Green Growth Background Paper

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Green Growth and water sector in Punjab

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Table of contents

List Tables

List Figures

List of Boxes

1 Introduction

The State of Punjab is located in the North Western region of India and is bound on the West by Pakistan, on the North by the state of Jammu and Kashmir, on the North East by Himachal Pradesh and on the South by Haryana and Rajasthan. Punjab has 22 districts and a population of 27.98 million. The state is predominantly an agrarian state and more than 62% of the population lives in rural areas. Punjab is a small state and occupies only 1.57% of the country's total geographical spread and is a part of the Indo-Gangetic plains formed due to alluvial deposits by rivers and tributaries. Two major rivers, the Sutlej and Beas, traverse the state and Ravi and Ghaggar touch its northern and southern borders, respectively. The state supports 2.4% of the country's population with a population density of 484 persons per sq km.

The state has a number of concerns in the present developmental scenario. In order to maximize the agricultural productivity of the state, the state over extracts ground water, uses excess chemicals, has an extensive and intensified rice and wheat cropping system. Along with these, practices on field burning of agriculture residues has led to degradation of water and soil. The other concerns include, loss in indigenous biodiversity of crops, saturation of agricultural productivity, drop in agricultural incomes, and rotting of grains due to limited storage space. The Urban habitats in Punjab are now over populated with inadequate housing, unscientific disposal of waste, inadequate coverage of water supply and sanitation especially in the slums and peri – urban areas, leading to incidences of climate triggered diseases. Also poor water and air quality is prevalent due to industrial activities.

2 Trends in water sector in Punjab

The state of Punjab is the wheat bowl of India. However, in order to maximize the agricultural productivity of the state, there is over extraction of ground water, excess usage of chemicals, pesticides and practice of extensive and intensified rice and wheat cropping system, many of which has led to degradation of water and soil. The other concerns include loss in indigenous biodiversity of crops, saturation of agricultural productivity, drop in agricultural incomes, and rotting of grains due to limited storage space. Wetland biodiversity is threatened by over extraction of water, pollution, encroachment, invasion of exotic weeds, soil erosion and land reclamation and due to excessive silting and sedimentation. The crop diversity in the state has been disturbed by the urban habitats, unscientific disposal of waste, inadequate coverage of water supply and sanitation especially in the slums and peri–urban areas, leading to incidences of climate triggered diseases.

Punjab has made great strides in making drinking water available to its population. However, accessibility of safe drinking water is still an issue. Water pollution due to discharge of industrial waste water, untreated discharge of municipal waste water in some towns and leaching of chemicals from synthetic fertilizers and pesticides into the soil, causes both surface water and ground water pollution. In addition to this the state is facing fluoride, chloride, nitrate and iron in ground water in areas of over extraction (Table 1).

There also exists the problem of salinity due to water logging in the western parts of the state.

Table 1: Indicators of groundwater quantity and quality

Groundwater balance	
Annual GW Availability	20.35 BCM
Net Annual Ground Water Draft	34.66 BCM
Annual Ground Water Draft	14.31 BCM
Ground Water Deficit	9.719 BCM
Stage of Ground Water development	170%
Ground Water Development & Management	
Over Exploited	64 blocks in 1964; 110 Blocks out of 136 blocks in 2009
Critical	3 Blocks in 2009
Semi-critical	2 Blocks
Water logged area	200,000 ha
Groundwater quality parameters	
Salinity (EC > 300 uS/cm at 25*C)	Firozepur, Faridkot, Bathinda, Mansa, Muktsar, Sangrur (Area -1 million ha)
Fluoride (> 1.5 mg/1)	Amritsar, Bathinda, Faridkot, Fatehgarh Sahib, Firozepur, Gurdaspur, Mansa, Moga, Muktsar, Patiala, Sangrur)
Chloride (>1000mg/1)	Firozpur, Muktsar
Iron (> 1.0 mg/1)	Bathinda, Faridkot, Fatehgarh Sahib, Ferozepur, Gurdasput, Hoshiarpur, Jalandhar, Kapurthala, Ludhiana, Mansa, Moga, Muktsar, Nawan Shaher, Patiala, Rupnagar, Sangrur

Source: CGWB (2010)

3 Key issues in the water sector

Punjab has been facing serious challenges in management of utilization of its water resources. It has reviewed and updated its existing water policy and came up with the Draft State Water Policy, 2008. This envisions that available water resources should be utilized efficiently and judiciously to meet drinking water needs and irrigation requirements in a manner that also promotes its conservation and community participation. Besides, the harnessing of water for commercial, industrial and hydro-power generation, its usage must take place in a sustainable manner ensuring desired quality of water. The policy also seeks to ensure that water, which is an essential requirement for sustaining all forms of life, is given due importance as a part of a larger ecological system.

The depleting water table (as depicted in Table-2) in Punjab is a cause of grave concern as it has given rise to water quality issues in Punjab. The groundwater reserves in central Punjab have gone down by over 20 metres in the past decade. The state requires 64.14 lakh crore litres of water to sustain its crops, but only 14.54 MAF (17.93 lakh crore litres) is available owing to a severely depleted water table. The Punjab government has been advocating direct seeding, which means sowing without prior tillage to prepare the soil, as a way to conserve water.

Table 2: Decline of water table in Central Punjab

	Percentage area with depth to water table more than		
Year	**10 m**	**15 m**	**20 m**
1973	3.7	0.6	0.4
1980	5.7	0.6	0.4
1990	26.7	2.9	0.4
2000	53.2	14.1	0.1
2001	65.7	21.7	1.2
2002	72.7	26.1	4.3
2003	79.9	32.7	5.7
2004	84.6	36.6	12.5
2005	85.4	42.1	14.5
2006	85.5	52.0	19.2
2007	80.4	46.4	26.3
2008	86.5	60.5	32.1
2009	81.9	62.9	34.5
2010	91.6	75.1	50.5

Source: (CGWB, 2013)

The high yielding varieties (HYV) of rice and wheat are the main consumers of water in agriculture sector in Punjab. The area covered under HYVs of wheat increased from 69% to 100% of the total area under wheat in Punjab between 1970 and 2001, and the total area under HYV wheat has increased from 3408 million ha to 3522 million ha in 2009-10 (Statistical Abstract, GoP, 2010), which clearly indicates an increasing trend in demand for water for irrigation over the years.

With increase in industrial units consumption of water is increasing proportionately. Between 1966 and 2009, medium and large industries have increased from 122 to 306 in Punjab and small scale industries have increased from 24 to 162559 during the same period (SoE, 2005 and Deptt of Industry, 2009). Similarly demand for drinking water in the state is continuously increasing as the population has increased from 1.35 crore in 1971 to 2.98 crore in 2012. Use of nitrogenous fertilizers and pesticides in agriculture is enhancing the nitrate concentration and accumulation of pesticide residues in water.

Consumption of synthetic fertilizers and pesticides in Punjab is the highest amongst all states and union territories in India (SAPCC, GoP, 2012). This is a serious issue to be taken up. Over usage of fertilizers and pesticides results in high Nitrate, Organo-Chloride and Organo-phosphates in drinking water sources. Further, rapid increase in population, urbanization and industrialization has polluted fresh water resources both in physiochemical and biological terms. The industrial pollution is mainly in the form of organic pollutants. Domestic and agriculture waste accumulate in the aquatic ecosystem and enter the primary, secondary and tertiary webs of the food chain.

Punjab government has demanded constitution of an appropriate tribunal for reallocation of the Ravi-Beas waters, due to the change in the circumstances which pertains to drastic reduction in the availability of Ravi-Beas waters from 17.17 million acre feet (MAF) to 14.37 MAF based on 1981-2002 flow series. The water has got further reduced to 13.38 MAF based on the latest flow series 1981-2013. Besides this, there is hydrological and environmental impact on Punjab on account of huge diversion of water to Yamuna basin areas, availability of additional water of 4.65 MAF to Haryana as provided in the Yamuna agreement.

4 Institutional framework and actors in the sector

The state of Punjab aims to undertake conservation and management of its water/water resources, improve water use efficiency, control water pollution, minimize wastage, and ensure equitable distribution of water across the state by addressing the impacts of climate change on water resources.

The Punjab government has initiated activities to maintain water quality and abate water pollution, such as identifying sources of pollution, regular water pollution monitoring through its various departments, setting up CETP (Common Effluent Treatment Plants) in various industrial areas to clean industrial waste water, putting up reverse osmosis systems to combat the impacts of fluoride and salinity, undertaking major programmes for cleaning up river waters amongst others. Punjab being an agriculture intensive state, the focus is majorly on agriculture and water issues. The three key elements of water management in Punjab 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 and are shown in Figure 1.

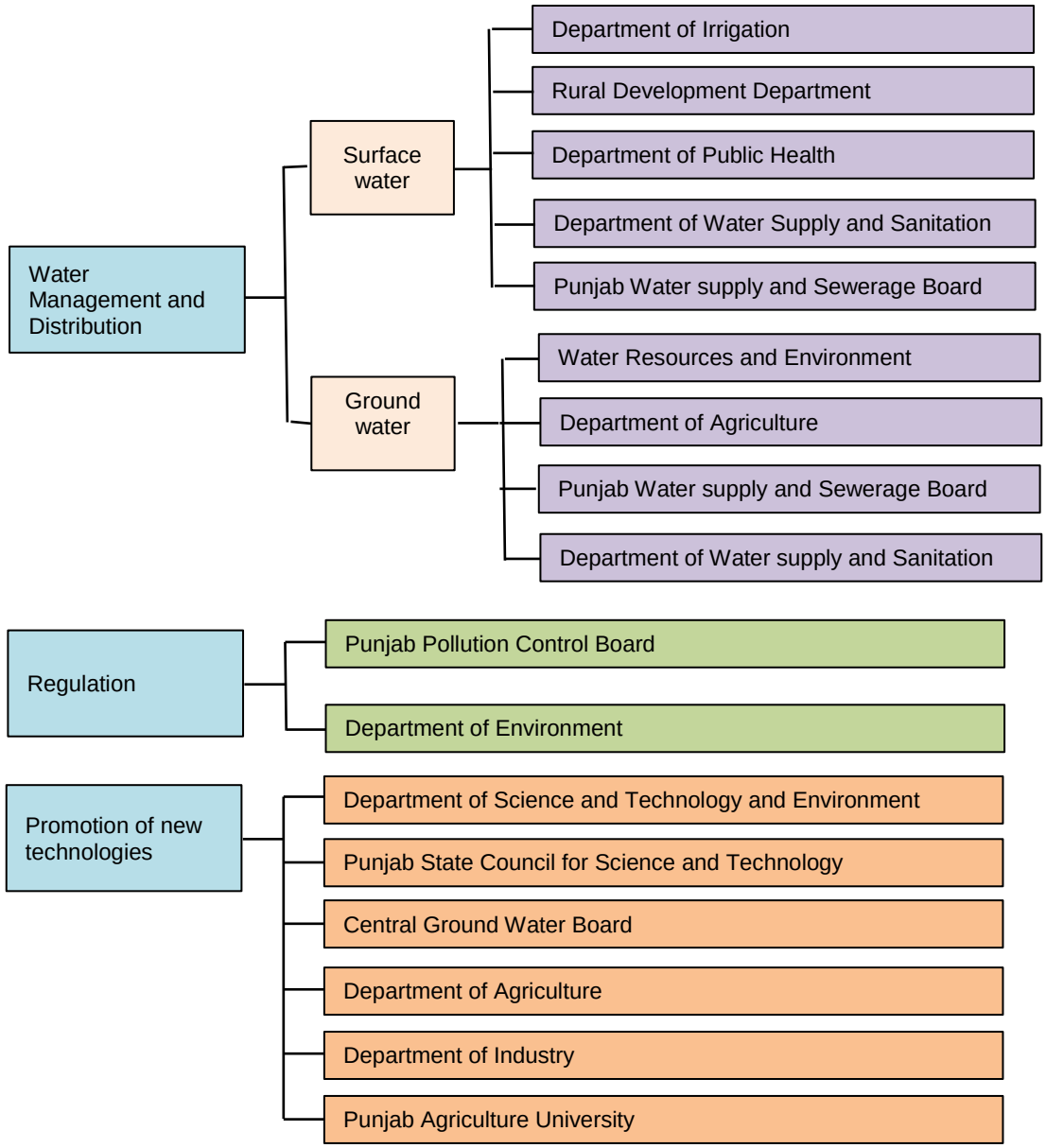

Figure 1: Institutions managing water in Punjab

Source: SAPCC Punjab Report, (2012)

The Punjab State Water Policy was first adopted in May 1997 on the lines of National Water Policy- 1987 (NWP-1987). Since Punjab has been facing serious challenges in management of utilization of its water resources, it reviewed and updated its existing water policy and came up with the Draft State Water Policy, 2008, which envisions that available water resources should be utilized efficiently and judiciously to meet drinking water needs and irrigation requirements in a manner that also promotes its conservation and community participation.

Punjab has undertaken measures such as:

1. Science, Technology and Environment- water pollution, waste management, research and development for environmental issue

2. Agriculture- Crop diversification, address paddy straw burning, input use (pesticide and fertilizer), groundwater management

3. Forest and Wildlife Preservation- Increase green cover according to state forest policy, biodiversity conservation, soil erosion, rainwater harvesting and recharging (including in Kandi areas),

4. Housing and Urban Development- Waste management, recycling, energy efficiency, water efficiency, solid waste management and sewage treatment

5. Rural Development and Panchayats- Crop residue management (collection through MG-NREGS), address soil erosion, soil preservation, rainwater harvesting, farmer training, roadside plantation

6. Irrigation- Groundwater, resource conservation, clean energy based pump-sets, rain water harvesting, flood management, management of water logging

7. Public works- Green buildings, energy efficiency, water efficiency

8. Water Supply and Sanitation- Water quality, improve sanitation, solid waste management and sewage treatment, bio-energy

9. Soil and Water Conservation- Water conservation, improve soil quality, water harvesting

Besides, the harnessing of water for commercial, industrial and hydro-power generation, its usage must take place in a sustainable manner ensuring desired quality of water. The policy also seeks to ensure that water, which is an essential requirement for sustaining all forms of life, is given due importance as a part of a larger ecological system.

The **Punjab Ground Water (Control and Regulation) Act, 1998** was enacted to regulate indiscriminate extraction of ground water. Further, in March 2009 the Punjab Legislative Assembly passed the **Punjab Preservation of Sub-Soil Water Act, 2009,** to restrict paddy transplantation not before 10th June. Punjab State Electricity Board has been requested to supply power only after 10th June to limit over extraction of ground water before monsoon. Building bye-laws have been amended (PUDA Building Rules, 1996) to make rain water harvesting system mandatory in all buildings of above 400 sq m/ 500 sq. yds. Municipal Corporations of Ludhiana and Jalandhar have also framed bye-laws to make rain water harvesting mandatory in new buildings.

In urban areas for all the residential projects, commercial projects and other mega projects, Punjab Pollution Control Board (PPCB) has made it mandatory to implement the rain water harvesting. While granting No Objection Certificate (NOCs) and other statutory clearances to the project proponents, the Punjab Pollution Control Board as well as the Ministry of Environment and Forests, New Delhi, stipulates special conditions to this effect. There are various 'Missions' in Punjab, which are aligned to the National Action Plan on Climate Change (NAPCC). The following missions have some of the green growth strategies for water sector and are mentioned in the Table 3 below:

Table 3: NAPCC Missions related to water resources in Punjab

Punjab Mission on Sustainable Agriculture	• Agriculture and Horticulture Crops promotes resource conservation of soil, water and energy • Fisheries ➢ Renovate/rehabilitate of village ponds and development of new ponds/tanks in saline affected waterlogged land in the south-west district of Punjab ➢ Develop Saline affected waterlogged area in the south-west districts of Punjab for fisheries • Determination of hydrological and physico-chemical characteristics of water bodies.
Green Punjab Mission	• Extend forest area in Punjab up to 10% of its geographical area by 2022- by using land for afforestation in saline and alkaline areas and in water logged areas, through agroforestry, by planting trees outside forests in institutional areas • Enhance forest density in moderate and open forest area- provide forest corridors for species migration, revitalize community based initiatives, promote climate hardy species, form forest fire management committees and involve remote sensing technology, undertake integrated watershed development in Shivaliks to prevent soil erosion and retain soil moisture, undertake enrichment plantation and aided natural regeneration in Shivaliks, and promote sacred groves Rainwater harvesting, increasing recharge capacities of soils, enhancing monitoring of disease prevalence, Energy efficiency, Conservation of energy and harnessing energy from waste will be some of the key tools for sustaining impacts of climate change.
Mission on Sustainable Habitats- Protecting settlements	• Gear up infrastructure in urban areas in order to : • Increase rainwater harvesting systems in the urban areas- ensure compliance, ➢ Increase water recharge capacity and ➢ Reduce evapo-transpiration from the soils to avoid runoff, ➢ To ensure adequate waste manage system to avoid clogging

Several centrally sponsored schemes, state schemes and loans from financial institutions such as NABARD, World Bank and the ADB, help to finance the various activities towards management of water resources in the state. State initiatives towards management of its water resources are as mentioned below:

In the Irrigation sector, the various Programme/project are:

- Accelerated Irrigation Benefit Programme
- Participatory Irrigation Management Programme

- Command Area Development and Water Management Programme
- NABARD assistance for lining of Abohar and Bhakra main line canal
- 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 canals etc.

The achievements in this sector are:

- Net area irrigated as of 2007-08 was 4112 thousand ha i.e 98.21% of the net sown area
- Assured irrigation to the farmers through 2 projects namely Sirhind feeder Phase-II and Bathinda canal Phase-II
- Cleaning up brackish/fluoride affected and water logged villages in the state.

In the Drinking water and Sewarage sector (Rural), the Programmes are:

- Accelerated Rural water supply programme
- Rajiv Gandhi National Drinking Water Mission
- Swajal Dhara
- 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
- Operation and Maintenance (O&M) of the completed rural water supply schemes is being handed over to Panchayats in NABARD assisted programme for Individual House Hold Latrines in rural Areas

The achievements in this sector are:

As of Feb 2012, 14013 rural habitations have access to drinking water out of the total 14605 total rural habitations achieving 99.3% coverage. For water quality monitoring every month, 4450 water samples monitored for chlorination / silver ionization; 3000 water samples collected for physical & chemical analysis; Around 2140 water samples collected to check indicative bacteriological contamination and installation of Reverse Osmosis (RO) technology in quality affected areas.

In the Urban sector, the projects are:

- Abatement of Pollution of rivers Sutlej 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

Achievements in this sector are:

- As of Feb 2012, 88% urban population in 139 towns has access to drinking water supply.
- 88 towns covered with sewerage covering 63% of the urban population
- Reuse of treated waste water after treatment of 45 MLD domestic waste water of Ludhiana at Bhatian.

There have been significant efforts in **pollution control**, under the National River Conservation programme. Regulating quality of Industrial & domestic waste water within standard limits is a priority for Punjab Pollution Control Board. The Board has achieved following in this direction:-

- Surface water monitoring through the Monitoring of Indian Aquatic Resources (MINAR) scheme
- Waste water pollution control programme
- Punjab Pollution Control Board (PPCB), advices, guides, encourages, persuades and helps the industry in putting up effluent treatment plants (ETPs) to control and reduce pollution.
- To reduce the point sources of industrial pollution, Punjab Pollution Control Board is encouraging the establishment of common effluent treatment plants (CETPs). For example, a common effluent treatment plant has been installed for leather Complex, Jalandhar and two CETPs have been installed for electroplating units at Ludhiana and Malerkotla respectively.
- All the large and medium electroplating units in Ludhiana have achieved zero liquid discharge.
- All the small scale electroplating industries of Ludhiana have become member of CETP & treated effluent from this CETP is being used for other industries.

- In case of electroplating units of Jalandhar area, the Board has directed these industries to join the CETP, Ludhiana and most of the units have now become the members of CETP. The treated effluent from the units shall also be re-circulated to nearby industries of CETP.

- In case of dyeing units, with the introduction of new technology, machines with less liquor ratio and better absorbing dyes, the quantum of waste water generation is reduced considerably

- PPCB Monitors water quality of all the four rivers of the State viz. Sutlej, Beas, Ravi & Ghaggar and also at Harike lake at 37 monitoring locations

- Discharge monitoring in towns of Jalandhar, Phagwara, Tanda, Dasuya, Mukerian, Baloth, Hoshiarpur, Moga, Phillaur and Banga along the Ghaggar and Sutlej

- PWSB is laying lateral sewers, main sewers and setting up STPs at 45 towns along these rivers into the rivers

- With the introduction of latest technologies like MEE the condensates generated from waste water are being recycled back in the process. This technology is already introduced in the field of Pharmaceutical sector.

- The Board has directed all the distillery units in the State of Punjab to adopt zero liquid discharge. Four of the units have already adopted this technology.

The achievements in this sector are:

- Monitors groundwater quality in industrial towns of Ludhiana, Jalandhar, Amritsar, Nangal etc.

- Sludge sampling of waste water discharge from tannery, beverage, chemicals, electro plating and other industries

- 5 CETPs set up in leather (2), dying (2 under proposal), Electroplating (1) in Ludhiana and 1 in MalerKotla), 8 more in electroplating industry, Bag tanning at Phillaur (1)

- RO Plants installed in industries for reuse of waste water

- 24 ambient air monitoring stations across Punjab

Furthermore, the Mission on Strategic Knowledge on Climate Change aims to

- Formulate knowledge networks among the existing knowledge institutions engaged in research and development relating to climate science and facilitate data sharing and exchange through a suitable policy framework and institutional support

- Establish global technology watch groups with institutional capacities to carry out research on risk minimized technology selection for developmental choices

- Develop a Centre for excellence in existing R&D body to address all research issues and technology development and demonstration issues

The Water Mission of Punjab has drawn out a number of innovative strategies for green growth in the water sector as mentioned in Box 1.

Box 1: Action Plan of the Punjab Water Mission

- Draft a State Water Policy to undertake an integrated water resource management at a basin level within the state with the aim to conserve water, minimize wastage and ensure equitable distribution in a climate change scenario
- Undertake a focused approach to augment ground water especially in critical and semi critical areas taking advantage of continued projection of excess rainfall with respect to base line scenario.
- Augment surface water resources to accommodate excess rainfall and runoff projected for mid-century.
- Enhance water use efficiency by 20% with respect to the present.
- Manage floods in a future excess rain fall scenario
- Contain the likely enhanced water logging situation in the south west districts of Punjab due to the projected rain fall exceeding 50% of the base line scenario in this region
- Abate continued water pollution likely to increase due to increase in industries, population in underground and surface water
- Establish adequate institutional support for efficient water resource augmentation, conservation, distribution and governance through development of basin level Integrated Water Management plans Suggested research and monitoring activities for effective decision making

Source: SAPCC Punjab, (2012)

The state aims to enhance water use efficiency by 20% (SAPCC, GoP, 2012) with respect to the present. The actions would include enhancement of share of waste water reuse in the total water used in different sectors. This is expected to reduce leakage through water distribution pipes, and implement metering of unauthorized connections, promotion of water use efficiency in agriculture, in the industrial sector, implementing differential pricing of water use for agriculture, industrial and domestic sectors and by reducing water allowances for agriculture in water logged areas thereby saving water.

The Government of Punjab has recognized that over-exploitation of groundwater is an issue of serious concern and has implemented the Punjab Preservation of Subsoil Water Act of 2009 to contain groundwater exploitation. The main purpose of the Act is to save groundwater by prohibiting sowing and transplanting paddy before specified dates in the hot and dry summer period. The Act prohibits farmers from transplanting paddy before 10 June in a year. Any farmer, who contravenes the provisions of the Act, shall be liable of penalty of INR 10000 for every month or part thereof, per hectare of the land till the period such contravention continues.

The Green Punjab Mission undertakes human resource development (HRD) and capacity building activities to implement Green Punjab Mission. Through the implementation of the State Action Plans for climate Change (SAPCC), it is envisaged that the climate change concerns will be integrated. However in order to do so it is essential to have capacity building programmes for various levels including at the policy level, at the scientific and technical level and at the grassroots level. Additionally, women centric capacity building programmes will be required to enable effective water and natural resource conservation. In

order to enhance agricultural productivity through customized interventions such as use of bio-technology to develop improved varieties of crops and livestock, promoting efficient irrigation systems, demonstration of appropriate technology, capacity building and skill development programmes are undertaken regularly.

5 Ways forward

Green growth strategies in the water sector requires balance between water use and water protection within an integrated water resources management framework. Effective regulation, coordination and management of water sector can help Punjab to sustainably manage its water resources, which at present is facing major water quality and availability issues.

The state is now at cross roads. The state's agriculture has reached a plateau under the available technologies and natural resource base and has become unsustainable and non-profitable. With increase in population, per capita availability of land and water is decreasing, thus affecting productivity per unit area. Further, the policy of free electricity to farmers has resulted in excessive mining of groundwater resources due to cultivation of water intensive crops like paddy. The subsidy on fertilizers has encouraged the farmers towards excessive use of nitrogenous fertilizers with relative under-utilization of other fertilizers and micronutrients leading to unbalanced fertilizer use which, in turn, has adversely affected soil quality over time, apart from causing environmental pollution. Over-usage of pesticides and insecticides has led to contaminated surface and underground water resulting in adverse health impacts. Immediate action needs to be carried out before the water quality issues and its health impacts magnify further.

An integrated set of interventions with implementation framework can be developed for reducing river and underground pollution and facilitate its participatory implementation with stakeholders. Short to medium term and medium to long term strategies for green growth in Punjab in the water sector have been discussed below:

5.1 Short to Medium term strategy

- Given the over-exploited groundwater tables, deteriorating groundwater quality in most of the blocks in Punjab, there is a critical need to develop a comprehensive water conservation and management plan to rejuvenate water bodies and restore lakes and rivers that ensures the replenishment of water to the local aquifers and in general improves the water availability scenario in the State.

- Electricity subsidies are widely perceived to be one of the main causes of groundwater overexploitation. They encourage farmers to extract ground water at unsustainable rates which causes lowering of water tables requiring more energy to extract groundwater thus raising the cost of agricultural products.

- Implementation and enforcement of existing laws is weak. For instance, Electricity Act 2003 made metering mandatory, but to no avail.

- The ownership of expensive agriculture machinery by individual farmers also needs to be reduced. These facilities should be provided by village cooperatives or private entrepreneurs on custom hiring basis so that groundwater is not exploited above sustainable levels affecting the water quality and availability.

- The feeders for supply of power for agriculture can be separated to curb misuse of electricity and thereby groundwater.

- Municipal and industrial effluents are discharged directly or indirectly into water bodies without adequate treatment. Treatment of municipal and industrial effluents should be mandatory before disposal to water bodies. Effective legislation at the State level would check these polluting sources. Developing a mechanisms is essential to facilitate all major commercial/institutional/industrial service entities to move to zero liquid discharge (ZLD) in a defined time frame.

- Review the limiting factors and existing gaps in wastewater treatment in river basin (with respect to the technical, social, financial, institutional/ regulatory aspects) in order to reduce future challenges.

- Adoption and application of "Clean Technology" at the industrial units would bring about reduction in production cost but also reduce pollution and enhance efficiency in resource management.

- There is urgent need to put a strategy in place to manage the resource for which the necessary condition is that we know the resource; credible estimates of total consumption of irrigation water, electricity and diesel disaggregated by crops, regions etc. This will help identify different aspects (technology, agronomic and other practices) which need to be targeted.

- There is urgent need to bring about changes in cropping pattern by reducing area under rice cultivation, promoting organic farming, bio-gasification of agricultural waste, after extensive consultations with farmers.

- Adopting demand driven approaches such as enhancing water use efficiency in all the three sectors, such as: agriculture, industries and domestic, would reduce unaccounted-for-water (UFW).

- Exploring alternative sources such as recycling of wastewater for non-potable use, improving operational efficiencies etc. would go a long way in addressing the water quality and water quantity issues in Punjab.

- The water conflicts between Punjab and neighboring states has been pending in judiciary for many years. The state government has pleaded that a time limit of one year be fixed under the Interstate Water Dispute Act for constitution of a tribunal after a complaint is filed, but more than 10 years have elapsed but Government of India has not taken any action in this matter. This needs to be expedited by constitution of an appropriate tribunal for reallocation of the Ravi-Beas waters.

5.2 Medium to long term strategies

- Punjab is yet to formulate a ground water policy. It needs to develop an implementation framework for policies and mechanisms for operationalizing them.

- There is a need for strengthening of groundwater authorities in the State by providing more autonomy. This would help promote water conservation and recharge of ground water. Several watershed development projects are being implemented in the state especially in Kandi area. This needs to be sustained for long term.

- Water use efficiency needs to be increased particularly in paddy cultivation. The State of Environment Report of Punjab estimated that a 10% increase in irrigation efficiency can help to bring additional 14 million ha area under irrigation. Punjab could take learning lessons from countries like Israel, which is based on the principle of 'More crop per drop'. They not only use water efficient technologies in agriculture (drip/sprinkler irrigation) but also adopt best available and water efficient technologies in all other sectors.

- The gap between irrigation potential created and actual irrigation achieved also needs to be bridged. This is possible by arresting siltation in canals and reservoirs and by remodelling, reconditioning, repair, maintenance and upgradation of existing canal system to provide assured water supply up to the tail end.

- Integrated wastewater management by treatment, recycle and re-use by identifying and designing innovative solutions for domestic and/or industrial sectors with appropriate use of decentralised and/or centralised options. Developing mechanisms and MIS platform with innovative information and communication technology (ICT) tools and technologies for an integrated and efficient monitoring, informed systemic responses and decision making.

- Developing water quality database and management using real time monitoring, linking billing with water supply network designs using Supervisory Control and Data Acquisition (SCADA) and cloud computing systems.

- Mechanisms for rational water pricing and sustainable financial performance of the local bodies.

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About TERI

A unique developing country institution, TERI is deeply committed to every aspect of sustainable development. From providing environment-friendly solutions to rural energy problems to helping shape the development of the Indian oil and gas sector; from tackling global climate change issues across many continents to enhancing forest conservation efforts among local communities; from advancing solutions to growing urban transport and air pollution problems to promoting energy efficiency in the Indian industry, the emphasis has always been on finding innovative solutions to make the world a better place to live in. However, while TERI's vision is global, its roots are firmly entrenched in Indian soil. All activities in TERI move from formulating local- and national-level strategies to suggesting global solutions to critical energy and environment-related issues. TERI has grown to establish a presence in not only different corners and regions of India, but is perhaps the only developing country institution to have established a presence in North America and Europe and on the Asian continent in Japan, Malaysia, and the Gulf.

TERI possesses rich and varied experience in the electricity/energy sector in India and abroad, and has been providing assistance on a range of activities to public, private, and international clients. It offers invaluable expertise in the fields of power, coal and hydrocarbons and has extensive experience on regulatory and tariff issues, policy and institutional issues. TERI has been at the forefront in providing expertise and professional services to national and international clients. TERI has been closely working with utilities, regulatory commissions, government, bilateral and multilateral organizations (The World Bank, ADB, JBIC, DFID, and USAID, among many others) in the past. This has been possible since TERI has multidisciplinary expertise comprising of economist, technical, social, environmental, and management.

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