and biological process prevailing in water.

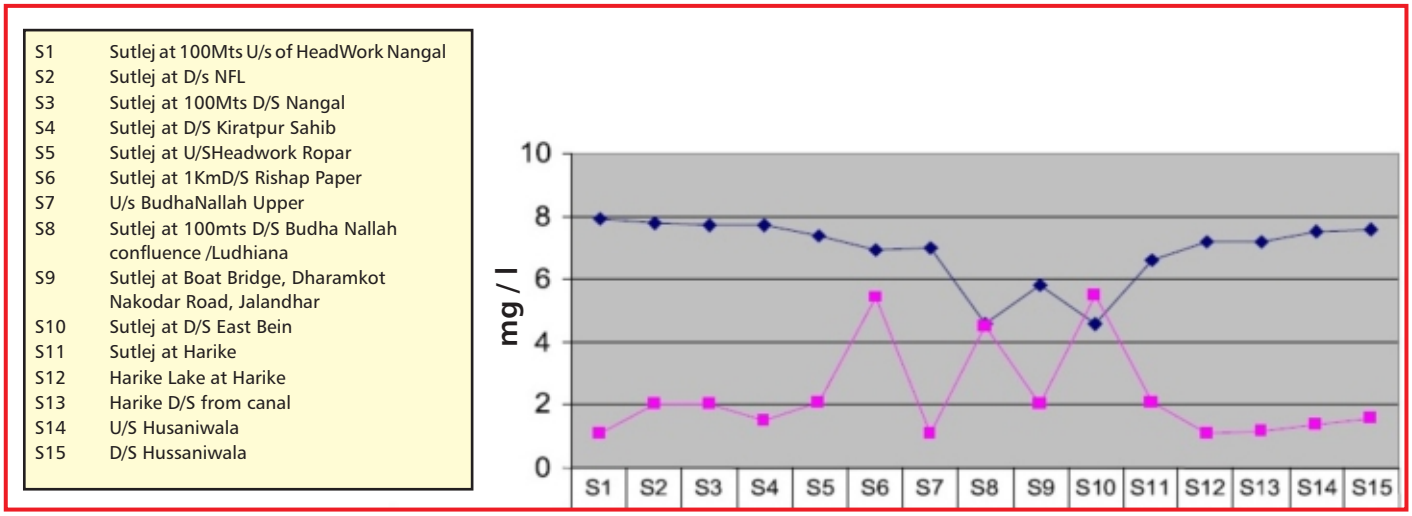
Biological Oxygen Demand (BOD): Biological Oxygen Demand gives an idea of quality of biodegradable organic material present in water, which is subject to aerobic decomposition of micro-organisms.

Chemical Oxygen Demand (COD): Chemical Oxygen Demand test is quite useful in finding out the pollution strength of industrial waste and sewage. High COD levels indicate toxic state of the waste water along with presence of bilogically resistant organic substances. It is the amount of oxygen required for a sample to oxidize its organic and inorganic matter.

Coliforms : Bacterial contamination in water is indicated by the presence of coliform bacteria that find their way into rivers mostly through untreated sewage and cause waterborne diseases.

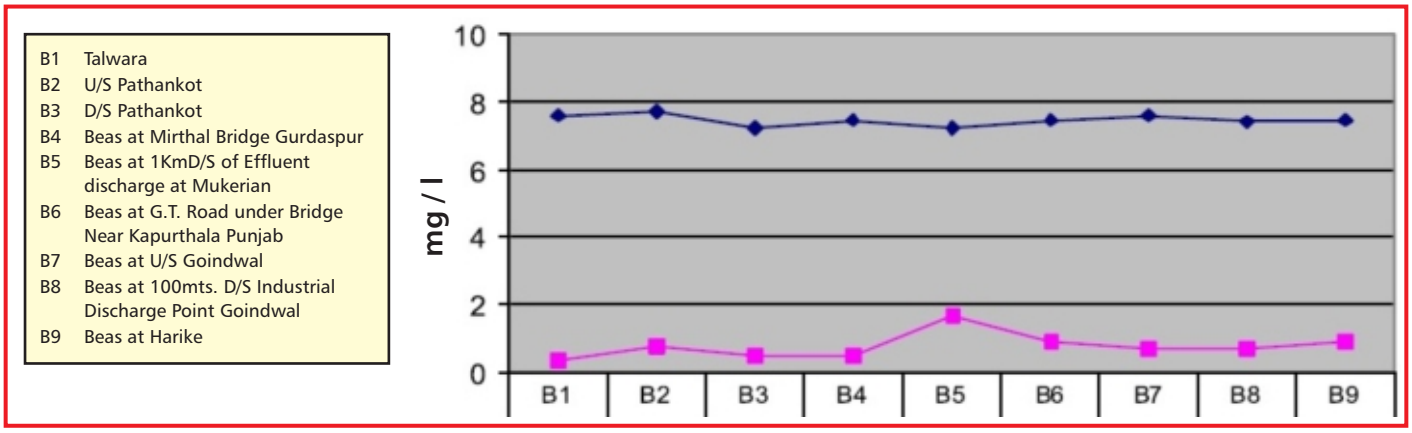
Source : *Punjab Pollution Control Board*

Fig.2 Annual average concentrations of Dissolved Oxygen (DO) and Bio-Chemical Oxygen demand (BOD) in river Sutlej, 2013-14.



Source: *Punjab Pollution Control Board, 2013*

Fig. 3 Annual average concentrations of DO and BOD in river Beas, 2013-14



Source: *Punjab Pollution Control Board, 2013*

Nawanshehar, Phagwara, Jalandhar etc. The water quality in this stretch is generally Class 'D'. However, by the time the river reaches Harike and Hussainiwala, the water quality improves to some extent due to its self purification capacity and it conforms Class 'B' to Class 'C' at Harike lake. D.

The annual average concentration of Dissolved Oxygen (DO) and Bio-Chemical Oxygen (BOD) demand for the year 2013-14 in river Sutlej at fifteen sampling stations is graphically shown in Fig 2.

River Beas

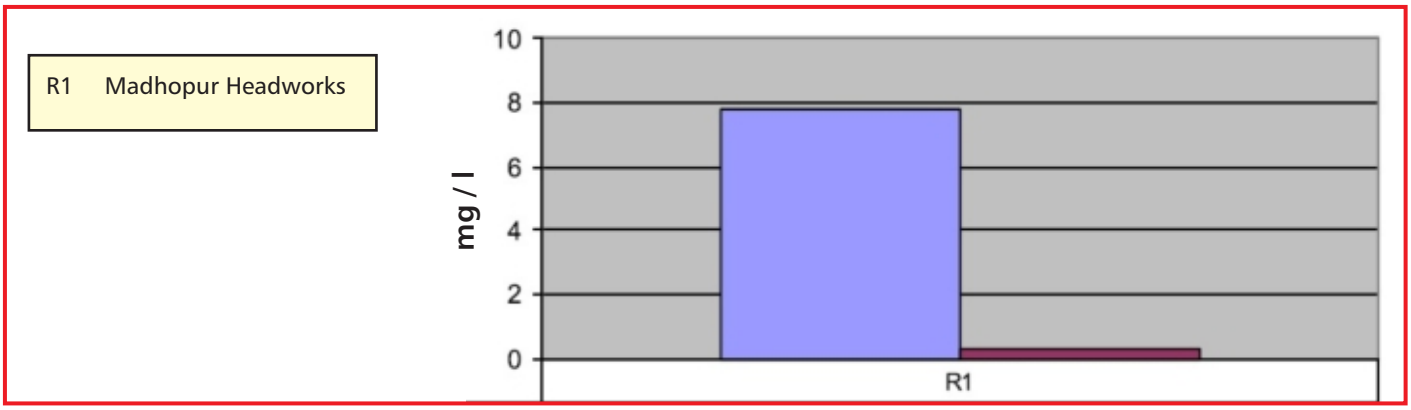
The water quality of river Beas after leaving Pong Dam in Talwara township is very good conforming to Class 'A' remained so till it receive the sewage from Mukerian town, Beas city & Goindwal Sahib and the quality comes down to Class "C" / "B" of water quality.

It reaches Harike with Class "B" water quality. There are 9 sampling stations at river Beas for monitoring purposes. The annual average concentration of DO and BOD in river Beas is graphically represented in **Fig 3**.

River Ravi

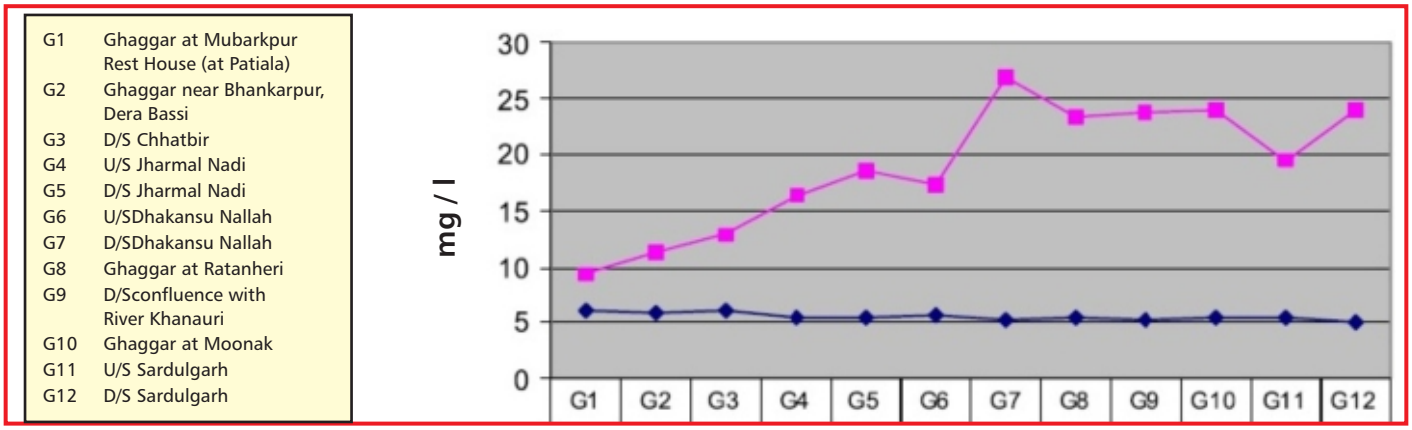
The water quality in the river is comparatively clean along its entire length since it is having a little human activity around it and it remains Class "A" throughout the year. There is only one sampling station on this river. The annual average concentration of DOand BOD in river Ravi is graphically shown as **Fig. 4**.

Fig. 4 Annual average concentrations of DO and BOD in river Ravi, 2013-14



Source: *Punjab Pollution Control Board, 2013*

Fig 5. Annual average concentrations of DO and BOD in river Ghagger, 2013-14



Source: *Punjab Pollution Control Board, 2013*

River Ghagger

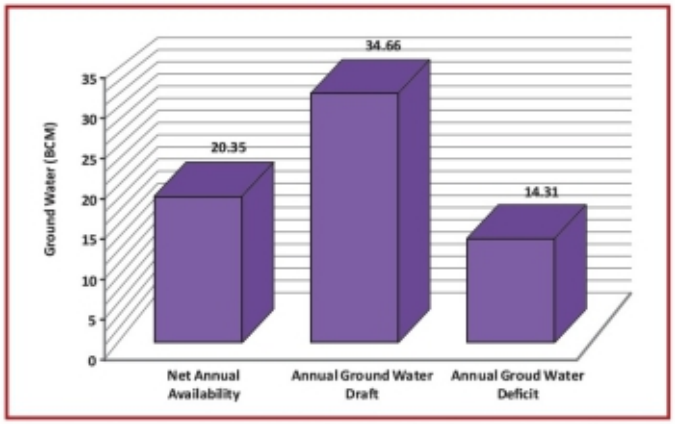
The Ghagger river has bad quality of water due to less flow in it. It carries the sewage from drains & cities. The quality of water at all the sampling location remains Class-D, throughout the year. The river carry surface run off from fields falling in their catchment area during rainy season alongwith sewage effluent of towns and cities situated along the river and other drains. There are 12 sampling stations on this river. The annual average concentration of DO and BOD in River Ghaggar is graphically shown as **Fig 5**.

Ground Water Availability & Development in Punjab

The total annual ground water resources in the state are estimated to be about 20.35 Billion Cubic Meter (BCM) as shown in **Fig 6**. The ground water is also a major source of drinking water. Agriculture in Punjab has a heavy requirement of water for irrigation purposes. The net irrigated area by different sources i.e. canals, tube wells and other sources in the state is shown in **Fig 7**.

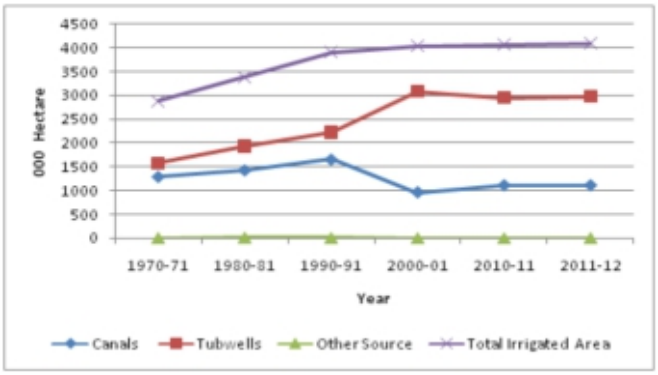
The dominance of rice and wheat monoculture cropping pattern over the years has led to overexploitation of ground water resulting in rapid decline of water table in the entire state (except south western part), as ground water is generally sweet and fit for irrigation. The depth of water table in the state is shown in **Map 4** and the state area with different water depths is shown in **Fig 8**.

Fig 6. Status of Ground Water Resources of Punjab



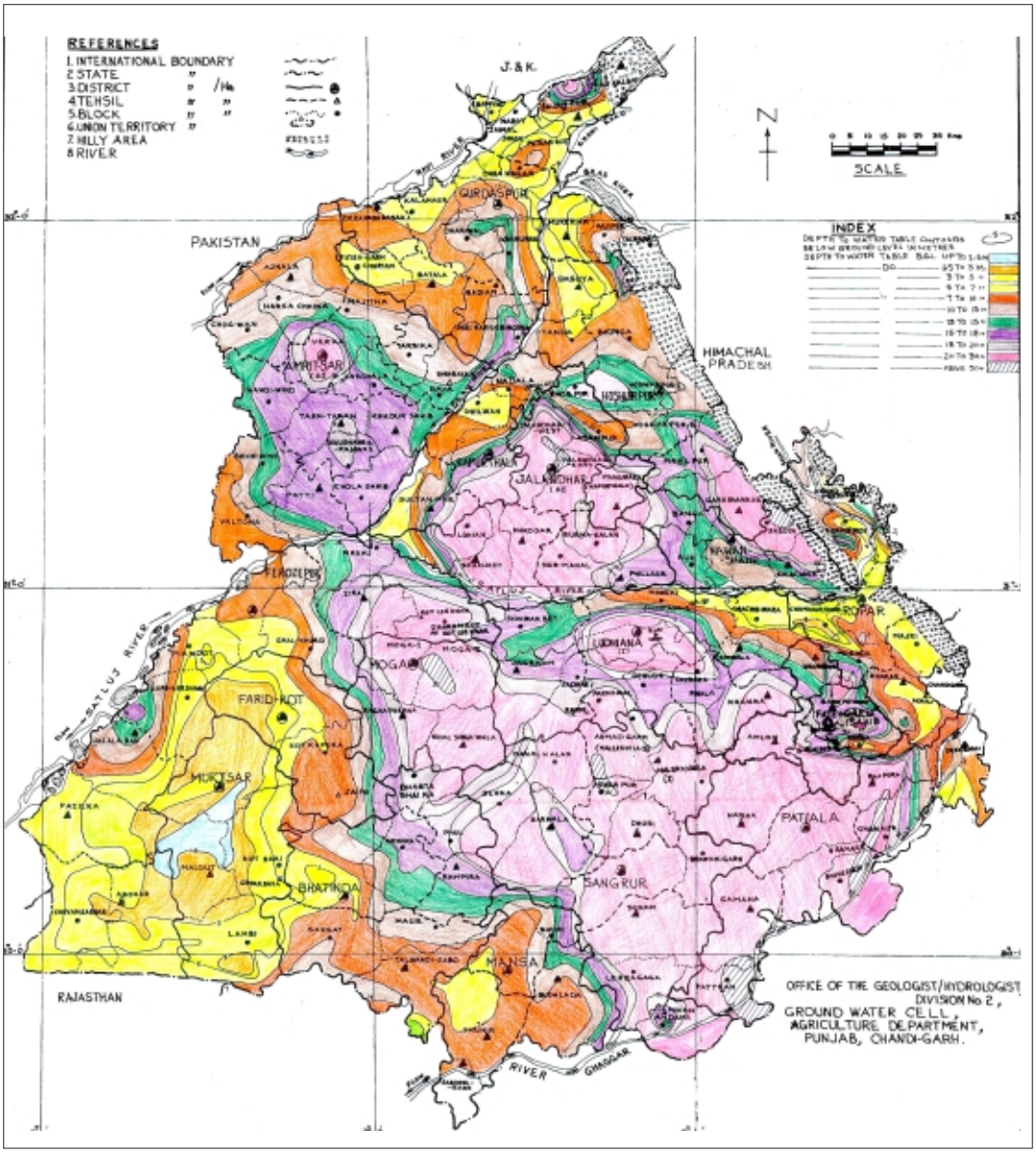
Source: Central Ground Water Board, Chandigarh, 2009

Fig 7. Net Irrigated Area (000 ha) by different sources in Punjab



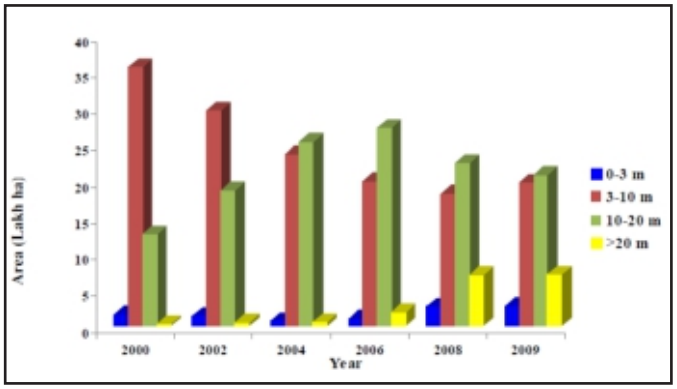
Source: *Statistical Abstract of Punjab, 2014*

Map 4. Depth of Water Table in June, 2010



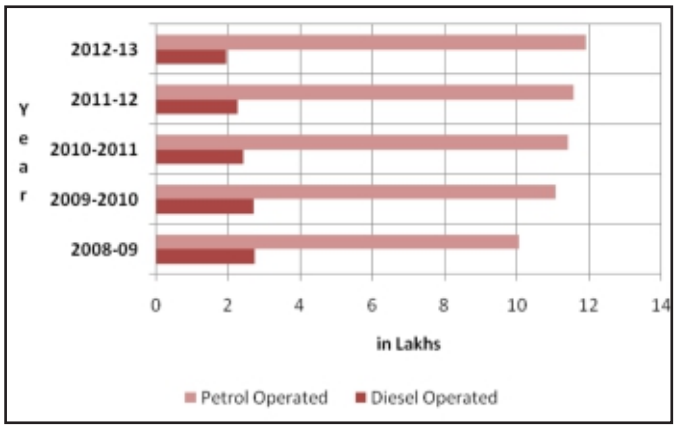
Source: *Department of Agriculture, Punjab*

Fig 8. Area under different water table depths in Punjab



Source: *Jain, 2013*

Fig 9. Growth of Tube wells in Punjab



Source: *Statistical Abstract of Punjab, 2012*

Table 2. Stage of Groundwater Development in Central Punjab

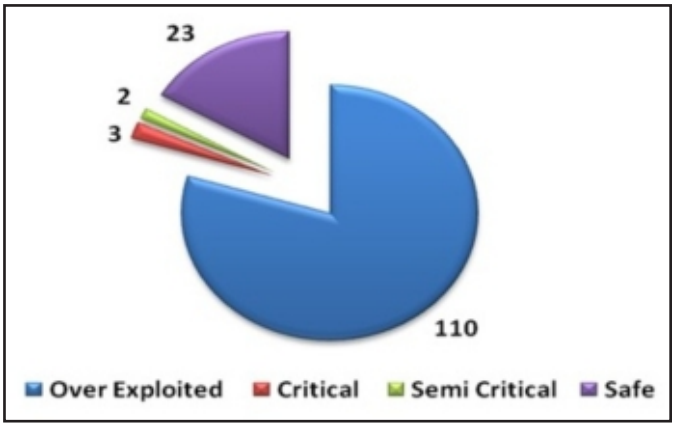
District	Groundwater Development (%)	
	Range	Average
Amritsar	161-199	179
Jalandhar	180-338	229
Kapurthala	192-369	235
Ludhiana	111-290	170
Moga	168-258	203
Patiala	149-409	195
Fateh Garh Sahib	197-243	210
Sangrur	217-360	264
Barnala	105-257	197
Tarn Taran	166-210	181

Source: *Water Resources and Environment Directorate, Punjab 2013*

As per the guidelines of Ground Water Resources Estimation Committee (GEC), the present ground water development (ratio of gross ground water draft for all uses to net ground water availability) in the state is 170 percent with an annual deficit of 14.31 BCM as on March 2009 as per latest data provided by Central Ground Water Board (CGWB), Chandigarh **(Fig 6)**. The state of ground water development is highest in central Punjab **(Table 2)**. The deficit is met through over exploitation of underground water reserves through tube-wells. The number of tube-wells in the state has increased from 6 lakhs in 1980 to 13.835 lakh in 2012 **(Fig 9)**.

The gravity of the situation can be gauged from the fact that ground water in 80 percent of total geographical area of the state (110 blocks) is over exploited in terms of stage of ground water development, as exploitation is more than 100 percent, 3 percent area of the state (5 blocks) is under the category of critical and semi critical category and only 17 percent area (23 Blocks) of the state is safe for ground water development **(Fig. 10)**. Data indicates that the number of dark/over exploited blocks have sharply escalated during the period 1992 to 2009 **(Fig 11)**.

Fig. 10. Categorization of Blocks in Punjab based on Ground Water Development



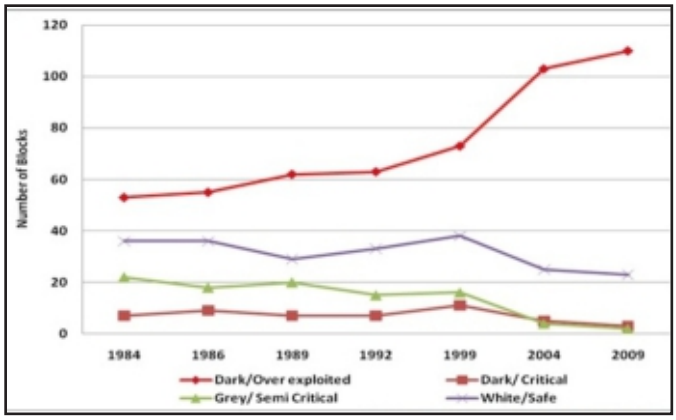
Over exploited: Exploitation > 100%, **Critical:** Exploitation > 90% ≤100%, **Semi Critical:** Exploitation > 70% ≤ 90%, **Safe:** Exploitation ≤70%.

Source: *Central Ground Water Board, 2009*

Decline in Water Table

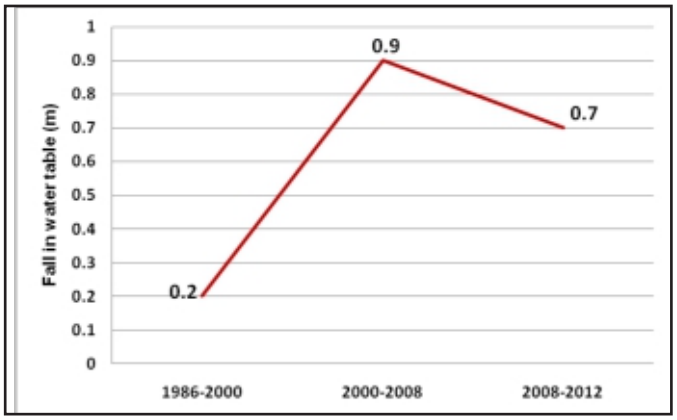
The use of ground water in excess of recharge is leading to fall in water table. As per Jain, 2013, the water table has receded at average annual rate of 0.70 metre (m) all across the state between 2008-12 with a range of water table decline from 0.10 m to 4.0 m **(Fig. 12)**. The situation has reached alarming proportion in central Punjab. Out of 73

Fig 11. Increase/Decrease in number of various categories of blocks in Punjab



Source: *Tiwana, et. al. , 2007*

Fig 12. Decline in water table (in meters) in Punjab



Source: *Jain, 2013*

blocks of central Punjab, the water table has gone down beyond 20 m depth in 34 blocks. The cumulative fall in ground water in central Punjab during last three decades is more than 9 m. The Sangrur and Patiala are worst affected districts. However, water table is rising in some south western parts of the state, where water extraction for irrigation purposes is limited due to its brackish and saline quality. In 2012, the Central Ground Water Authority has notified 45 blocks in state for restricting and banning the construction of new structures for extraction of ground water for any use other than drinking.

Ground Water Quality in Punjab

Ground Water Quality in Punjab has huge variation in different zones of the state, The quality of ground water changes from good to poor from North to South/South West. The ground water in South Western district of Punjab namely, Mansa, Bathinda, Muktsar, Ferozepur and Faridkot contain varying concentrations of soluble salts and their use for irrigation adversely affects agricultural production. The ground water of the state has been grouped into three categories i.e. good, marginal and poor. This has been based upon the variation in Electrical Conductivity (EC) and Residual Sodium Carbonate (RSC) Values. For good quality of Ground water, RSC shall be below 2.5me/L & EC below 2.00 dS/m (Source: Directorate of Water Resources & Environment, Punjab).

- **Good Quality Ground Water:** This category of ground water occupies about 51percent of total geographical area of the state. The good quality ground water is present along the flood plains of Sutluj, Beas, Ravi and Ghaggar rivers and also in the vicinity of major canals due to recharge of ground water aquifer with fresh water. Uppar Bari Doab plain and Doab belt has maximum area of good quality water.

- **Marginal Quality Ground Waters:** Marginal Quality Ground Waters occupy 37percent area of the state. Water under this category is saline, sodic or both. The extent of marginal quality ground waters is highest in the south-western zone.

- **Poor Quality Ground Water:** This category occupies nearly 6percent area of the state. The continuous use of poor quality water renders the soils unproductive or barren over a period of time. These waters are unsuitable for irrigation due to high EC or high RSC or both. The poor quality waters are present in S-W zone and Satluj-Ghaggar plain.

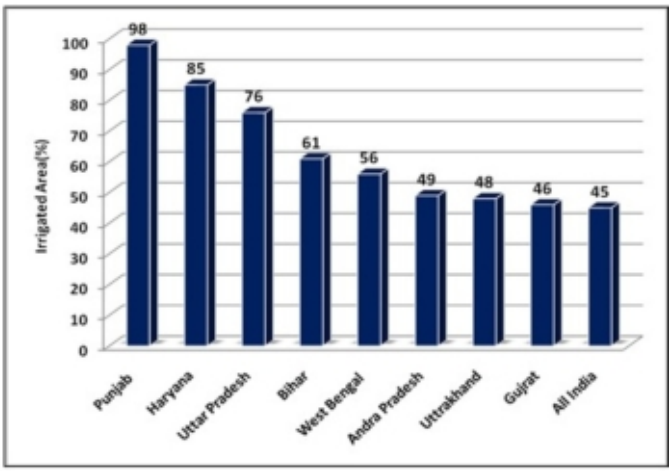
Access to safe drinking Water

Punjab tops the chart among Indian states in the availability of safe drinking water to 97.6percent households, which is significantly high as compared to the national average of 77.9 percent (Economic Survey, 2010-11). The water is sourced from canals, tube wells and percolation wells and from hand pumps. The water supply in urban areas has so far covered 88 urban centres (cities and towns) and reached 103.87 lakh population or 88 percent of the total urban population. Water is supplied through 11868 kms network of pipes, 1972 tube wells and through 354 overhead storage reservoirs (Source: Punjab Water Supply and Sewerage Board).

Some Issues and Challenges in Water Sector

- **Extensive Irrigation and exploitation of Ground Water:** The state has highest net irrigated area (percentage) in India **(Fig. 13)** and agriculture sector accounts for about 85 percent of water consumption in the state. Out of the total area of 4158 Th. ha under agriculture in state, an area of 4070 Th. ha (97.9 percent) is getting irrigation from canals (27percent) and tubewells (73percent). However, there has been a significant reduction canal irrigated area in the state since 1990 and area irrigated by centrifugal tubewells has been increasing **(Fig. 7)**. This is due to increased demand of water, reduction in canal capacity due to siltation and the easy credit facilities for tubewell installation with some subsidy, besides liberal facilities for electrification of tubewells. Hence, the ground water is being over exploited to meet the increasing demands of water for irrigation intensive agricultural practices The present ground water development in the state is 170 percent with ground water in 80 percent geographical area of the state is over exploited. The centrifugal pumps are becoming redundant and being replaced with submersible pumps especially in central Punjab due to depletion of underground water table.

Fig. 13. State wise Irrigated Area in India



Source: *State of Indian Agriculture, 2012-13*

- **Ground Water related Problems:** The problems are summarized in **Table3.**

- **Water pollution in Punjab:** In Punjab, rapid increase in population, urbanization, industrialization and agricultural practices are the major causes of water pollution. These sources have heavily polluted the fresh water resources of Punjab, both in physico-chemical and biological terms. The industrial, domestic and agricultural wastes accumulate in the

Table 3. Ground Water related Problems

Water logged area	200,000 ha
Salinity (EC > 3000 μS/cm at 25° C)	Ferozepur, Faridkot, Bathinda, Mansa, Muktsar, Sangrur (Area ~1 million ha)
Fluoride (>1.5 mg/l)	Amritsar, Bathinda, Faridkot, Fatehgarh Sahib, Ferozepur, Gurdaspur, Mansa, Moga, Muktsar, Patiala, Sangrur
Chloride (> 1000 mg/l)	Ferozepur, Muktsar
Iron (>1.0 mg/l)	Bathinda, Faridkot, Fatehgarh Sahib, Firozepur, Gurdaspur, Hoshiarpur, Mansa, Rupnagar, Sangrur
Nitrate (>45 mg/l)	Bathinda, Faridkot, Fatehgarh Sahib, Ferozepur, Gurdaspur, Hoshiarpur, Jalandhar, Kapurthala, Ludhiana, Mansa, Moga, Muktsar, Nawanshahr, Patiala, Rupnagar, Sangrur

Source : *www.jerath et.al., 2014*

Table 4. Water Polluting Industries in the State of Punjab (2002-12)

	Large and Medium (No. of Units)		Small Scale Industries (No. of Units)		Categories (No. of Units)		
Year	With ETP	Without ETP	With ETP	Without ETP	Red	Orange	Green
2002-03	386	1	1847	751	7989	-	4916
2008-09	353	1	2101	96	8804	-	7868
2009-10	456	-	3200	106	12238	-	9289
2010-11	496	-	3558	41	12971	19*	83*
2011-12	460	2	3013	37	11256	673	5852**
2012-13	498	-	3621	10	13174	58	118*

ETP = Effluent Treatment Plant

* This information is for large and medium scale industries only.

** Information is for operating units in the State and not includes the figures of regional office, S.A.S. Nagar.

Source: *Punjab Pollution Control Board, 2013*

aquatic ecosystems and then enter the primary, secondary and tertiary webs of the food chain. As wastes move along the food chain, these get magnified. During the past two decades, rapid increase in population, urbanization, industrialization and agricultural practices have heavily polluted the surface water resources of Punjab, both in Physicochemical and biological terms by one or more of the following ways:

- **Direct point sources:** Transfer of pollutants from industrial and municipal waste water disposal sites and refuse.
- **Diffuse agricultural sources:** Run off and soil erosion from agricultural lands carrying chemical fertilisers, herbicides and pesticides.

The Water Polluting Industries in the Punjab from 2002-12 are shown in **(Table 4)**.

Thus, the Challenges of Water Sector in Punjab are namely, ever increasing demand, depletion of Ground Water, canal efficiency below their designated capacity, deterioration of water quality, water logging in south-western districts and potable drinking water accessibility in South-

Water Pollution

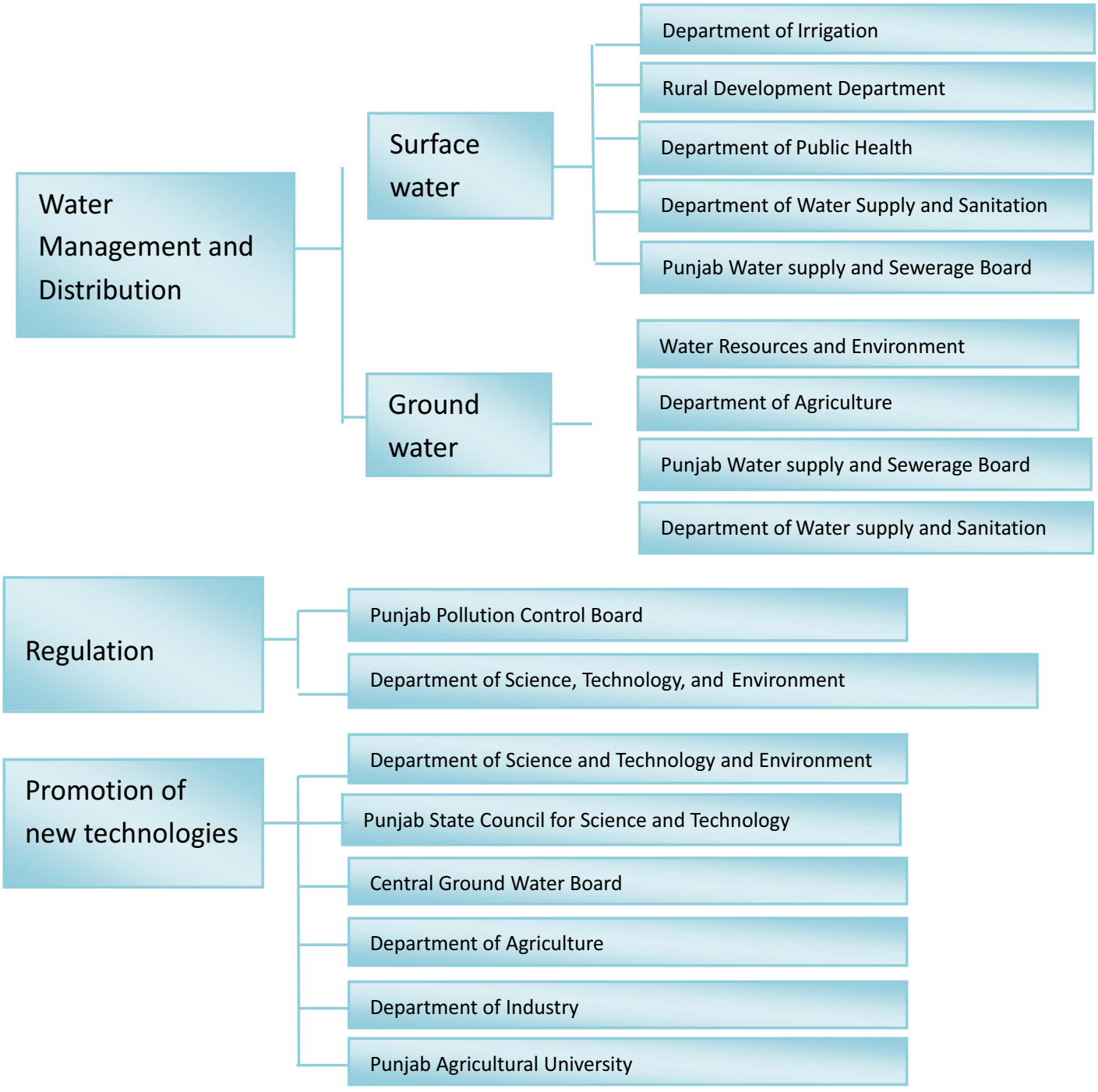
Water Logging in Fields

Western districts.

Management of Water Resources in Punjab

The three key elements of water management include (i) water source creation/augmentation and distribution, (ii) Regulation - which implies implementation of laws and monitoring and (iii) Promotion of new technologies for water conservation and improving water quality. These functions are carried out by various departments of the Punjab government.

Chart 1. Institutions Managing Water in Punjab



Major Initiatives for Management of Water Resources

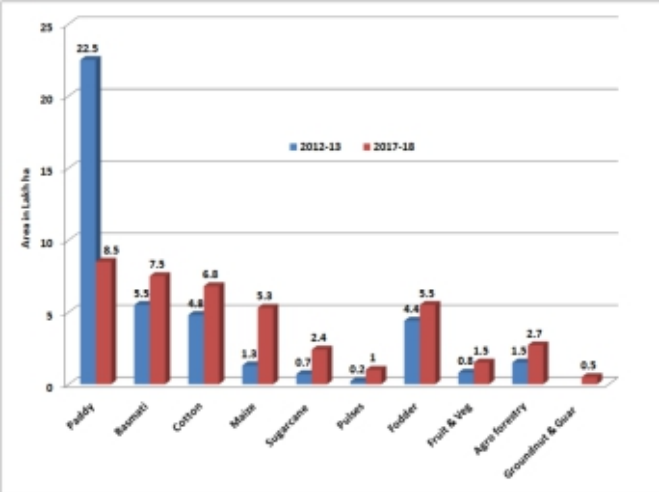
1. Irrigation related initiatives :

- Diversification of Agriculture : The State Govt. has envisaged a diversification plan to re-orient agriculture in the state by replacing 12 lakh hectares of area from paddy to other crops like maize, cotton, basmati, sugarcane, agroforestry, pulses and fruits and vegetables, pulses, fruits and agroforestry by 2017-18 **(Fig. 14)**. The major objectives of proposed plan are to arrest the depletion of sub-soil water table, control the mounting power subsidy bill and break the stagnation in terms of yield in the wheat-paddy cycle.
- Promoting Timely Plantation of Paddy: The State Govt. has enacted Punjab Preservation of Sub Soil Water Act, 2009 to preserve groundwater by prohibiting sowing paddy nursery before May 10 and transplanting paddy before June 15 to avoid the high evaporation rates in early summer. Estimates show that the Act has the potential to achieve annual savings of about 2,180 million cubicmeters of water (7percent of annual groundwater draft) and 175 million KWh of energy used for pumping groundwater **(Fig. 15)**.

Happy seeder in Agricultural field

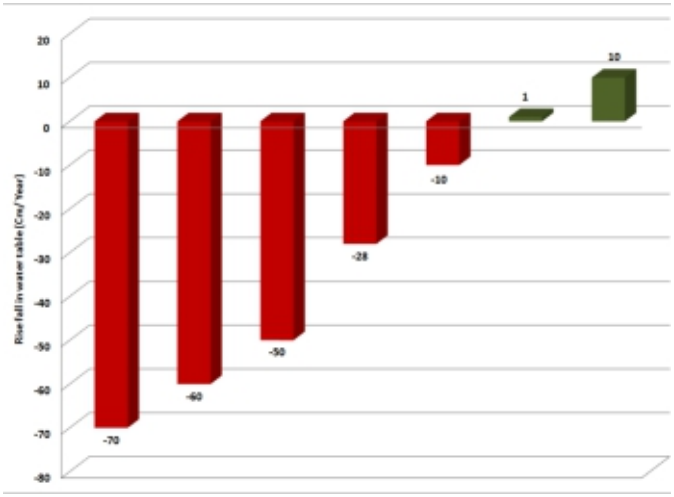
- Promotion of resource conservation technologies i.e zero tillage, direct seeding of paddy, ridge planting of paddy, leaf colour chart, tensiometre and machinery (on subsidy) such as Zerro till drill, Happy seeder, Laser leveling, Rotavator, Bailers, etc.
- Promotion of conjunctive use of water through Community Underground Pipeline Systems and Micro Irrigation (sprinkler & drip) as shown in **Table 5**.
- Coverage of an area of 55074 ha under contour bunding, gully reclamation and wasteland development.

Fig 14. Proposed Plan for Diversification of Agriculture in Punjab



Source: Department of Agriculture, Punjab, 2013-14

Fig 15. Rise / Fall of water table with date of Transplantation of Paddy



Source: Jerath et. al., 2007

Table 5 : Area covered under Underground Pipeline Systems and Micro Irrigation

Year	Area covered (ha)	
	UGPL	Micro Irrigation
2007-08	2696	4187
2008-09	5950	7396
2009-10	8461	11924
2010-11	23257	16849
2011-12	45402	21758
2012-13	49298	24548

Source: *Department of Soil & Water Conservation, Punjab, 2013-14*

- **Implementation of following Irrigation Programmes / Schemes :**
  - Accelerated Irrigation Benefit Programme (75 percent)
  - Command Area Development and Water Management Programme
  - Participatory Irrigation Management Programme
  - NABARD assistance for lining of Abohar and Bhakra main line canals
  - Project to rehabilitate ponds in all villages of the state
  - Project for modernization, remodeling, renovation and extension of canals, deep tube wells, lining of water courses, cleaning of head works, repairing of gates etc.

2. Drinking water and Sewerage related initiatives :

- Accelerated Rural water supply programme
- Rajiv Gandhi National Drinking Water Mission
- SwajalDhara
- National Rural Drinking Water Programme
- Punjab Rural Water Supply and Sanitation Project
- NABARD assistance for drinking water supply to NC Rural habitats
- Rejuvenation of Drinking Water Supply Schemes including the Operation and Maintenance (O&M) of the completed rural water supply schemes
- Abatement of Pollution of rivers Satluj and Beas
- Water supply and sewerage schemes for religious towns
- Rehabilitation of existing sewerage system in walled city area of Amritsar
- Water supply under UIDSSMT (Urban Infrastructure Development Scheme for small and Medium Towns)
- Sewage Treatment Plant for Ludhiana, Jalandhar, Bathinda, Phagwara under JNNURM
- Water supply/ sewerage/storm water drainage under JNNURM for Gidderbaha, Patti, Amritsar, Tarn Taran, Talwandi Sabo.

3. Pollution Control related initiatives :

- National River Conservation programme
- Surface Water monitoring under the MINAR scheme
- Waste Water Pollution control programme.
- PPCB advices, guides, encourage, persuade & help the industry in putting up effluent treatment plants (ETPs) to control and reduce pollution.
- Water quality programme.

4. Wetland Management related initiatives:

- Conservation measures at Harike, Kanjli, Ropar and Nangal Wetlands
- Conservation & management of state wetlands.

5. For Control of floods and Water logging:

- Flood Management Programme
- Flash flood control Programme
- NABARD scheme for construction of subsurface drainage.

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IMPORTANT WEB LINKS

www.agripb.gov.in
Department of Agriculture, Punjab

www.cgwb.gov.in
Central Ground Water Board

www.cwc.nic.in
Central Water Commission

www.dswcpunjab.gov.in
Department of Soil and Water Conservation

www.nih.ernet.in
National Institute of Hydrology

www.pbdwrss.gov.in
Department of Water Supply and Sanitation, Punjab

www.pbirrigation.gov.in
Department of Irrigation, Punjab

www. wrmin.nic.in
Ministry of Water Resources, Government of India

IMPORTANT NEWS

Climate change warming groundwater

Groundwater has not escaped climate change, according to a new study that found groundwater's temperature profiles echo those of the atmosphere.

Researchers used long-term temperature measurements of groundwater flows around the cities of Cologne and Karlsruhe, where the operators of the local waterworks have been measuring the temperature of the groundwater, which is largely uninfluenced by humans, for 40 years.

"For us, the data was a godsend," said Peter Bayer, a senior assistant at ETH Zurich's Geological Institute in Switzerland.

Evidently, it is less interesting or too costly for waterworks to measure groundwater temperatures systematically for a lengthy period of time.

Based on the readings, the researchers were able to demonstrate that the groundwater is not just warming up; the warming stages observed in the atmosphere are also echoed.

"Global warming is reflected directly in the groundwater, albeit damped and with a certain time lag," said Bayer.

The data also shows that the groundwater close to the surface down to a depth of around sixty metres has warmed up statistically significantly in the course of global warming over the last 40 years.

This water heating follows the warming pattern of the local and regional climate, which in turn mirrors that of global warming.

The groundwater shows how the atmosphere has made several temperature leaps at irregular intervals. These "regime shifts" can also be observed in the global climate.

The Earth's atmosphere has warmed up by an average of 0.13 degrees per decade in the last 50 years.

And this warming doesn't stop at the subsoil, either, as other climate scientists have demonstrated in the last two decades with drillings all over the world.

However, the researchers only tended to consider soils that did not contain any water or where there were no groundwater flows.

Source: *12 November, 2014, The Times of India*

20,000 solar pumps to provide drinking water to remote parts of India

The drinking water and sanitation ministry has set a target of installing 20,000 solar power-based pumping systems in tribal and inaccessible hamlets/ habitation during this financial year to provide potable piped water to the locals.

In such areas, piped drinking water is almost impossible due to non-availability of electricity. As per the plan, Chhattisgarh, Jharkhand, Odisha and Rajasthan would get 2,000 pumping systems each. Other states that have been identified for 1,500 such pumps are Bihar, Madhya Pradesh and Uttar Pradesh while Andhra Pradesh, Maharashtra, and Telangana would get 1,000 pumps each.

The central government has implemented similar innovative scheme in Integrated Action Plan (IAP) districts during last financial year in which a single phase, one horse power, solar energy-based submersible pump was installed in a high yield borewell, which already is a hand pump. In such cases, water pumped from the system can be stored in an elevated tank and the water can reach every household through pipes.

Such schemes can meet requirement of about 250 persons - population of a small village. Each such system costs about Rs 4.9 lakh; excluding the borewell and cost of water treatment.

The drinking water and sanitation ministry had earlier proposed to the new and renewable energy ministry for partial funding of this project.

Now the drinking water ministry has asked all the states to identify habitations and submit consolidated project report for approval. The renewable energy ministry has now agreed to put their state renewable energy development agencies as a technical support organization to the state water supply agencies to identify the hamlets, prepare the schemes and help in implementation.

Rural development and drinking water minister Nitin Gadkari had earlier announced the plan to provide more solar-based pumps to bring all areas under piped water supply scheme of government.

Source: *17 October, 2014, The Tribune*