Water Crisis: Issues and Challenges in Punjab

A Dissertation Report

Submitted by
VISHAL GARG
(Roll No. 4607)

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Dr KUSUM LATA
Associate Professor , Urban and Regional Planning
IIPA, New Delhi

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WATER CRISIS : ISSUES AND CHALLENGES IN PUNJAB

The hallmark of great leadership is the ability to recognize a problem before it becomes an emergency.

Edmund Burke

CERTIFICATE

I have the pleasure to certify that **Shri Vishal Garg** has pursued his research work and prepared the present dissertation titled **"Water Crisis : Issues and Challenges in Punjab"** under my guidance and supervision. The dissertation is the result of his own research and to the best of my knowledge, no part of it earlier comprised any other monograph, dissertation or book. This is being submitted to the Indian Institute of Public (IIPA) for the Master's Diploma in Public Administration (MDPA) in partial fulfilment of the requirement of the Advanced Professional Program in Public Administration (APPPA).

I recommend that the dissertation of Shri Vishal Garg is worthy of consideration for the award of MDPA of IIPA.

Kusum Lata

Dr Kusum Lata
Associate Professor
Urban and Regional Planning
Indian Institute of Public Administration
I.P. Estate, Ring Road,
New Delhi - 110002

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(VISHAL GARG)

ABSTRACT

The land-augmenting and productivity-enhancing role of groundwater has been well documented in India and elsewhere. As an integral component of Green Revolution technology, groundwater irrigation played a catalytic role in averting food crisis in India during mid-sixties. But injudicious utilisation and excessive reliance on this precious natural resource has resulted into emergence of a groundwater crisis, especially in North-West region of the country.

Groundwater depletion has emerged as the major constraint in sustaining growth in agriculturally advanced state of Punjab. The deterioration in groundwater resources is the outcome of technology and policy led shift in cropping pattern (towards paddy), irrigation source (towards groundwater) and energy source (towards electricity) in Punjab. Presently, total annual groundwater draft in the state is 72 per cent higher than the sustainable limit of 20 BCM. Agriculture being the largest user of groundwater draft bears the prime responsibility in averting groundwater crisis. Paddy emerged as the most water-guzzling crop consuming 45 to 88 per cent higher groundwater than other crops. Consequently, paddy had highest groundwater footprints (cum/kg) and lowest groundwater productivity (Rs/cum). Further, there exists large scale inefficiency in groundwater use for paddy cultivation.

Injudicious surface water irrigation policies, excessive ground water pumping due to free electricity coupled with irrational irrigation and agricultural practices have led to a situation wherein fresh ground water resources of the state have depleted at an alarming rate in most parts of the state. It is believed that the water table in the state is falling by up to one metre per year.

The optimum level of groundwater use for paddy cultivation should be about 52 per cent less than the present level of 1.2 ha-metre. Interestingly, large farmers emerged as more efficient user of groundwater resources and productive as compared to farmers with smaller land holdings. The strategy to ensure sustainability must include both groundwater supply augmentation and demand reduction measures with greater emphasis on improving water use efficiency and curtailing non-productive use of groundwater resources.

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ACRONYMS

ADB – Asian Development Bank

BCM – Billion Cubic Meter

BGL – Below Ground Level

CETP – Central Effluent Treatment Plant

CGWB – Central Ground Water Board

DBI – Doubling Farmers Income Committee

DBTE – Direct Benefit Transfer of Electricity subsidies

DDGWE – Draft Dynamic Ground Water Estimation Report

EC – Electrical Conductivity

ETP – Effluent Treatment Plant

FICCI – Federation of Indian Chamber of Commerce and Industry

GEC – Groundwater resource Estimation Committee

GOP – Government of Punjab

GW – Ground Water

HAM – Hectare Meter

HYV – High Yielding Varieties

IMD – Indian Meteorological Department

IWDP – Integrated Watershed Development Programme

JNNURM – Jawaharlal Nehru National Urban Renewal Mission

KWH – Kilowatt Hour

MAF – Million Acre Feet

MCM – Million Cubic Meter

M.CU.M – Million Cubic Meter

MEE – Multi Effect Evaporator

MGNREGS – Mahatma Gandhi National Rural Employment Guarantee Scheme

M HAM – Million Hectare Meter

MINAR – Monitoring of Indian Aquatic Resources

MSP – Minimum Support Price

NABARD – National Bank for Agriculture and Rural Development

NAPCC – National Action Plan on Climate Change

NITI – National Institution of Transforming India

NOC – No Objection Certificate

NWP – National Water Policy

O&M – Operation and Maintenance

PPCB – Punjab Pollution Control Board

PSEB – Punjab State Electricity Board

PSPCL – Punjab State Power Corporation Limited

PUDA – Punjab Urban Development Authority

PWSB – Punjab Water supply and Sewerage Board

RO – Reverse Osmosis

RSC – Residual Sodium Carbonate

SAPCC – State Action Plan on Climate Change

SAS Nagar – Sahibzada Ajit Singh Nagar

SCADA – Supervisory Control and Data Acquisition

STP – Sewage Treatment Plant

SWAR – System of Water for Agriculture Rejuvenation

SYL – Sutlej Yamuna Link Canal

UFW – Unaccounted for Water

UIDSSMT – Urban Infrastructure Development Scheme for Small and Medium Towns

WHO – World Health Organization

ZLD – Zero Liquid Discharge

CHAPTER – I

INTRODUCTION

1.1 Background

Water is one of the fundamental resources and indispensable element of life on earth. Out of total available water on earth, 97.2% water is saline and only 2.8% is fresh water. Even out of this 2.8% fresh water, 2.1% is found in the form of ice/glaciers, while only 0.37% is available in the form groundwater, and 0.02% as surface water. In surface water, 87% is in lakes, 11% is in swamps, and only remaining 2% is in rivers.

In the last few decades, overpopulation, industrialization and vast agricultural practices are making situation more critical and it is becoming difficult to meet the water demand for drinking and other purposes. Worldwide, around one billion people are devoid of safe drinking water. Half of the world's wetlands have been lost since 1900. It can be predicted based on increasing water demand and declining freshwater availability that future conflicts over water may result into water wars.

India has 18% of the world's population but only 4% of the world's renewable water sources. Hence, it is a big challenge to meet the demand of safe drinking water of such a huge population with inadequate water resources. Therefore, in our country, unsafe water and lack of basic sanitation is causing several types of diseases and killing many people every year. Even almost 30,000 children under 5 years of age die every week due to consumption of unsafe water and unhygienic living conditions.

In order to address India's water problems, it is important to understand that the roots of the current water crisis do not lie in a deficient or delayed monsoon as is being made out by the Indian media. In fact, it is years of government neglect, wrong incentives and outright misuse of the country's water resources which has led to the current crisis. Moreover, it is important to understand that climate change would exacerbate India's current water scarcity in the coming decades. According to a report by the World Bank, a global mean warming of 2°C above pre-industrial levels, the mismatch between water demand and supply will increase dramatically and will have serious implications on India's food security. Although, the country has witnessed a dramatic increase in water demand for all uses: agricultural, industrial, and domestic, agricultural irrigation accounts for 90% of India's freshwater withdrawals. Therefore, any serious effort towards water management in the country should focus on the management of agricultural irrigation in India. India's annual agricultural water withdrawal is the highest in the world followed by China and the United States (Table 1). Further, the table shows that China, which has a larger area equipped for irrigation (69 million hectares) than India (67 million hectares), withdraws much less water for agricultural purposes. This is clearly inefficient and off course unsustainable.

Table 1: Countries with the largest agricultural water withdrawals

Country	Agricultural Water Withdrawals (billion m^3)	Total Water Withdrawals (billion m^3)	Share of Agricultural Water Withdrawal in Total Water Withdrawal (%)	Area Equipped For Irrigation (m ha)
India	688	761	90	67
China	358	554	65	69
United States	175	486	40	26
Pakistan	172	184	94	20
Indonesia	93	113	82	7

Source: World Bank (2018)

Over the years, India has witnessed a major shift in the sources of irrigation. The share of canal irrigation in net irrigated area has declined rapidly and groundwater irrigation now covers more than half of the total irrigated area. It is this overexploitation of groundwater resources, more so, in the north-western part of the country which is one of the main reasons for India's water crisis. Moreover, groundwater is used to cultivate some of the most water intensive crops like paddy and sugar cane in states like Punjab, Uttar Pradesh, and Maharashtra. Rice, which is India's main food crop consumes about 3,500 litres of water for a kilogram of grain produced.

The most important crops of India — rice, wheat and sugarcane, are the most water consuming crops. Rice, which is a major export crop, consumes about 3,500 litres of water for a kilogram of grain produced. Punjab, which is the third largest producer of rice, is completely dependent on groundwater for the production of rice. Although, the state fares well in terms of land productivity, it is way behind the eastern states in terms of water productivity. Punjab requires two to three times as much water as Bihar and West Bengal to produce a kilogram of rice. State procurement policy and subsidised electricity makes it profitable for farmers to produce rice whereas farmers in states like Bihar, West Bengal, Assam, and Tripura which are better endowed in terms of rainfall lack these incentives. Unfortunately, India has emerged as a major exporter of rice which means a water scarce country like India is actually exporting millions of litres of water annually. Same is the story of sugar cane, another water guzzling crop in Maharashtra. Farmers in Maharashtra cultivate sugar cane using groundwater because they are assured of marketing by the sugar mills whereas Bihar which is more suitable for the production of sugarcane only produces 4% of the country's total sugar cane output. Therefore, state governments should encourage cultivation of less water intensive crops like pulses, millets and oilseeds in water stressed regions and water guzzler crops, particularly rice should be grown only in water rich areas. In addition to the faulty cropping pattern, water use efficiency in agriculture is also very low. Flood irrigation is the most common form of irrigation in India which leads to a lot of water loss.

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 overpopulated 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.

Punjab is called as breadbasket of nation. It is a cocktail of heavy agricultural practices and industrialization activities. Now, this Indian state is coming under threats of deficit of water resources. The water table is falling rapidly, and it is a serious matter of concern not only from state point of view but also from national perspective. Additionally, the water quality of the state is also deteriorating rapidly.

Punjab, an agricultural state of India, is facing a severe water crisis due to lesser annual rainfall than normal (700 mm) since 1998. Further, Punjab is not getting adequate amount of river water due to political reasons like Indus treaty, damming and diversion of river water, water conflict with Haryana, Rajasthan, and central government. However, the irrigation water demand (4.45 million hectare metre, (m ham) is significantly more than total irrigation water availability (3.04 m ham). Hence, in most parts of the Punjab state, groundwater is being overexploited for irrigational purpose.

Apart from this water scarcity or depletion problem, water quality is also being deteriorated and not suitable for drinking purpose. Basic groundwater parameters such as salinity, electrical conductivity (EC), chloride (Cl^-), and nitrate (NO_3^-) have surpassed the maximum permissible limit in most of the parts of this state. Even toxic heavy metals [like selenium, uranium, arsenic, and lead] and pesticides have also been reported in groundwater samples of several regions of Punjab. Intake of these heavy metals and pesticides contaminated water is affecting the health of native people. The condition of groundwater depletion and quality deterioration is most severe in Malwa region of Punjab. The poor water quality and presence of toxic heavy metal may be linked with the prevailing health issues in this region.

1.2 Statement of the Problem

1.21 Backdrop

The economy of Punjab is highly dependent on agriculture which has been the prominent occupation of its inhabitants since centuries. Punjab is the major contributor to the national food grains pool. Agricultural activities of Punjab have heavy requirement of water for irrigation purpose. Rivers, groundwater, canal water and rainfall are the major sources of water in Punjab. Canal and tube wells are the main sources of irrigation. The total water demand of the State is 35.77 MAF out of which broadly 27% is met by river water and balance 73% is met by groundwater. Groundwater is depleting at fast pace in almost 85% of the area – at the rate of 0.70 meter/year (Central Ground Water Board (CGWB) report 2017). The reduced availability of river waters is further putting pressure on the groundwater of the State.

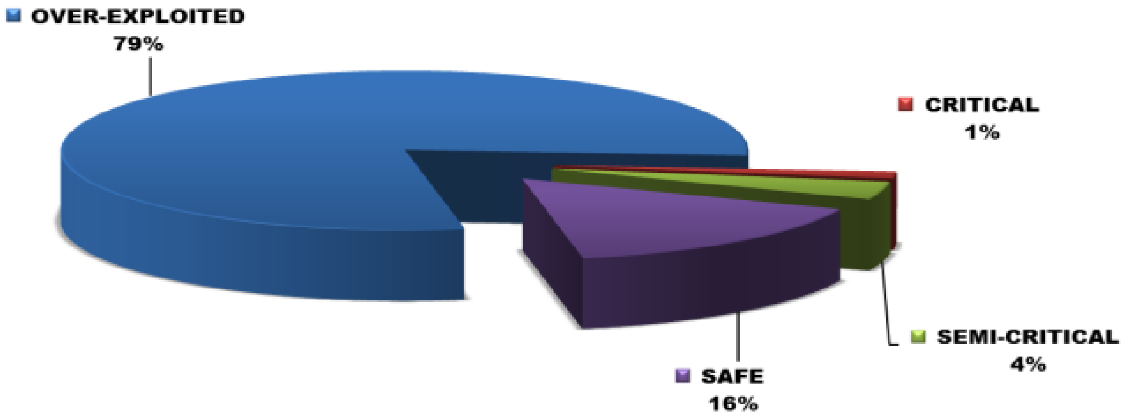
Table 2: CATEGORY WISE WATER USAGE

SECTOR	MCM (Million Cubic Meters)	MAF (Millions Acre Feet)	%
Domestic	1,303	1.06	2.95
Livestock	197	0.16	0.45
Industry	326	0.26	0.74
Thermal Power generation	594	0.48	1.35
Agriculture	41,685	33.81	94.51
Total	44,105	35.77	100

Source: Data as per State Irrigation Plan (2011)

1.22 Punjab tops country in over-exploitation of groundwater

The over-exploitation of groundwater resources is the highest in Punjab among all other states in the country. The extraction of groundwater is increasing in the agrarian state, government data has revealed. In Punjab, 79 per cent of the assessment units showed the annual groundwater extraction to be more than the assessed annual extractable groundwater resources, according to information placed by the Department of Water Resources, River Development and Ganga Rejuvenation in the ongoing session of the Rajya Sabha. This figure was 76 per cent last year.



Graph 1: Percentage of blocks under different categories (Source CGWB 2017)

Punjab is followed by Delhi with 65 per cent and Rajasthan with 63 per cent. In Haryana, 61 per cent of the assessment units were being over-exploited. While over-exploitation of groundwater is the highest in this region, there are many states and union territories where there is no over-exploitation. Irrigation accounts for over 96 per cent of groundwater use in Punjab. A major reason for over-exploitation of groundwater is the largescale cultivation of paddy in Punjab, which is water-intensive and the dependence on groundwater over canal or river water in many parts of the state. Monsoon is an important factor in recharge of groundwater. The rains in Punjab this season have been 10 per cent below the long period average so far. From June 1 to September 14, the state received 391.3 mm against the normal of 437.2 mm, according to the India Meteorological Department.

The Ministry of Jal Shakti has constituted a committee under the Central Ground Water Board (CGWB) for fresh assessment of dynamic groundwater resources in the country for 2020 in collaboration with the states and UTs. Earlier, such assessments were done in 2013 and 2017. According to a CGWB official, the wheat and paddy cropping pattern in Punjab has led to manifold increase in demand for water. About 90 per cent of the state's area is underlain by quaternary alluvial deposits that are important sources of abundant and dependable groundwater supplies which are being exploited.

Though there is no proposal to restrict the use of groundwater in the agriculture sector, central and state authorities are regulating the groundwater use by industries and mining projects. As per the ministry's assessment, the annual groundwater extraction for all uses is 249 billion cubic metres, out of which 89 per cent is utilised for irrigation and the remaining 11 per cent for industrial and domestic use.

1.23 Reason for depletion of groundwater

The main reasons for the depletion of underground water in the state of Punjab are:

- Punjab is the biggest contributor of food grains to the national pool. This has been possible due to intensive irrigation through an extensive tube-well network. There has been intensive groundwater extraction in the last five decades through installation of shallow tube-wells by individual farmers, the number of tube-wells in the state has increased from 6 lakhs in 1980's to 14.76 lakh in 2017-18 (this includes the tube-wells installed only for agriculture) showing an increase of more than 200% during last 35 years.

- Paddy, the most water guzzling crop is sown in 75% of the cropped area. The area under paddy cultivation has increased from 11.83 lakh hectares in 1980 to 28.86 lakh hectares in 2017-18.
- Approximately, 3300 litres of water is required to raise 1 kg of paddy.
- Due to free, unmetered availability of electricity for agriculture there is huge consumption of ground water.

1.24 Latest status – as per CGWB report 2017

According to ground water data for the period 2012-2016, out of the total 147 blocks of the State taken for study, 117 blocks are over exploited where stage of ground water development is more than 100%. The annual replenishable ground water resource of the state has been estimated as 21.58 BCM (17.51 MAF) and the annual ground water draft is 35.78 BCM (29.02 MAF) and stage of ground water development is 166% (CGWB report 2017).

Table 3: GW Availability & Withdrawal for the Period 2008-2012 Vs 2012-2016

Sr. No.	Item	Period	
		2008-2012	2012-2016
1	Annual Percolation	23.39 BCM	21. 58 BCM
2	Annual withdrawal for Irrigation	34.05 BCM	34. 56 BCM
3	Annual withdrawal for Domestic & Industrial Use	0.77 BCM	1.22 BCM
4	Total Annual Withdrawal	34.81 BCM	35. 78 BCM
5	Annual Excess Withdrawal	11.42 BCM	14.20 BCM
6	Withdrawal as percentage of percolation	149%	166 %

(Source: CGWB 2017)

1.3 Purpose of the Study

The purpose of the research is to assess the status of water resources in the state of Punjab at district level, identify the issues and propose ways and means to rectify the issue. Further, to look for the policies that are required to be constituted and implemented by the government, which are beneficial for the environment as well as for all the citizens. That may require a compatible policy set and support (from the Union and state governments) and an alternative crop combination (with MSP and assured market clearance) which could give farmers at least the same amount of per-hectare returns which they are getting from paddy. The policy in respect of free power to agriculture has been analysed to address the issue of diversification and depleting water table. Specific objectives of the study are:

1. To study the quantum of water use to assess its usage has increased or decreased.

2. To analyse the rationale and consequences of overuse of water.

3. To study the available modern technologies in agriculture activities and account for their role in restoring the water balance.

4. To suggest measures to minimize the ill-effects of over-exploitation of this natural resource.

5. To suggest a participatory framework for variety of agricultural solutions for conserving and harvesting water and its optimum utilisation for improving productivity and profitability.

1.4 Rationale

There is an urgent requirement of studying, testing and implementing practical, rapidly scalable solutions to Punjab's groundwater depletion crisis because of the following reasons:

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

- The state is now at crossroads. The state's agriculture has reached a plateau under the available technologies and natural resource base and has become unsustainable and nonprofitable. With increase in population, per capita availability of land and water is decreasing, thus affecting productivity per unit area.
- As water tables in Punjab fall further, desperate farmers are digging deeper, getting trapped in debt and depleting aquifers.
- A new report by Central Ground Water Board has warned of Punjab turning into a desert state in next 25 years.
- Paddy is the biggest water guzzler, but its cultivation continues unabated as agricultural reforms fail to take root. Water use efficiency needs to be increased particularly in paddy cultivation.
- 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 intensive irrigation coupled with rapid industrialization and urbanization has brought in water quality degradation vis-a-vis development of water resources with space and time.
- 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.

- The gap between irrigation potential created and actual irrigation achieved also needs to be bridged.

1.5 <u>Research Questions</u>

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. Punjab has been facing serious challenges in management of utilization of its water resources. In this connection, this study attempted to explore the following questions:

- Which type of irrigation is being used in agriculture in Punjab and what modifications can be carried out in this regard?
- What are the repercussions of over usage of water on the general environment and health of the inhabitants?
- How can we save the breadbasket of the nation from the looming water crisis and which modern technologies for water conservation and improving water quality be used to check the current situation?
- Can remedial measures such as water footprint as a parameter for deciding for trade and water budgeting be useful for farmers too so that groundwater and other water resources are not depleted to alarming levels?

- Which integrated set of interventions with implementation framework can be developed for reducing river and underground pollution and facilitate its participatory implementation with stakeholders?

1.6 Research Strategy

Types of research methods which have been utilised can be broadly divided into two quantitative and qualitative categories.

- Quantitative research describe, infer, and resolve the problem using numbers. Emphasis has been placed on the collection of numerical data, its collation, analysis and then drawing of inferences from the data. Hence, majority of the research for the subject problem has been quantitative in nature.
- Qualitative research, on the other hand, has been based on words, feelings, emotions and other non-numerical and unquantifiable elements. In the ibid problem, some of the information is not quantitative in nature and the same cannot be analysed by means of mathematical techniques. These characteristics mean that certain incidents in this study does not take place often enough to allow reliable data to be collected.

1.7 Research Design/ Methods

The research design will be **Analytical** and efforts will be made to make it **Conclusive**.

It has been fundamentally Analytical as the facts and information already available has been used and analysed in order to make a critical evaluation of the available data. Since, current times are not conducive for collecting data from the field, this study has been pursued based on the literature available and the data from the secondary sources. Efforts has been made to refer to the data and studies from the authentic secondary sources published through papers, articles, reports, conference proceedings, court judgements and books with the objective of establishing a theoretical framework and applied implication to facilitate the understanding of impending 'Water crisis in Punjab' in relation to the sustainable development.

Finally, the aim has been to arrive at decisive answers to the research objectives thus making the research conclusive. For this, it has been endeavoured to make it well-structured and systemic in design. It has a formal and definitive methodology that needs to be followed and tested to overcome this crisis. The conclusive research has been carried to test the formulated hypothesis.

1.8 Scope and Limitations

The study intends to confine itself to analysis of secondary data. It has analysed the relevant policies, state framework regulations and other pieces of data published by CGWB, State Irrigation Ministry, journals, papers, articles, reports and books. The focus is on a broad, vast array of related aspects about water, its management in the form of a logical build up starting from its importance, available resources, present mode of use and related policies, problem areas and finally the recommendations. The focus shifts from a broader plane to zero on to the relevant policies which are required to be implemented on priority for water conservation and improving the water quality. However, because of the limited time available, the study has mainly been limited to over exploitation of water in the agriculture sector. In addition, groundwater resources in comparison to domestic demand and supply of water in selected cities of Punjab has also been studied.

1.9 Methods Applied and Data Sources

Primarily the secondary data of Research papers and articles published in various newspapers, journals and periodicals has been analysed. The facts and information already available have been analysed to make a critical evaluation of the material. Since, the current times are not conducive for collecting the primary data from the field, this study was pursued based on the literature available and the data from the secondary sources. Efforts have been made to refer to the data and studies from the authentic secondary sources published through papers, articles, reports, conference proceedings, court judgements and books with the objective of establishing a theoretical framework and applied implication to facilitate the understanding of impending **'Water crisis in Punjab'** in relation to the sustainable development.

Endeavour has been made to get the first-hand information by preparing a questionnaire on the lines of the questions as given above and get the inputs from the various entities online, who are directly or indirectly linked with this crisis.

CHAPTER – II

LITERATURE REVIEW

Review of literature is a very vital part of any study or research. It helps in knowing the research areas where studies had focussed on and certain aspects which were untouched or very few studies have been done by the researchers.

2.1 Groundwater depletion in Punjab: Measurement and countering strategies

by Karam Singh, Agricultural Economist, Punjab State Farmers Commission, Government of Punjab (2011): This study examines the annual water table situation from 1973 to 2005 in the three agro-climatic regions of the state, derives the estimates of depletion/deficit and examines the strategies to meet the deficit. The objectives of the study are: (i) To scan the behaviour of water table in Punjab in its three agro-climatic regions. (ii) To estimate the total underground water that has been withdrawn in excess of the recharge, i.e. the total water depletion. (iii) To approximate the excess withdrawal as equivalence of the rainfall, which is the major source of recharge and (iv) To short-list the strategies and policy regimen needed to meet the deficit. Further, the underground water in Punjab is being overdrawn, where rice is extensively grown, by the farmers because of its relative profitability ensured by the nation through various continuous policy initiatives such as more remunerative minimum support price, an effective procurement system, etc., for its food security. It has suggested some techniques for water use efficiency but the economic evaluation of such technologies and accounting for their role in restoring the water balance has not been carried out.

2.2 Electricity Subsidy in Punjab Agriculture: Extent and Impact *by Karam Singh Indian Journal of Agricultural Economics (2012)*: The main theme of the paper is to analyse comprehensively the extent and impact of electricity subsidy on the farm economy and the possibilities of restructuring the incentives to contain the electricity subsidy for moving towards achieving the long-term goals of efficiency and resource conservation. The objectives of the paper are (i) to study the trends in the consumption of electricity, the cost recovery and the subsidy in Punjab agriculture, (ii) to estimate the average cost per tube well irrigation, the electricity consumption per irrigation over time and contrast it with the fall in water table in Punjab, (iii) to examine the impact of electricity subsidy on the profitability of rice and wheat over time and their relative profitability as compared with other competing crops, (iv) to examine the equity issues of the electricity subsidy distribution vis-s-vis the farm size distribution of operational holdings, and (v) to examine the impact of crop substitution of high water-cum-electricity using rice crop by the low water-cum-electricity using cotton crop, which also marks important agro-ecological regional characteristics of the state , and other policy related issues. However, the study has not commented on the political angle of extending the electrical subsidy to the farmers by the political parties for garnering votes at the cost of over exploitation of groundwater and obstacle to diversification.

2.3 **Building SYL canal a zero-sum game** *by former Chief Secretary, Punjab (2017)*: It clearly analyses the crucial issue of Sutlej-Yamuna Link canal for the state of Punjab and Haryana in particular. The introduction to the dispute is necessitated to put the issue in perspective and to trace its chequered and bloody past. Pursuing construction of the canal without first determining the total quantum of water that is available for distribution amongst various states, its current usage, and quantification of surplus water, if any, for allocation to Haryana through a process of fair and judicious adjudication under the relevant laws would only be tantamount to putting the cart before the horse. It is also to examine the myth that construction of the canal is a win-win and cost-free venture for both the stakeholders. That it is quite to the contrary is evident. However, this article is written keeping the interest of the state of Punjab only, without giving any viable solution to resolve the long outstanding issue between the two states.

2.4 The Punjab Water Resources (Management and Regulation) Act, 2020

Punjab Govt. Gaz. (Extra), February 12, 2020: In an endeavour to manage and regulate the water resources efficaciously, besides ensuring its judicious, equitable and sustainable utilisation, the Punjab Cabinet paved the way for setting up a Water Regulation and Development Authority by approving enactment of this Act. Through this Act, a Punjab Water Regulation and Development Authority will be set up, consisting of a Chairman and two other members to be appointed by the Government. The Authority will be responsible for management and conversion of water resources of the state in a judicious, equitable and sustainable manner, and will be empowered to take all such measures as it deems necessary or expedient for this purpose.

The authority will also be empowered to issue directions and guidelines for the conservation and management of the water resources, besides issuing tariff orders specifying the charges to be imposed by entities supplying water for drinking domestic, commercial or industrial use.

An Advisory Committee on Water Resources will also be constituted, to be notified by the Government. It will consist of experts and ex-officio members from various government departments, to advise the authority. The authority may also engage experts on its own.

The authority shall have, and maintain, a separate fund, to be called the Punjab Water Regulation and Development Authority Fund, in which the grants/loans would be credited by the Punjab Government. It also empowers the Government to issue to the Authority general or specific directions in writing, in the matters of policy involving public interest, and the Authority shall be bound to follow and act upon such directions. Tariff fixation would be done by the Authority as per the policy prescribed by the Government.

The move is prompted by the fact that due to over exploitation of ground water for agriculture and other requirements, the ground water table is declining very rapidly. Moreover, due to pollution caused by industrialisation and urbanization, there is significant deterioration in the quality of water. All this has threatened access to water for livelihoods and to safe drinking water as well.

CHAPTER - III

SOURCES OF WATER AND THEIR STATUS IN PUNJAB

3.1 Hydrogeological Conditions of Punjab

3.11 General Features

Punjab is one of the North Western States of India and covers an area of 50,362 sq km falling between latitude 29º30' N to 32º32' N and longitude 73º55' E to 76º50'E. There are 22 Districts and 145 Blocks in the State. It is one of the most developed State of India where all villages are approachable by metalled roads and all the houses in villages have electricity.

The Punjab State is a flat alluvial plain except a thin belt along north eastern border, where it is mountainous and in the south western parts, where stable sand dunes are seen dotting the landscape. The slope of the plain is towards South and South West which seldom exceeds 0.4 m/km.

There are three perennial rivers namely Sutlej, Beas and Ravi and one non-perennial river Ghaggar in the State. These rivers feed a vast network of canal system in the State and even provide water to Haryana, Rajasthan and Jammu and Kashmir.

3.12 Geology

The alluvial deposits in the state comprise of sand, silt and clays often mixed with kankar. Sandy zones of varying grade constitute a vast ground water reservoir. The alluvial plain towards the hills is bordered by the piedmont deposits comprising Kandi and Sirowal. Immediately south-west of the hills, Kandi belt is 10 to 15 km wide followed by Sirowal which imperceptibly merges with the alluvial plain. Kandi deposit explored almost down to 450 m bgl show a gradation from boulders to clays, at places an admixture of various grades in different proportions. The Sirowal is essentially composed of finer sediments but occasional gravel beds are also encountered. The saturated sand, gravel or boulder beds constitute the aquifers.

3.13 Hydrometeorology - Climate

The climate of the State is semi-humid to semi-arid in the North, arid in the South and southwest and semi-arid in the remaining part of the State. The state experiences four seasons in the year namely, cold season from November to March, hot season from April to June, southwest monsoon season from last week of June to mid of September and post monsoon season from September to beginning of November. During cold weather season, seasons of western disturbances affect the climate of the state and bring rainfall of light intensity.

The State has well-defined rainy period from July to September. There is about 80% rainfall during this period due to South-West Monsoon. Long dry spells are often experienced necessitating irrigation from man-made systems for agriculture.

3.2 Rainfall Distribution

There are two periods of rainfall in the state. The southwest monsoon season, the principal source of ground water sets in last week of June and withdraws towards end of September and constitutes about 80% of annual average rainfall. Another period of rainfall is winter rain from December to March is about 20% of total rainfall which is mostly absorbed into the soil.

The rainfall distribution in Punjab State is erratic both in time and space. The annual rainfall in the state varies from about 1000 mm in the northeast to less than 300 mm in the southwest. The areas to the north of Gurdaspur and near the Shivalik hills receive maximum amount of rainfall while the areas situated in the southwestern side of Punjab (Fazilka) receive minimum amount of rainfall. In the central part of the state, average long-term rainfall varies from 400 mm to 600 mm. The highest and the lowest annual average rainfall in the state for the year 2016 are recorded in Pathankot and Fazilka districts which are 1110 mm and 82 mm respectively.

Average annual rainfall in recent past has been quite low as compared to that in the earlier years as is clear from data given below:-

YEAR	**AVERAGE ANNUAL RAINFALL (in mm)**
1970	672 mm
1980	739 mm
1990	754 mm
1997	710 mm
1998	477 mm
1999	392 mm
2000	392 mm
2001	463 mm
2002	315 mm
2003	460 mm
2004	375 mm
2005	448 mm
2006	418 mm
2007	438 mm
2008	529 mm
2009	385 mm

YEAR	AVERAGE ANNUAL RAINFALL (in mm)
2010	472 mm
2011	480 mm
2012	366 mm
2013	620 mm
2014	385 mm
2015	547 mm
2016	427 mm

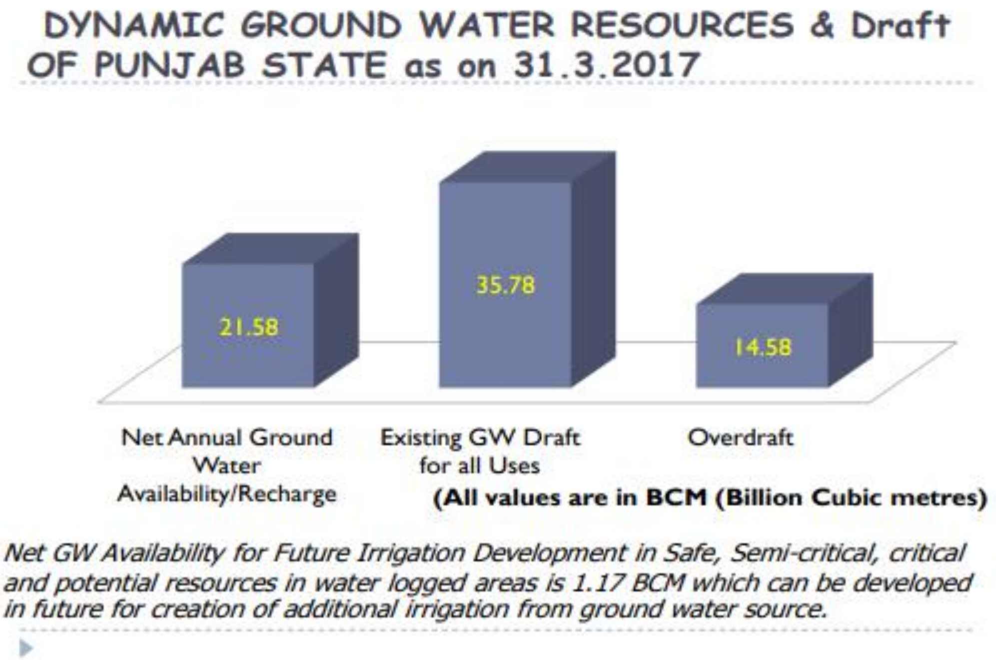
Table 4: Average Annual Rainfall

The status of rainfall is less than normal (700 mm) since 1998. The state faced a severe drought due to low rainfall in this region. After 2005, the state is facing continuous low rainfall problems (*Indian Metrological Department 2017*).

3.3 Groundwater

Agricultural activities of Punjab have heavy requirement of water for irrigation purpose. Rivers, groundwater, canal water and rainfall are the major sources of water in Punjab. Canal and tube wells are the main sources of irrigation. The dominancy of rice and wheat cropping system has overexploited groundwater resources, resulting in rapid decline of groundwater table of the entire state (approximately). Tube wells are the major source of over exploitation of underground water reserves. The number of tube wells in the state has been increased from 1.92 Lakhs in 1970 to 13.8 Lakh in 2011. Approximately, one tube well is there for every 2 ha in this state. The irrigation water demand (4.45 m ham) is significantly more than total irrigation water availability (3.04 m ham). The estimated net available groundwater is around 21.58 Billion Cubic Meter

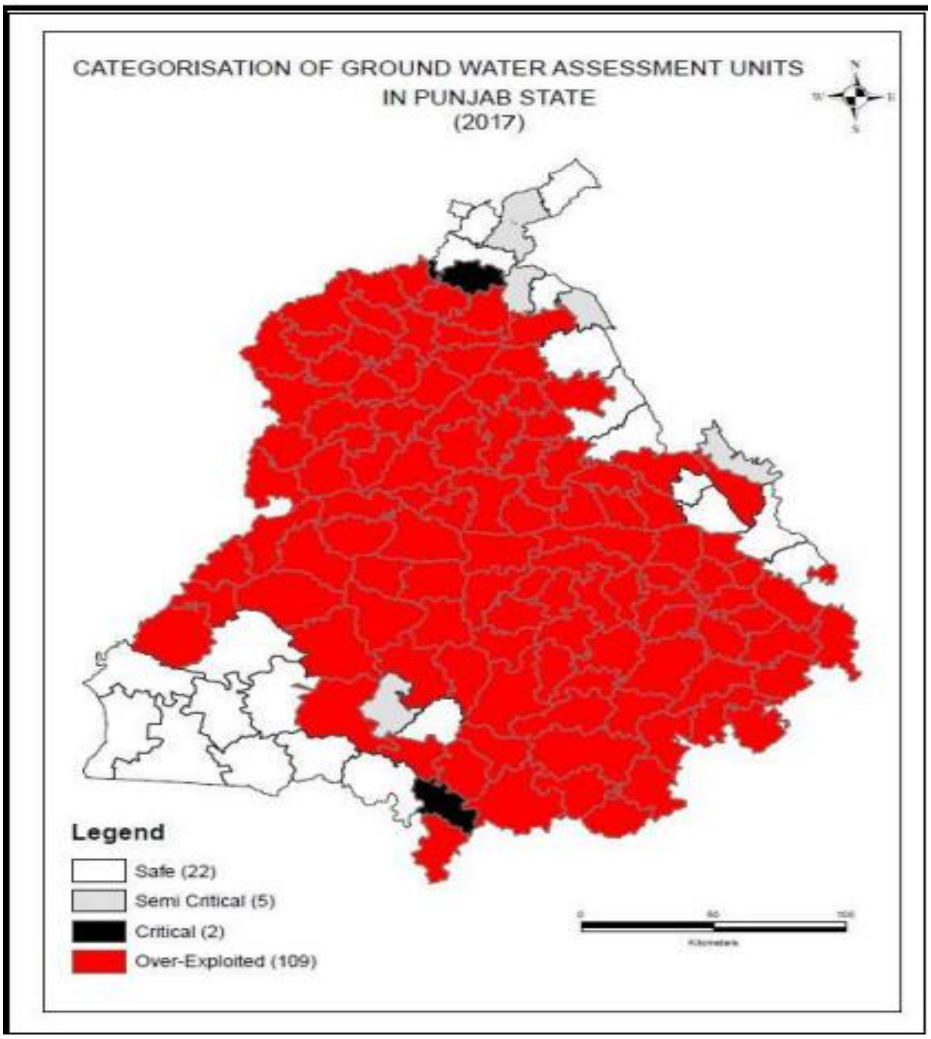
(BCM), which is less than annual demand 35.78 BCM. The annual deficit of groundwater is determined as 14.58 BCM.



Graph 2: Ground Water Resources and Draft of Punjab State (CGWB 2017)

Seventy-nine per cent of the total geographical area of the state (109 blocks) is categorized as overexploited, 5% area (7 blocks) as critical and semi-critical, whereas only 16% area (22 Blocks) is under safe category for groundwater development (CGWB 2017). During 2012–2016, the water table all across the state has receded at average annual rate of 0.70 m and range of water table decline varies from 0.10 to 4.0 m. Sangrur and Patiala are the most affected districts in concern of water table.

Ideally, groundwater should be available at a depth of 50 ft to 60 ft, but in Punjab, its level has significantly dropped to 150ft to 200 ft in most places. Many attribute this drastic fall to an indiscriminate extraction of groundwater in the last two decades. However, the water table is rising in some southwestern parts of the state. The reason behind that in those regions, groundwater extraction is limited for irrigation purposes due to brackish and saline quality of water.



Graph 3: Categorisation of Ground Water Assessment in Punjab (CGWB 2017)

3.4 Rivers and Canal

Beas, Chenab, Jhelum, Ravi, and Sutlej are the main rivers of Punjab state. All rivers are tributaries of river Indus. These five rivers are divided between India and Pakistan. However out of five, three rivers Sutlej, Beas, and Ravi flow through the Indian state of Punjab. Area of Punjab between rivers of Beas and Sutlej is called Doaba, which includes Jalandhar, Hoshiarpur, and Nawanshahr. The area of Majha lies between Beas and Chenab and also at both the sides of Ravi.

S. No.	Name of canal system	Length of main canal (in km)
1	Sirhind Canal	59.44
2	Bist Doab Canal	43.00
3	Upper Bari Doab Canal	42.35
4	Sirhind Feeder	136.53
5	Eastern Canal	8.02
6	Bhakra Main line	161.36
7	Shahnehar Canal	24.23

Table 5: Canal Networks of Punjab (Source: Department of Irrigation, Punjab)

The Majha part is called heart of Punjab and includes Amritsar, Gurdaspur, Faridkot, and Ferozepur cities. Malwa region is located in southern Punjab at range of Sutluj River and the major cities include Ludhiana, Patiala, Sangrur, Malerkotla, Shahabad, and Abohar. Although, Punjab has one of the largest canal systems of the country, but this state is not getting adequate amount of river water due to political reasons, i.e., Indus treaty, damming and diversion of river water, water conflict with Haryana, Rajasthan, and central government. Almost 30.88 lakh hectare of the cultivated area comes under canal networks. The estimation of river water is approximately 14.22 MAF, distributed into 7th main canal system of this state (Department of Irrigation, Punjab).

Further, an inadequate amount of rainfall is the major reason for the deficiency of required amount of water in the rivers as well as canals. The insufficient amount of canal water for irrigation purpose leads to overexploitation of groundwater.

CHAPTER – IV

TRENDS AND KEY ISSUES IN WATER SECTOR IN PUNJAB

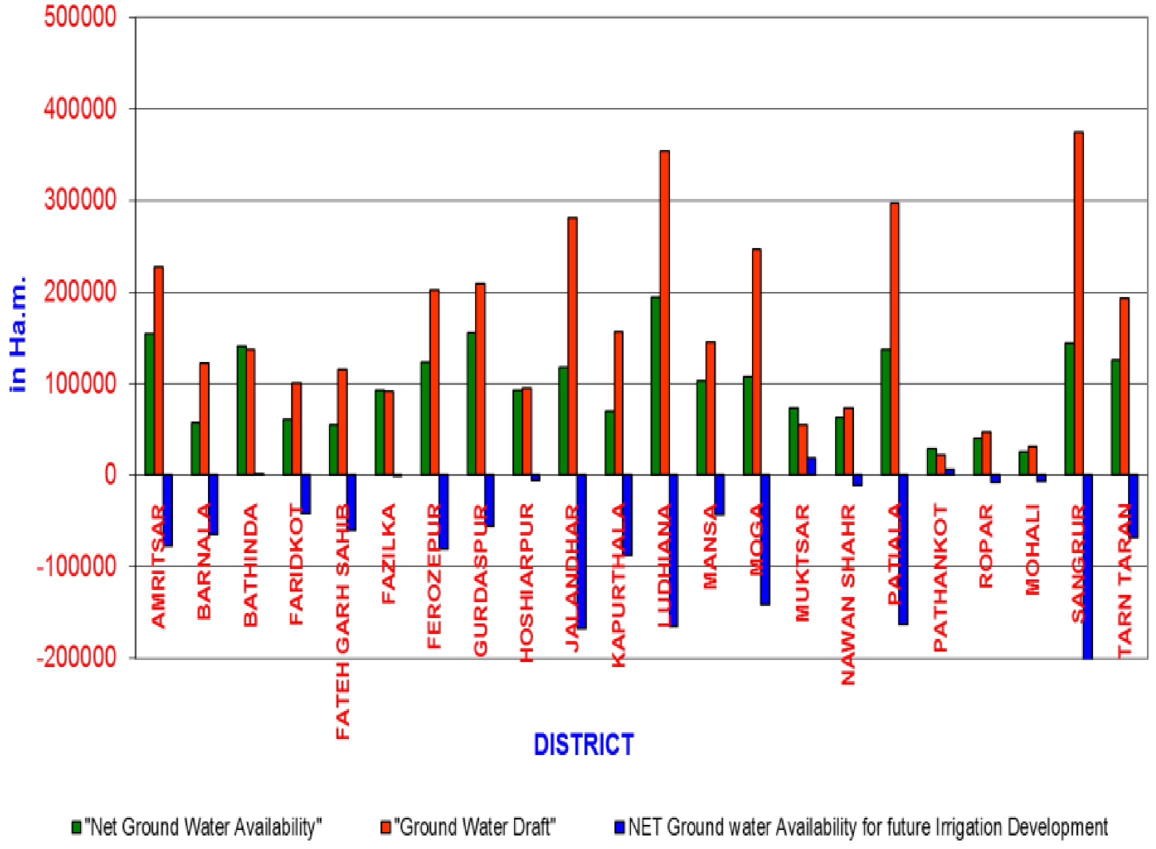
4.1 Trends in Water Sector in Punjab

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 wastewater, untreated discharge of municipal wastewater 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. There also exists the problem of salinity due to water logging in the western parts of the state.

4.2 Key Issues in 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.



Graph 4: District wise Ground water availability, Ground water draft and Net ground water availability for future irrigation in Punjab (CGWB 2018)

The depleting water table 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.

	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)

Table 6: Decline of Water Table in Central Punjab

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 freshwater 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.

4.3 Farmers' Practices and Water Requirement

It is not only increase in rice area and government policies that the water use has gone up, but the farmers, by way of their faulty practices are also responsible for aggravating the problem of water scarcity as discussed under:

a) Early Transplanting of Rice:

Against the recommended time of transplanting of second week of June, about 25% rice area in the state is transplanted in the month of May. The reasons advocated by the farmers were that the early rice crop escapes pests and diseases and gets longer growing period resulting in higher yield. Similarly, the low opportunity cost of family and permanently engaged labour and farm machinery lowers the cost of cultivation if the crop is transplanted early. The estimated evapotranspiration of rice crop has been averaged to 780 mm in the month of May as compared to 605 mm in case of timely transplanted. Thus, the early transplanted rice crop has about 29% higher water requirements and over-exhausts the annual water resources in the state by 7.3% every year. The policy of late procurement of paddy by the state agencies has recently helped to restrict the early transplanting to some extent.

b) Long Duration Varieties:

The varietal picture of rice crop in Punjab indicates that some varieties which are of long duration and are not recommended by the experts but still the farmers have adopted on a large area. For example, PUSA 44 variety has been cultivated on 30% area and thus the water requirement of the crop increased tremendously. Conversely, basmati, a superior strain of rice having lesser water requirement has almost doubled from about 5% to about 10% of total area under rice crop during the last 4-5 years. However, the global demand for basmati has pushed up basmati production recently, helping in water saving.

c) Ignorance about ill-effects of water use in paddy:

The water use by the farmers is in excess of the requirement of the paddy crop. Higher intensity and a greater number of irrigations were, largely due to ignorance of the majority of farmers that good crop requires standing water throughout and also due to low price of water.

d) Lack of suitable water management practices

There are a number of agronomic practices through which enormous saving of water can be made possible. For example, in place of open flooding system, ground pipeline furrow irrigation/ raised beds, drip and sprinkler irrigation, in-situ retention of rainwater, mulching could improve the water use efficiency. Apart from timely transplanting with suitable varieties avoiding early and long duration varieties, conjunctive use of water, renovation of village ponds for irrigation, encouraging crop diversification (substituting high water requiring crops/ cultivars) are some other ways to solve the problem through various policy measures.

Therefore, to curb the over exploitation of water, policy legislation and extension, education of farmers in this respect are required for which in place of providing free electricity for the tube wells, subsidies on water saving technologies should be provided.

e) Water pricing and productivity

The average productivity of water was estimated on the basis of state average yield of crops and post-harvest prices. The value of by-product was also taken into account in the estimation process. The total quantity of water used was worked out on the basis of number of irrigations applied and 7.5 cm as an effective irrigation. It is evident from studies that per cubic meter of water, the gross return varied from crop to crop viz. Rs 2.43 in case of paddy, Rs 6.75 for rapeseed & mustard crop, Wheat crop yielded Rs 12.36, while the cotton crop promised Rs 11.40/cu.m of water. Viewing it from another angle, to produce one kg of paddy grain required 4334 liters and wheat as 1080 liters. The cotton crop needed as much as 2394 liters of water for one kg output of seed cotton. Therefore, production and even export-import policy of agriculture sector, apart from economic parameters should take a serious view of requirements of natural resources especially water.

4.4 Electricity Subsidy in Punjab Agriculture

4.41 *Backdrop*

The electricity subsidy for the Punjab farmers, particularly since 1997-98 when it was extended as totally free, continues to be a debatable issue. A part of the electricity cost was recovered from the farmers on the per unit basis of consumption upto late 1970s. It was changed to horsepower of the motor irrespective of the consumption for the convenience (economy) in collection of the amount, upto 1996- 97. There was also an occasional recovery in small amounts during 2002-2005 and 2010-11. Thus, the electricity subsidy for agriculture was a small amount to begin with but assumed gigantic proportion over time as its consumption increased. The number of electric tube wells has increased, the area under rice, which means that major irrigation requirement has increased, while the water table has gone down, which means more power is needed to draw out the same quantity of water and the cost of electricity supply has also increased. All these issues are inter-related; and the free electricity to the farm sector is often quoted as the main precursor to the increase in the rice area, over-exploitation of groundwater and as an obstacle to diversification. The main theme of the paper is to analyse comprehensively the extent and impact of electricity subsidy on the farm economy and the possibilities of restructuring the incentives to contain the electricity subsidy for moving towards achieving the long-term goals of efficiency and resource conservation.

4.42 *Electricity Consumption in Punjab Agriculture*

The electricity consumption in Punjab agriculture increased from 1850 million kWh in 1980-81 to 10150 million kWh in 2010-11. Thus, over three decades, the electricity consumption in agriculture has increased by more than 5 times, which amounts to a point-to-point annual growth rate of 5.84 per cent. The number of electric tube wells has also increased from 280 to 1106 thousand during this period, i.e., by about four times. The other variables effecting the increase in electricity consumption have also increased such as cropping intensity from 161 to 190 per cent, the area under rice from 1183 to 2826 thousand ha and the water table has gone down by more than 2.5 times in the major tube well irrigated area in central Punjab.

It may also be noted that Punjab had 81 per cent of area irrigated even in 1980-81 and by 1990-91, all the possible area that could be irrigated was already under irrigation; by canals, electric operated tube wells and diesel operated tube wells. The data regarding irrigated area by electric and diesel operated tube wells is not separately available; most of the electric tube well farmers also have standby diesel engine. The hiring in of irrigation water from the tube well-owners remains a common practice, which, however, has also declined over time as more and more farmers acquired their own tube wells. Even in areas where canal water had been available, it had been extensively supplemented by the tube wells, depending upon the fitness of groundwater.

A word about the electricity consumption figures as per Punjab State Electricity Board (PSEB) is also in order. These had been in general more than the actual consumption by the farmers, earlier partly because of the non-metered supply (flat rates charges, which were introduced in early 1980s) and later on when it was extended totally free to the farmers that prompted PSEB to inflate the supply to agriculture in order to play down the transmission and distribution losses.

4.43 *Impact of Electricity Subsidy on the Relative Profitability of Important Crops*

Rice in kharif and wheat in rabi are not only the most dominant crops but these have been the most profitable with electricity subsidy. It is often argued that if the electricity subsidy is withdrawn, the relative profitability, particularly of rice, which requires maximum number of irrigations (and hence, the free electricity), would be so much adversely affected; so much so that, it would promote diversification to other crops. The comparative economics of important crops with and without electricity subsidy at the recommended technology package shows that these crops still remain more profitable in the respective seasons. However, basmati, which requires less number of irrigations than the other paddy, becomes slightly more profitable; of course, its market (price) vulnerability (no support price mechanism for basmati) would keep determining its area on a year-to-year basis. But cotton does come to compete with rice if there were no electricity subsidy. Also, as cotton is more predominant in the canal irrigated region of the state, and the canal water supply also being free to farmers, the impact of withdrawing electricity subsidy would be relatively much lower in affecting the profitability of cotton, which would become relatively higher than rice.

The subsidy is for the electricity used, which is directly proportional to the size of land operated by a farmer and the type of crops grown. As there is inequality in the farm size operated and there are differences in the relative proportion, particularly of rice, which requires the highest number of irrigations and hence electricity, the inequality in the electricity subsidy may be even more than the inequality in the farm size.

4.44 *How to Contain/Restructure Electricity Subsidy in Punjab*

In the long run, the electricity subsidy must be contained significantly whereby everybody pays something but the rich should pay more. But, there are other important measures to contain the electricity subsidy, which include restructuring the incentives, improving the water use efficiency, providing one time subsidy to harness the eco-friendly and non-polluting solar power energy along with the drip irrigation, and considering the partial recovery from the large and commercial farmers, most of whom, as per press reports quite often, want more reliable supply of electricity rather than the free electricity, because their expenditure on diesel to meet the timely irrigation needs of the crops runs into more than the money they would have to pay for the electricity for their tube wells. Any farmer would want free canal water and free electricity and in Punjab he would grow rice on his farm even if the other agronomic requirements are sub-optimal. That is not without rationale. But the state has to fix the policy matrix including the incentives and restraints that fit in with the natural environment and resource complex in the long run.

The ecological resource structure of the state demands that the South Western region is more of a cotton region and hence the incentives should make the cotton to be more profitable for this region. Shifting an acre of rice area to cotton area in the South Western region would save about 5 acre feet of water, which would be the canal water. Shifting the saved water to the Central region (which, on the canal route, comes earlier than the South Western region) would not only improve the ground water situation in the Central region but would also save an equivalent amount of electricity and hence, the power subsidy.

The cost of electricity is more than Rs.600 per hectare of irrigation. Shifting one hectare of rice to cotton in the South Western region and the canal water saved to the central region, would save the electricity subsidy equivalent of about 16 irrigation hectares, i.e., about Rs.10000; the same electricity savings sold commercially would fetch another about Rs.7000 to the PSPCL and more than Rs.3000 as taxes to the government. Thus, the public exchequer would be saving more than Rs.20000 from one hectare substitution of rice by cotton. Even if the entire amount is passed as incentives for promoting the shift, the society would still benefit in the long run in the form of the reduction in water logging in the South Western districts and, thereby, the reduced capital investment in drainage and the improvement in the water table in the central region, which would further reduce the electricity requirements for irrigation.

Shifting some 2 lac ha out of some 8 lac ha area under rice in the South Western region would save about Rs.400 crores of the electricity subsidy every year. Likewise, shift to maize in the central zone would also bring the equivalent savings in the electricity subsidy, additional revenue to the PSPCL from the commercial sale of the saved electricity, improvement in the ground water table, etc.

The Indian government has recently released a draft Electricity Amendment Act that calls for Direct Benefit Transfers of Electricity subsidies (DBTE) to subsidised categories of consumers, including agricultural consumers. The DBTE idea has a lot of merit, and we think it may be able to thread the needle of improving efficiency without harming unproductive farmers.

The key is that a DBTE programme to replace present subsidies must be unconditional. Under an unconditional DBTE programme, electricity prices are increased to social cost, but farmers, at the same time, are compensated for this increase with a lump-sum entitlement, set equal to the value of the power (and water) they use today. Highly productive farmers can use more electricity, if it profits them, while poorer or less productive landholders can choose whether to use the full ration or cut back and keep more of their cash transfer. Farmers that save power and water will be left with cash in hand.

4.5 <u>Waterlogging in Punjab</u>

While groundwater is declining at an alarming rate in freshwater regions, the south-western parts of Punjab are facing problems of severe water logging and salinization. The state can in fact be characterized by two distinct topographical and hydro-geological settings: high yielding fresh groundwater regions in northern and central districts and the saline groundwater regions in south western districts. Groundwater depletion on one side and water logging on the other, are perhaps two sides of the same coin; however, these two extreme scenarios in close proximity to one another are probably a unique case of extreme ecosystem vulnerabilities that require intensive, extensive and sustained solutions.

An area is said to be waterlogged when the water table rises to such an extent that the soil pores in the root zone of a crop become saturated, resulting in restriction of normal circulation of air, decline in the level of oxygen and increase in the level of carbon dioxide. The harmful depth of water table would depend on the type of crop, type of soil and quality of water.

Water logging causes depletion of oxygen and increase of carbon dioxide in the root zone of crops which causes loss of plant nutrients and the loss of useful microorganisms at the expense of the growth of harmful ones. It also causes chemical degradation due to accumulation of salts at the soil surface leading to an ecological imbalance. It invariably becomes difficult to carry out agricultural activities in the areas affected by water logging. All these factors result in reduced or near zero productivity.

Waterlogging and salinization, which have emerged as a major impediment to the sustainability of irrigated lands and livelihoods of the farmers in South-West Punjab, are the result of a multitude of factors. These include seepage from unlined earthen canals system, inadequate provision of surface and subsurface drainage, poor water management practices, insufficient water supplies and use of poor quality groundwater for irrigation. Seventy per cent of the South-western regions of Punjab area are canal irrigated. The application of excess irrigation and recharge from irrigation distribution network in these regions causes gradual rise of ground water table and when the water table rises within 2m of the soil surface, the root zone available to plants becomes restricted and salts rise to the surface by capillary action. The resulting salinization renders the land unsuitable for cultivation.

The Government of Punjab has indicated that about 2 lakh hectares (Ha) of fertile agricultural land is waterlogged and there are certain patches where not even a single crop has been grown for more than a decade. Under the present circumstances more than 200,000 farmers have lost their primary income source from agriculture as their lands have become unproductive. The situation of farmers is further aggravated by a decrease in land holdings, heavy debt burden leading to suicides, crop failures, ground water pollution and agro-industrial sickness. The farmers whose fields have become waterlogged have limited sources of income and are forced to work as labourers. There is a serious threat of the region turning into a desert over the longer run if appropriate actions are not taken now. Furthermore, the contamination of drinking water in the waterlogged area with Uranium, Arsenic and Heavy Metals etc. is posing a grave threat to the region. The situation is further aggravated by the fact that there are early indications that the saline water of South-West Punjab may be beginning to flow into the depleted sweet water aquifers of central Punjab, the heartland of the Green Revolution, on account of the hydraulic gradients induced by shallow water levels in Southwestern Punjab and deeper water levels in the Northern parts.

4.51 *Causes of Waterlogging*

The twin problems of waterlogging and salinization in South-west Punjab are broadly attributed to the depressional location of the area coupled with the lack of proper drainage system, poor percolation because of impervious clay strata and constant seepage from Rajasthan Feeder Canal & Sirhind Feeder Canal. Moreover, intensity of irrigation and land-levelling leading to a major obliteration of the natural topography and drainage, coupled with major shifts in cropping patterns and practices (such as the periods of transplanting of paddy) have together undergone major changes during the last 50 to 60 years, all of which seem to have contributed and compounded the dual problem of water logging and salinity. Much of the unsaturated zone (vadose zone) in large parts of Southwestern Punjab has 'thinned' with the rise in groundwater levels. The capillary fringe now operates more actively in the soil-zone than in the sediment below, clearly giving rise to salinization and decreased hydraulic drainage of soils.

4.52 *Combatting Waterlogging and Salinization*

A comprehensive anti-water logging program is clearly the need of the hour in the state of Punjab. To deal with the twin problems of water logging and salinization, the Expert Group has suggested the following short-term, medium-term and long-term solutions:

a) Diversification to Low-Water Requiring Crops in Punjab:

For long term sustainability, it is necessary to divert significant area from paddy to other low water requiring crops. This demands some concerted policy initiatives.

1. Research needs to be liberally funded in the long-term horizon to: • Develop high-yielding basmati and short duration rice hybrids. • Improve the yield-potentials of maize-hybrids. • Develop high-yielding, uniformly maturing varieties of pulses.

2. Maize needs to be provided the same facilities of assured price and marketing as given to paddy and wheat.

3. Product specific markets, especially maize markets with mechanical driers are needed to facilitate the handling of the produce and its aggregation for purchasers.

4. Likewise, incentives for cotton are needed to keep it continuously more competitive than paddy.

b) Dairy Development in Waterlogged Areas

While recognizing the constraints in the development of dairying in the waterlogged areas, where the underground water is saline and unfit for crops and animals, the report presents a set of measures that could be taken to encourage dairy development:

1. Constructing water trenches to provide drinking water for animals

2. Improving the availability of good quality fodders

3. Extending the veterinary services to the farmers at their doorsteps

4. Disseminating the dairy technology to the farmers through training in dairy development.

c) <u>Micro-Irrigation System with Solar Energy</u>

To reverse the water-logging conditions, it is important to promote drip irrigation especially energized by the solar pumping system. There is a need to increase the subsidy on the solar energy systems along with the drip irrigation.

d) <u>Development of Fisheries</u>

Steps that need to be taken to address the roadblocks in promoting brackish water aquaculture include -- promotion of seed production activities in seed deficit States such as Punjab; establishment of brood banks at the District level/State level and up-gradation of hatcheries for maintaining and holding the brood stock as well as seed; in situ production of seed for stocking of reservoirs and other large water bodies; mandatory accreditation and certification of hatchery and seed; import of technology for breeding of commercially important fishes; public private partnerships for fish seed production and marketing.

e) <u>Development of Bio-Drainage for Water Logged Soils</u>

In order to develop sustainable technologies for the bio drainage of waterlogged and saline soils using Eucalyptus and Atriplex Amnicola, a technical programme needs to be put in place.

f) On-Farm Water Management

Adoption of proper water management practices at farm level is essential for sustainable production as well as productivity of crops. This calls for promotion of awareness among the farmers for optimal usage of irrigation water as well as construction of suitable irrigation structures for equitable distribution of irrigation water, which eventually reduces the possibility of occurrence of water logging. This can be achieved through closer participation of beneficiary farmers.

g) Conjunctive use of Surface and Ground Water

Planned use of surface and groundwater (conjunctive use) serves the dual purpose of increasing the area under irrigation by utilizing the ground water on one hand and lowering the adjoining water table on the other, thereby reducing the possibility of water logging. Lift irrigation through tube-wells and dug-wells should, therefore, be emphasized along with surface flow irrigation, especially for areas prone to water logging. Farmers using canal water for irrigation purposes should be encouraged to switch to the tube well wherever the water is of good quality (they should be supported in cash or kind). In fact, canal water supply may be cut in such fields. The exact ratio in which surface and ground water should be used can be determined after testing the available ground water. This will allow the two to be used in real conjunction.

CHAPTER - V

WATER QUALITY AND HEALTH ISSUES

Apart from depletion of water, quality of groundwater is also not suitable for drinking purposes. Rapid increases in population, urbanization, industrialization, and extensive agricultural practices have deteriorated water quality of this region. The intense agricultural activities of Punjab help to achieve national food security. But, large quantity of fertilizers and pesticides being used for better and enhanced crop yield, are also contaminating both groundwater as well as surface water bodies. Pesticides adversely affect human health and linked to certain types of abnormalities. The enhanced level of basic physicochemical characteristics is detected in several districts of Punjab. Contaminated water causes serious health hazards and people of this region are affected by various water-borne diseases.

Contaminants	Districts affected (in part)
Salinity (EC > 3000 µS/cm at 25 °C)	Firozepur, Faridkot, Bhathinda, Mansa, Muktsar, Sangrur
Fluoride (>1.5 mg/l)	Amritsar, Bhatinda, Faridkot, Patiala, Fatehgarh Sahib, Firozepur, Sangrur, Gurdaspur, Mansa, Moga, Muktsar,
Chloride (>1000 mg/l)	Firozepur, Muktsar
Iron (>1.0 mg/l)	Bhathinda, Faridkot, Fatehgarh Sahib, Firozepur, Gurdaspur, Mansa, Hoshiarpur, Rupnagar, Sangrur
Nitrate (>45 mg/l)	Bhathinda, Faridkot, Fatehgarh Sahib, Firozepur, Gurdaspur, Patiala, Hoshiarpur, Jalandhar, Kapurthala, Ludhiana, Mansa, Moga, Muktsar, NawanShaher, Rupnagar, Sangrur

Table 7: Status of physicochemical parameters of districts of Punjab

Increasing water pollution due to urbanization, industrialization and increased use of fertilizers and pesticides is causing deterioration of surface and groundwater resources. Groundwater at Shallow depth is largely contaminated caused by surface water pollution. The physico-chemical characteristics of shallow groundwater in the State indicate wide variations in mineral contents. The quality of groundwater is classified as Fit, Marginal and Unfit on the basis of Electrical Conductivity (E.C.) and Residual Sodium Carbonate (R.S.C.) which is indicative of salinity and alkalinity effect. Nearly 50-60% of the groundwater up to 60 meters depth in the State is fresh and fit and generally found in North, North-eastern and Central parts of the State comprising of districts of Amritsar, Gurdaspur, Hoshiarpur, Jalandhar, Kapurthala, Nawanshahar, Ropar, Ludhiana, Fatehgarh Sahib and SAS Nagar. Nearly 20-30% of the groundwater generally found in North-western and Central parts of the State comprising of districts of Tarn Taran, Patiala, Sangrur, Barnala and Moga is moderately saline and of marginal quality. About 15-25% of the groundwater is saline/alkaline and not fit for irrigation use and generally found in isolated patches in South and Southwestern parts of the State in districts of Muktsar, Bathinda, Mansa and Sangrur. Groundwater in South and Southwestern districts of the State namely Faridkot, Ferozepur, Muktsar, Bathinda, Mansa, Barnala and Sangrur contain varying concentration of soluble salts and its use for irrigation adversely effects agricultural production. Depth-wise study in South and Southwestern part of the State reveals that quality of native groundwater is largely fresh/fit at shallower depths and generally deteriorates with depth. The study shows that groundwater quality is fresh and fit in 60% of area at 10 metres depth which decreases to nearly 30% and 18% at 35 metres and 60 metres depth respectively. Similarly, groundwater quality is saline/ alkaline in nearly 17% of the area at depth of 10 metres which increases to 50% and 52% at the depth of 35 and 60 metres respectively. Ground water quality problem is more severe in terms of salinity in the districts of Muktsar, Mansa and Bathinda. Contaminations notably of Nitrate, Fluoride, heavy metals and radio-active element such as uranium in groundwater has been reported in significant proportion beyond the permissible limit in South and Southwestern part of the State by various agencies.

In general, about 60% of ground water is fresh and of good quality mostly in districts of Amritsar, Fatehgarh Sahib, Nawan Shahr, Gurdaspur, Ropar, Hoshiarpur, Jalandhar, Ludhiana and Kapurthala, nearly 30% is saline/alkaline (marginal to moderate) in districts of Patiala, Moga, Ferozepur and Mansa and nearly 10% is saline/alkaline which is unsafe for all purposes mostly in districts of Faridkot, Muktsar, Bathinda and Sangrur.

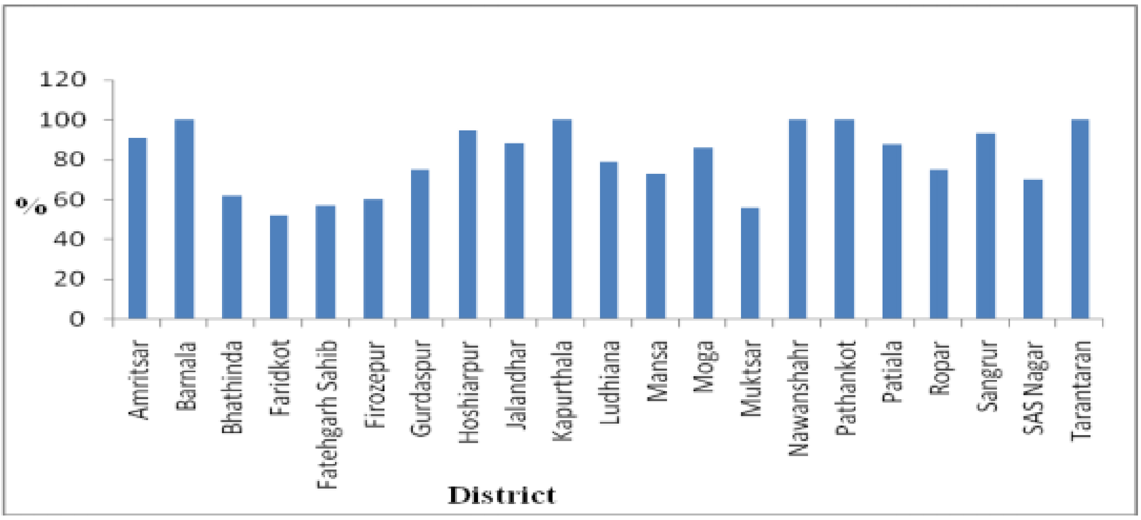
As per reports of Central Groundwater Water Board, water quality of rivers is getting degraded at several locations. Ghaggar River flows during monsoon rains and the water quality of this river is generally observed worst at all locations. After that, deterioration in water quality of Sutluj and Beas rivers by discharge of industrial effluents and municipal waste has also been reported. Water-borne diseases have been reported in Moga, Jalandhar, and Barnala locations due to the presence of microorganisms in water (CGWB, Ministry of Water Resources Report 2019).

Metals	Health effects	Reported areas of Punjab
Mercury	Abdominal pain, headache, diarrhea, haemolysis, chest problems	Presence in Budhanala water sample
Lead	Anemia, vomiting, loss of appetite, convulsions, damage of brain, liver and kidney	Highly reported in Bathinda and Ropar area
Arsenic	Lung cancer, disturbed peripheral circulation, metal problems, liver cirrhosis, hyper kurtosis, gastrointestinal tract ulcers, kidney damage	Bathinda and Mansa
Cadmium	Growth retardation, diarrhea, bone deformality, kidney damage, testicular atrophy, anemia, injury of central nervous system and liver, hypertension	In Canal water of Aboher and Bathinda area
Selenium	Damage of liver, kidney and spleen, fever, nervousness, vomiting, blood pressure, blindness, and even death	Ferojpur, Bathinda, Mukatsar District
Chromium (hexavalent)	Diseases in central nervous system, cancer, diarrhea, nephritis gastrointestinal ulceration	Scarce amount detection in some places of Malwa region
Uranium	Cancer, Infertility, diseases in central nervous system, mental abnormalities	Mostly in Villages of Bathinda, Firojpur, Mansa, and Sangrur District

Table 8: Health effect of polluted water in Punjab: Source CGWB 20012 & 2016

The groundwater pollution has crossed all the limits established by various national and international agencies. Several reports have already described the presence of high content of nitrate, fluoride, total dissolve solids, electric conductivity, chloride and sulphate in the groundwater of this region. The presence of toxic heavy metals like arsenic (As), uranium (U), lead (Pb), cadmium (Cd) and selenium (Se) has also been reported in groundwater.

Heavy metals like As and Pb are classified as the carcinogenic chemicals by WHO. Further, in case of U, reports suggested that its radiological risks may be linked with cancer. Due to the extensive deterioration of groundwater, the Malwa region of Punjab is facing serious health issues. The presence of U and As like carcinogenic chemicals of this region indicates their probable link with health. The presence of U concentration in the hair samples of breast cancer patients was reported in this region. Not only anthropogenic activities, the natural geomorphologic structure of this region is also responsible for deterioration of water quality.



Graph 5: District wise Distribution of Potable Water in Punjab (Source CGWB 2019)

The water quality of canal system is considered better and more suitable for human consumption than groundwater of this region. So, Punjab government has decided to give more emphasis on use of canal water as portable water. Moga and Barnala districts have been chosen under 300-crore pilot project, to set up conventional water treatment plant for supplying potable water to residents of the villages affected by toxic heavy metals problems like arsenic and uranium.

The Draft Dynamic Ground Water Estimation Report-2017 raised concerns about the deteriorating quality of groundwater due to pollution caused by urbanisation, industrialisation and an increased use of fertilisers and pesticides. It said that while nearly 50%-60% of groundwater was “fresh and fit”, 20%-30% was “moderately saline and of marginal quality”. Further, about 15%-25% of the groundwater was “saline, alkaline and not fit for irrigation. Water in south and southwestern districts — like Sangrur, Muktsar, Bathinda and Mansa — came under the last category, containing “varying concentration of soluble salts” and its use for irrigation will adversely affect agricultural production, said the report.

CHAPTER - VI

GROUNDWATER RESOURCES vs. DOMESTIC WATER DEMAND AND SUPPLY FOR SELECTED CITIES IN PUNJAB

6.1 INTRODUCTION

In NITI Aayog report entitled "Composite Water management Index – A Tool for water management" it has been mentioned that 21 cities across India are expected to run out of water by 2020. In this connection, CGWB was entrusted to study the ground water situation in 24 cities and a committee was constituted on 27 Jul 2018 to study the ground water situation and submit a report.

The committee obtained information from the Regional Offices on ground water situations along with demand vis-à-vis supply in 2018 and projected demand and supply for 2021, 2031 & 2041. The data on water demand and supply was collected by CGWB Regional Offices from respective State Agencies and the methodology adopted for the analysis of the same has been enumerated below:

1. The demand & supply from surface water & ground water sources in 2018 and projected demand & supply from surface water & ground water sources for 2021, 2031 & 2041 were obtained from the concerned State Agencies. In the absence of data on projected supply for the subsequent years, data for the year 2018 has also been considered for subsequent years.
2. The demand & supply data obtained for 2018, 2021, 2031 & 2041 have been linearly distributed for arriving at the demand and supply figures for the intervening years.

3. The ground water resources as in 2017 were worked out for each city, using GEC 2015 methodology for determination of annual replenishable and in-storage resources in the aquifer. As the NITI Aayog report mentions about drying up of cities, an exercise has been made by CGWB to assess the in-storage resources of the aquifer (if de-watered) to find about the total availability. However, for any policy decision, annual replenishable resources are only to be considered. Use of in-storage resources, which means mining of ground water, may lead to serious, undesirable consequences and hence, it is advocated not to use the in-storage resources.
4. The ground water resources as assessed in 2017 have been considered as annual ground water availability for subsequent years of projected demand.
5. The gap between demand and total supply for domestic purpose has been worked out for each year.
6. An attempt was initially made to find out the availability of ground water to meet the proposed water supply from the annual replenishable resources and if found inadequate, the available in-storage resource has been considered. In case, the total in-storage resource is also found inadequate, the balance available replenishable resources are shown as only available resources every year for the subsequent years.
7. Subsequently, an attempt was made to find out the possibility of ground water meeting the gap between demand and supply. In this attempt, initially only annual replenishable resources were considered and if found inadequate, the available in-storage resource has been considered. In case, the total in-storage resource is also found inadequate, the balance available replenishable resources will be the only available ground water resources every year.

6.2 <u>CITY WISE DEMAND VIS-A-VIS SUPPLY</u>

6.21 <u>AMRITSAR</u>

6.21(1) Groundwater System

The city forms part of Upper Bari Doab and is underlain by formations of Quaternary age comprising of alluvium deposits belonging to vast Indus alluvial plains. Sub surface geological formations comprise of fine to coarse grained sand, silt, clay and kankar. Gravel associated with sand beds occurs along left bank of Ravi. The beds of thin clay exist alternating with thick sand beds and pinches out at short distances against sand beds. Based on the available data, three aquifer systems have been delineated in the area. The aquifer group I occur under unconfined condition and found between the depth of 17m bgl and 114m bgl with a thickness 79m. The specific yield of the aquifer is 7.2%. The transmissivity values range from 1450 sqm/day to 2424 sqm/day. Aquifer is fresh and comprises of sand.

The aquifer group II and III occurs at a depth varying from 125m bgl to 179m bgl and 185m bgl to 300m bgl, with the thickness of 29m and 89m, respectively. Depth of ground water level in the Amritsar city is 25.56m bgl (Verka) and 26.6m bgl (Jandiala Guru Pz). Ground water level is shallow in western part of the city. Deeper ground water levels ranging from 21m bgl to 25m bgl occurs in the central part of the city covering Golden Temple Complex, Ram Bagh and Bus Stand areas.

6.21(2) Analysis and Discussion

As per the data supplied by the State Agencies, the demand would increase from 79.60 M.Cu.m in 2018 to 117.10 M.Cum in 2041. There is no surface water supply & ground water supply to meet the demand from 2018 to 2041 is 104.80 M.Cu.m. The share of ground water in water supply has been provided by State Government Agency 100% from 2018 to 2041. Overall, the total supply to meet the demand is constant i.e., 104.80 M.Cu.m from 2018 to 2041, there by resulting in no gap between demand and supply from 2018 to 2031. However, there is a gap of 12.30 M.Cu.m in 2041.

An attempt was made to find out the availability of ground water to meet the proposed water supply from ground water sources by the State Agencies. The annual replenishable resources are not sufficient to meet the proposed water supply. However available in-storage would be able to meet the envisaged supply. Subsequently, an attempt was also made to find out whether the gap in the water supply can be met from available ground water resources. It is seen that the available ground water resources including the in-storage will be able to meet the gap.

6.21(3) <u>Conclusion</u>

Demand has been assessed as 79.60 M.cu.m in 2018, 94.10 M.cu.m in 2021, 100.70 M.cu.m in 2031 & 117.10 M.cu.m in 2041. Total supply has been assessed as 104.80 M.cu.m from 2018 to 2041 and the share of ground water in water supply is 100% from 2018 to 2041. There is no gap in 2018, 2021 and 2031; however, it increases to 12.30 M.cu.m in 2041. The annual replenishable ground water resources (dynamic) as in 2017 is 28.92 M.cu.m and in-storage is 2385.57 M.cu.m with a total of 2414.49 M.cu.m. As per the water supply plan of state agencies, the share of ground water in water supply is 100% and it cannot be met from the annual replenishable resources. However available in-storage would be able to meet the envisaged supply. The groundwater resources including the in-storage will be able to meet the envisaged gap between demand and supply in 2041.

6.22 JALANDHAR

6.22(1) Groundwater System

The Jalandhar city is a part of Indo-Gangetic plain and Sutlej sub-basin of main Indus basin. The alluvial deposits comprise of sand, silt, clay and often associated with Kankar. Fine to medium grained sand horizon forms the potential aquifer in the area. The ground water from unconfined aquifer is abstracted through hand pumps and shallow tube wells up to the depth of 65 meters. Generally, the granular zones occurring between 29-35 m, 40-48 m and 56-68 m are tapped by shallow irrigation tube wells. However medium depth tube wells for the purpose of irrigation and drinking are being drilled up to the depth of 200m.

The ground water resources have been assessed down to a depth of 300m bgl. The annual replenishable resources has been assessed as in 2017 as 26.41 M.Cu.m and in-storage as 1174.43 M.Cu.m and total storage as 1200.84 M.Cu.m.

6.22(2) Analysis and Discussion

As per the data supplied by the State Agencies, the demand would increase from 62.39 M.Cu.m in 2018 to 87.63 M.Cu.m in 2041. There is no surface water supply to meet the demand from 2018 to 2041. However, the ground water supply will be 126 M.Cu.m from 2018 to 2041 which is more than the demand. The share of ground water in water supply has been provided by State Government Agency 100% as in 2018. Overall, the total supply to meet the demand will be 126 M.Cu.m from 2018 to 2041, for all the years and the gap is nil. The supply is 200% of demand in 2018, 193% in 2021, 165% in 2031 & 126 % in 2041, thereby indicating that groundwater development is more than the requirement. However, it has been informed that due to losses during water supply, supply is kept more than demand.

An attempt was made to find out the availability of ground water to meet the proposed water supply from ground water sources by the State Agencies. The annual replenishable resources are not sufficient to meet the proposed water supply. Subsequently, an attempt was also made to find out whether the gap in the water supply can be met from available ground water resources. It is seen that even the in-storage ground water resources are likely to be used up by the year 2029 and thereafter only annual replenishable resources would be available every year.

6.22(3) <u>Conclusion</u>

Demand has been assessed as 62.39 M.Cu.m in 2018, 65.38 M.Cu.m in 2021, 76.50 M.Cu.m in 2031 & 87.63 M.Cu.m in 2041. Total Supply has been assessed as 126 M.Cu.m from 2018 to 2041, and the share of ground water in water supply is 100%. Due to losses during water supply, supply is envisaged to be more than demand. There will be no gap between demand and supply from 2021 to 2041 as per data received from State agencies. The annual replenishable ground water resources (Dynamic) as in 2017 is 26.41 M.Cu.m and in-storage is 1174.43 M.Cu.m with a total of 1200.84 M.Cu.m As per the water supply plan of State Agencies, the share of ground water in water supply is 100% and it cannot be met from the annual replenishable resources. If the ground water resources are to be used for meeting the envisaged water supply, the in-storage ground water resources are likely to be used up by the year 2029 and thereafter only annual replenishable resources would be available every year. However, depleting water level may trigger increased lateral flow from the surrounding areas. Hence, the ground water resources are likely to last more than the estimated period.

6.23 <u>LUDHIANA CITY</u>

6.23(1) Groundwater System

The area is underlain by the Indo-Gangetic alluvium of Quaternary age. The alluvium is underlain by Pre-Cambrian basement rocks. The exploratory drilling carried out within Ludhiana City reveals that the thickness of unconsolidated alluvium is likely to be more than 373 m (Guruam Nagar). The alluvium is mainly of fluvial type and comprises of thick beds of fine to coarse grained unconsolidated sand, silt, clay, kankar etc., in various proportions. In the southern and eastern part, thick clay beds alternating with sand beds occur beyond 160 m. The lithological data of the area indicates the presence of many sand beds forming the principal aquifers separated by clay beds at various depths. The sand content in the aquifer in the area varies from 50% to 80%. Clay beds though thick at places occur mostly as lenses and pinch out laterally. The granular material becomes coarser with depth. In the shallow aquifer down to a depth of 50m, ground water occurs under unconfined/ semi-confined conditions, whereas in deeper aquifer, semi-confined/ confined conditions exist. This aquifer is tapped for domestic purpose by shallow tube wells and hand-pumps with a depth range of 40-60m. The tube wells constructed by Municipal Corporation and other agencies have tapped deeper aquifer down to depth of 200m. The deep tube wells constructed by CGWB tapped deeper aquifers below 150m, which are semi confined/ confined in nature.

The ground water resources have been assessed down to a depth of 258m bgl. The annual replenishable resources has been assessed as in 2017 as 41.66 M.Cu.m and in-storage as 1447.44 M.Cu.m and total storage as 1489.10 M.Cu.m.

6.23(2) ***Analysis and Discussion***

As per the data supplied by the State agencies, the demand would increase from 167.17 M.C.um in 2018 to 234.69 M.C.um in 2041. There is no surface water supply to meet the demand from 2018 to 2041. However, the ground water supply remains 231.41 M.Cu.m from 2018 to 2041. The share of groundwater in water supply has been provided by State Government Agency as 100%. The gap is nil, except for the year 2041, which is 3.28 M.Cu.m. The supply is more than the demand by 138% in 2018, 130% in 2021, 112% in 2031 and only 98% in 2041, resulting in gap only in 2041.The groundwater development is more than the requirement as it has been informed that supply has been kept higher than the demand due to losses during water supply.

An attempt was made to find out the availability of ground water to meet the proposed water supply from ground water sources by the State Agencies. The annual replenishable resources are not sufficient to meet the proposed water supply. Subsequently, an attempt was also made to find out whether the gap in the water supply can be met from available ground water resources. It is seen that the in-storage ground water resources are likely to be used up by the year 2025 and thereafter only annual replenishable resources would be available every year.

6.23(3) ***Conclusion***

Demand has been assessed as 167.17 M.Cu.m in 2018, 178.49 M.Cu.m in 2021, 206.59 M.Cu.m in 2031 & 234.69 M.Cu.m in 2041. Total supply has been assessed as 231.41 M.Cu.m from 2018 to 2041 and the share of ground water in water supply is 100%. The supply has been kept higher than the demand due to losses during water supply. There is no gap between demand & supply except in 2041 which is 3.28 M.Cu.m. The annual replenishable ground water resources (Dynamic) as in 2017 is 41.66 M.Cu.m and in-storage is 1447.44 M.Cu.m with a total of 1489.10 M.Cu.m As per the water supply plan of State Agencies, the share of ground water in water supply is 100% from 2018 to 2041 and it cannot be met from the annual replenishable resources.

If the ground water resources are to be used for meeting the envisaged water supply, the in-storage ground water resources are likely to be used up by the year 2025 and thereafter only annual replenishable resources would be available every year. However, depleting water level may trigger increased lateral flow from the surrounding areas. Hence, the ground water resources are likely to last more than the estimated period.

6.24 MOHALI CITY

6.24(1) Groundwater System

The S.A.S Nagar district is occupied by Quaternary Alluvial deposits belonging to the vast Indo-Gangetic alluvial plains, which forms the main aquifer system. Ground water occurs under phreatic conditions in the shallow aquifers while leaky confined to confined conditions occur along the deeper aquifers of Quaternary alluvial deposits. CGWB has delineated three aquifer groups in the area. The aquifer group I occur under unconfined to confined extending down to a depth of 9.89m bgl to 108m bgl and the thickness of granular zones is 34m. The aquifer group II occurs at a depth of 130m bgl to 201m bgl and the thickness of granular zones is 24m. The aquifer group III occurs at a depth of 220m bgl to 300m bgl with a thickness of 19m for the granular zones. The transmissivity varies from 687 sqm /day to 1395 sqm /day and a discharge rate of 2857 m^3 /day to 3466 m^3 /day for aquifers underlying the area. Presently, there are 6 monitoring stations in the city. The average depth of water level during May 2018 in the city is of the order of 12.16m bgl.

The ground water resources have been assessed down to a depth of 300m bgl. The annual replenishable resources has been assessed as in 2017 as 7.51 M.Cum and in-storage as 140.69 M.Cum and total storage as 148.20 M.Cum.

6.24(2) <u>Analysis and Discussion</u>

As per the data supplied by the State Agencies, the demand would increase from 25.77 M.Cum in 2018 to 32.63 M.Cum in 2041 and the supply is 15.46 M.Cum from surface water and 10.31 M.Cum from ground water resulting in a total supply of 25.77 M.Cum in 2018. There is no change in surface water supply & groundwater supply to meet the demand from 2018 to 2041. As a result the demand supply gap has been increased from nil in 2018 to 6.86 M.Cum in 2041. The share of ground water in water supply has been provided by State Government agency, as 40%.

An attempt was made to find out the availability of ground water to meet the proposed water supply from ground water sources by the State Agencies. The annual replenishable resource is not sufficient to meet the proposed water supply. However, the available in-storage will be able to cater to the proposed supply. Subsequently, an attempt was also made to find out whether the gap in the water supply can be met from available ground water resources. It is seen that the in-storage ground water resources are likely to be used up by the year 2039 and thereafter only annual replenishable resources would be available every year.

6.24(3) ***Conclusion***

Demand has been assessed as 25.77 M.Cu.m in 2018, 26.75 M.Cu.m in 2021, 29.69 M.Cu.m in 2031 & 32.63 M.Cu.m in 2041. Total Supply has been assessed as 25.77 M.Cu.m from 2018 and the same is considered for the subsequent years. The share of ground water in water supply is 40%. The Gap has been assessed as nil in 2018, 0.98 M.Cu.m in 2021, 3.91 M.Cu.m in 2031 & 6.86 M.Cu.m in 2041.The annual replenishable groundwater resources (Dynamic) as in 2017 is 7.51 M.Cu.m and in-storage is 140.69 M.Cu.m with a total of 148.20 M.Cu.m. As per the water supply plan of State Agencies, the share of ground water in water supply is 40% and it cannot be met from the annual replenishable resources. However, the available in-storage will be able to meet the envisaged supply.

If the ground water resources are to be used for meeting the envisaged gap between demand and water supply, the in-storage ground water resources are likely to be used up by the year 2039 and thereafter only annual replenishable resources would be available every year. However, depleting water level may trigger increased lateral flow from the surrounding areas. Hence the ground water resource is likely to last more than the estimated period.

6.25 PATIALA CITY

6.25(1) ***Groundwater System***

The city is occupied by Indo-Gangetic alluvial plain of Quaternary age and falls in the Ghaggar basin. The groundwater occurs in alluvium formations comprising fine to coarse sand, which forms the potential aquifers. In the shallow aquifer, ground water occurs under unconfined/water table conditions, whereas in deeper aquifer, semi-confined/confined conditions exist. Three aquifers have been demarcated down to 300 m depth (Aquifer I from 20.48m bgl to 103m bgl, Aquifer II from 130m bgl to 185m bgl, Aquifer III from 232m bgl to 300m bgl). The average water level during May 2018 in the city is of the order of 30.88m bgl.

The ground water resources have been assessed down to a depth of 300m bgl. The annual replenishable resources has been assessed as in 2017 as 8.08 M.Cu.m and in-storage as 445.33 M.Cu.m and total storage as 453.41 M.Cu.m.

6.25(2) <u>Analysis and Discussion</u>

As per the data supplied by the State Agencies, the demand would increase from 29.20 M.Cum in 2018 to 45.63 M.Cum in 2041, while there is a significant increase in surface water supply from NIL to 20.44 M.Cum, respectively from 2018 to 2041 while the ground water supply is 25.19 M.Cum in 2018 & is retained till 2041. The share of ground water in water supply has been provided by State Government Agency is decreasing from 100% in 2018 to 55% in 2041. The total supply to meet the demand has increased from 25.19 to 45.63 M.Cum from 2018 to 2041, there by resulting in a gap of 4.01 M.Cum in 2018 and no gap in subsequent years.

An attempt was made to find out the availability of ground water to meet the proposed water supply from ground water sources by the State Agencies. The annual replenishable resource is not sufficient to meet the proposed water supply. However, the available in-storage would be able to meet the envisaged supply. Subsequently, an attempt was also made to find out whether the gap in the water supply can be met from available ground water resources. It is seen that the ground water resources including the in-storage will be able to meet the demand in the projected years till 2041.

6.25(3) ***<u>Conclusion</u>***

Demand has been assessed as 29.2 M.Cu.m in 2018, 31.39 M.Cu.m in 2021, 38.33 M.Cu.m in 2031, and 45.63 M.Cu.m in 2041. Total Supply has been assessed as 25.19 M.Cu.m in 2018, 31.4 M.Cu.m in 2021, 38.33 M.Cu.m in 2031 & 45.63 M.Cu.m in 2041 and the share of ground water in water supply is 100% in 2018, 80% in 2021, 66% in 2031 & 55% in 2041. The Gap has been assessed as 4.01 M.Cu.m in 2018 and there is no gap in subsequent years. Groundwater Availability: The annual replenishable groundwater resources (Dynamic) as in 2017 is 8.08 M.Cu.m and in-storage resources are 445.33 M.Cu.m with a total of 453.41 M.Cu.m.

As per the water supply plan of State Agencies, the share of ground water in water supply is 100% in 2018 and it cannot be met from the annual replenishable resources alone. However, the available in-storage would be able to meet the envisaged supply. The ground water resources including the in-storage will be able to meet the demand in the projected years till 2041. However there will be a huge depletion in in-storage ground water resource which may trigger lateral inflow from surrounding areas.

CHAPTER - VII

INSTITUTIONAL FRAMEWORK AND ACTORS IN THE SECTOR

7.1 Introduction

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 wastewater, 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.

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 MGNREGS), address soil erosion, soil preservation, rainwater harvesting, farmer training, roadside plantation.
6. Irrigation- Groundwater, resource conservation, clean energy-based pump-sets, rainwater 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, bioenergy.
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 rainwater 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:

7.2 __Punjab Mission on Sustainable Agriculture__

1. Agriculture and Horticulture Crops promotes resource conservation of soil, water and energy
2. Fisheries
    a) Renovate/rehabilitate of village ponds and development of new ponds/tanks in saline affected waterlogged land in the south-west district of Punjab
    b) Develop Saline affected waterlogged area in the south-west districts of Punjab for fisheries
3. Determination of hydrological and physico-chemical characteristics of water bodies.

7.3 __Green Punjab Mission__

1. 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 waterlogged areas, through agroforestry, by planting trees outside forests in institutional areas.
2. 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.

7.4 <u>Mission on Sustainable Habitats - Protecting settlements</u>

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:

7.51 *In the* ***<u>Irrigation sector</u>****, 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, remodelling, renovation and extension of canals, deep tube wells, lining of water courses, cleaning of canals etc.

7.52 *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 waterlogged villages in the state.

7.61 *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 Household Latrines in rural Areas

7.62 *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.

7.71 *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

7.72 *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 wastewater after treatment of 45 MLD domestic wastewater of Ludhiana at Bhatian.

7.81 There have been significant efforts in pollution control, under the **National River Conservation programme**. Regulating quality of Industrial & domestic wastewater 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

¬ Wastewater 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 wastewater 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 wastewater 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.

7.82 *The achievements in this sector are:*

- ❖ Monitors groundwater quality in industrial towns of Ludhiana, Jalandhar, Amritsar, Nangal etc.
- ❖ Sludge sampling of wastewater 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 wastewater.
- 24 ambient air monitoring stations across Punjab

7.9 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 state aims to enhance water use efficiency by 20% with respect to the present. The actions would include enhancement of share of wastewater 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 waterlogged 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 biotechnology 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.

CHAPTER - VIII

FUTURE PROSPECTS

8.1 Way 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 crossroads. The state's agriculture has reached a plateau under the available technologies and natural resource base and has become unsustainable and nonprofitable. 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.

The preventive measures taken by the concerned authorities to meet the challenges regarding water related issues are insufficient. Now, time demands to take effective preventive measures massively to regulate the water usage and to introduce the water-saving measures like sprinkling system, rainwater harvesting, and underground piping system for irrigation on a large scale. The canal system requires to be revamped. The regulation or check on the farm and industrial sector on pumping out water should be imposed because almost more than 3 crore gallons of water is pumped out by industries in Ludhiana alone. The state government should constitute Water Regulatory Authority and also promote less water-consuming crops such as maize and sunflower. Role of public investment in water sector should be examined. The penalty or punishment should be strictly imposed on the person or industries, involved in contamination and wastage of water. The political reasons should be removed and the implementation of government policies should be done effectively with zero tolerance.

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:

8.2 <u>Short to Medium term strategy</u>

1. 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.
2. 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.

3. Implementation and enforcement of existing laws is weak. For instance, Electricity Act 2003 made metering mandatory, but to no avail.
4. 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.
5. The feeders for supply of power for agriculture can be separated to curb misuse of electricity and thereby groundwater.
6. 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 mechanism is essential to facilitate all major commercial/institutional/industrial service entities to move to zero liquid discharge (ZLD) in a defined time frame.
7. 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.
8. 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.
9. 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.

10. 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.
11. 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).
12. 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.
13. The water conflicts between Punjab and neighbouring states have 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.

8.3 Medium to long term strategies

1. Punjab is yet to formulate a ground water policy. It needs to develop an implementation framework for policies and mechanisms for operationalizing them.
2. 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.
3. 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.

4. 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.
5. 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.
6. 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.
7. Mechanisms for rational water pricing and sustainable financial performance of the local bodies.

CHAPTER - IX

SOLVING THE WATER CRISIS BY SAVING MONEY IN AGRICULTURE

9.1 Punjab's Water Supply Dilemma

The Green Innovation Centre India works to support India's smallholder farmers in accessing innovations along the agri-value chain for staple crops like tomato, potato and apple. One project explored water use and found that water is being mismanaged due to the fact that electricity is subsidised for farmers. Farmers are prone to using excessive water for their new crops which leads to greater groundwater extraction. The power runs constantly, but in unpredictable waves, so many farmers run their pumps and irrigation systems continuously to make maximum use of available electricity. The machines then pump continuously and extract more water from the soil than needed. The groundwater level drops until it can no longer be reached by the pumps. So, saving water could also mean saving energy.

Available resources must be planned and preserved to make farming models both sustainable and economical. In terms of irrigation, there are three main challenges that illustrate how ecological and economic success are linked. Firstly, irrigation often has high labour costs, as farmers have to open and close their valves manually. Secondly, the excessive consumption of water reduces the groundwater table. Finally, inefficient or wrong amounts of water can lead to lower yields, higher costs, poor plant health and an increased chance of root disease.

In order to meet these challenges, the Green Innovation Centre India is testing various innovative solutions.

9.2 <u>Laser Land Leveller</u>

9.21 Introduction:

Uneven soil surface has a major impact on the germination, stand, and yield of crops due to inhomogeneous water distribution and soil moisture. Therefore, land levelling is a precursor to good agronomic, soil, and crop management practices.

Traditionally farmers level their fields using animal drawn (Fig: 1.a) or tractor-drawn levellers (Fig: 1.b). These levellers are implements consisting of a blade acting as a small bucket for shifting the soil from higher to the low-lying positions. It is seen that even the best levelled fields using traditional land levelling practices are not precisely levelled (Fig. 2) and this leads to uneven distribution of irrigation water.

Fig: 1(a)

Fig:1(b)

Fig:2

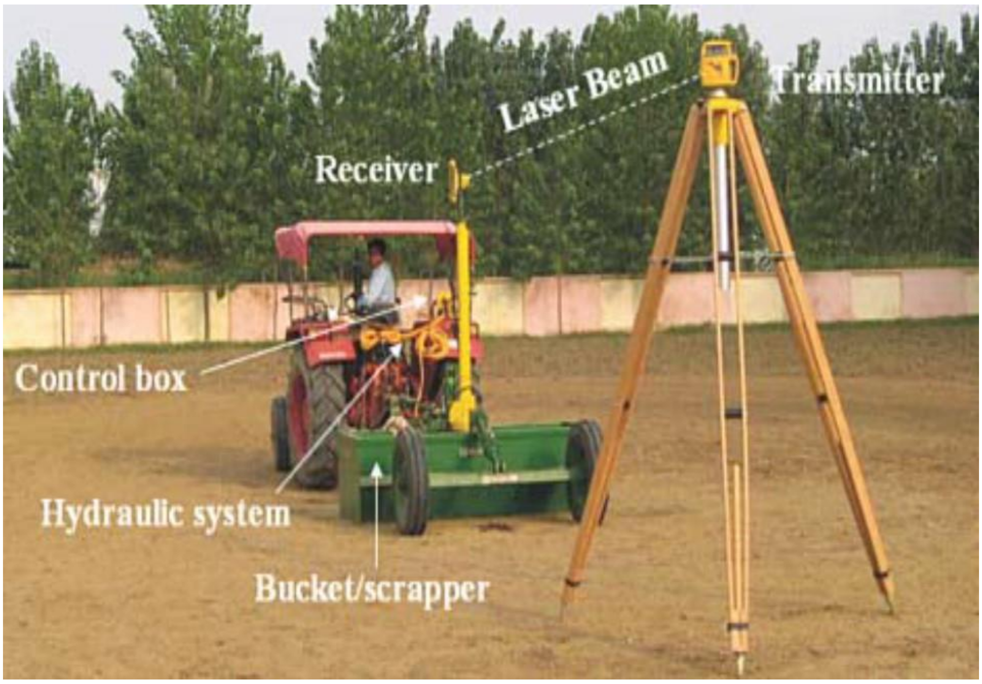
The common practices of irrigation in intensively cultivated irrigated areas are flood basin and check basin irrigation systems. These practices on traditionally levelled or unlevelled lands lead to water logging conditions in low-lying areas and soil water deficit at higher spots.

The advanced method to level or grade the field is to use laser-guided levelling equipment. Laser land levelling is levelling the field within certain degree of desired slope using a guided laser beam throughout the field.

9.22 Working mechanism of Laser Leveller:

The system includes a laser-transmitting unit that emits an infrared beam of light that can travel up to 700m in a perfectly straight line. The second part of the laser system is a receiver that senses the infrared beam of light and converts it to an electrical signal. The electrical signal is directed by a control box to activate an electric hydraulic valve. Several times a second, this hydraulic valve raises and lowers the blade of a grader to keep it following the infrared beam. Laser levelling of a field is accomplished with a dual slope laser that automatically controls the blade of the land leveller to precisely grade the surface to eliminate all undulations tending to hold water.

Laser transmitters create a reference plane over the work area by rotating the laser beam 360 degrees. The receiving system detects the beam and automatically guides the machine to maintain proper grade. The laser can be level or sloped in two directions. This is all accomplished automatically without the operator touching the hydraulic controls.



9.23 Benefits of laser land levelling over conventional land levelling:

- Reduction in time and water for irrigation
- Uniform distribution of water
- Less water consumption in land preparation
- Precise level and smoother soil surface
- Uniform moisture environment for crops
- Lesser weeds in the field

- Good germination and growth of crop
- Uniformity in crop maturity
- Reduced seed rate, fertilizers, chemicals and fuel requirements

9.24 Benefits of precise land levelling:

- Saves irrigation water >35 %
- Reduced weed in the field
- Increase in field areas about 3.5 %
- Reduce farm operating time by 10 %
- Assist topsoil management
- Saves labour costs
- Saves fuel/electricity used in irrigation
- Increase productivity up to 50 %

9.25 Conclusion:

Laser levelling of agricultural land is a recent resource-conservation technology. It has the potential to change the way food is produced by enhancing resource-use efficiency of critical inputs without any disturbing and harmful effects on the productive resilience of the ecosystem.

In spite of several direct and indirect benefits derived from laser land levelling technology, it is yet to become a popular farming practice in the developing and the underdeveloped countries. For accelerating its popularization and large-scale adoption, it requires a number of well-considered and synchronized research, extension, participatory, economic and policy initiatives keeping in view the long-term sustainability of our production systems.

Popularization of this technology among farmers in a participatory mode on a comprehensive scale, therefore, needs appropriately focused attention on priority basis along with requisite support from researchers and planners. The change in our vision of future agriculture in relation to food and nutritional security, environmental safety and globalization of markets demands improving resource-use efficiency considerably to reach the desired growth levels in food production and agricultural productivity. Laser levelling is evidently one of the ways by which we can address these issues to a great extent.

9.3 Underground Irrigation

Most farmers use drip irrigation to save water. Although it is already a considerable improvement over traditional flood irrigation, there is still room for improvement. Instead of a water outlet on the surface, the new “System of Water for Agriculture Rejuvenation” (SWAR) technology provides underground irrigation. Like drip irrigation, a pipe runs along the field ridges, connected by smaller pipes every few metres which go to the root zone level of the particular crop. A plastic container the size of a golf ball is attached to the end of these small tubes. It has small holes and is filled with quartz stones.

When water flows through the pipe and reaches the container, the stones distribute it and let it wet the ground gradually. SWAR technology has been tested on tomato, chilli and saline fields and the results show that this technology increases plant height, number of branches and biomass production with similar levels of yield. The main differentiator is that the technology uses 40 per cent less water, so the farmer saves money and conserves precious water resources.

9.4 Precision Irrigation

The automated irrigation system “Water-Hand”, developed by Farm Hand, delivers a precise amount of water at a specific time based on information using the crop’s lifecycle, local weather and soil conditions. This means significantly less water is used than current practices.

9.5 The Future of Punjab's Water Resources

Long-term use is expected to yield significant benefits. These include a 30 per cent increase in yield and a 60 per cent reduction in the amount of water and energy consumed. This is because the technology allows for the right amount of water to be distributed at the right time. As well as this, it should lead to more accurate fertilizer use as over-irrigation is linked to the loss of nutrients which might escape with water runoff. By automating the switching on and off of valves, labour should also be significantly reduced.

India, the world's largest groundwater user, extracts a dangerously high amount of 250 cubic kilometres of water per year. As water becomes increasingly scarce, this will make the irrigation of fields more difficult and expensive. Innovations that reduce water use by making it more efficient are therefore urgently needed.

The examples of underground and precision irrigation show that the protection of natural resources and market interests can be met at once. Both examples saw the reduction of water consumption, saving energy and money for the farmer.

These sorts of win-win innovations can serve all stakeholders in the agricultural sector as inspiration for new technologies. With a creative and sometimes even simple approach, both the ecological future and economic prosperity of Indian farmers can be strengthened.

The project Green Innovation Centres for the Agriculture and Food Sector – India, is part of the special initiative *One World – No Hunger Initiative, c*ommissioned by German Federal Ministry for Economic Cooperation and Development (BMZ) and implemented by Deutsche Gesellschaft fuer Internationale Zusammenarbeit (GIZ) GmbH.

The concept called conservation agriculture (CA) consists of three agro-ecological practices: no ploughing, maintaining a permanent soil mulch or cover, and diversification in the cropping system. CA addresses both water management and checking soil degradation. This system increases water supply by capturing and releasing water in aquifers, with zero-tilled soil acting as a catchment. It also downsizes the crop demand for water by reducing evaporation and transpiration losses.

The 2020 World Water Development Report has endorsed CA for water management. Other alternative sustainable agriculture practices, including zero-budget natural farming, permaculture and direct-seeded rice, also adopt some principles of CA, although not all.

9.6 Reusing Wastewater for Crops Could Reduce Water Scarcity, If We Can Stomach It

WHAT HAPPENS TO water after washing your hands or flushing the toilet? Worldwide, over 80% of wastewater is released untreated into the environment. Cleaning that water and recycling it for use in agriculture could cut down on pollution of lakes and streams and slow the rate at which food production depletes freshwater. And the nutrients in partially treated wastewater can nourish plants, diminishing the need for fertilizers.

A new paper in Agricultural Water Management by researchers at the University of Alicante in Spain analyzed 125 studies for themes related to the acceptance and use of recycled wastewater for irrigation in agriculture. It found that while the public is concerned about health risks, farmers also consider the long-term effects of the wastewater on the quality and health of their soil, which can vary. And beyond practical considerations of risks and benefits, recycling wastewater has an inherent “yuck factor” to be overcome.

Unsurprisingly, the researchers found that the yuck factor is less of an issue for farmers during times of drought or when the quality of the recycled wastewater is high. Economics can overcome the yuck factor, too. In the Thessaly region of Greece, 57.9% of farmers responded that they would pay for reclaimed water if it cost half the price of freshwater. Only 8.4% would pay for recycled water if it cost only a little less than freshwater.

Consumers, on the other hand, appear more likely to accept the use of wastewater to irrigate crops if they trust the institutions managing the water and if they understand the treatment process, environmental benefits, and issues of water scarcity. One strategy to build trust in wastewater treatment, the researchers say, is to build and run small-scale demonstrations before implementing full-scale water reuse programs so the public can see the quality of the water themselves. Because seeing is believing and feeling is truth.

Recycled water is treated to different extents depending on its future use. For example, recycled water entering the drinking water supply is treated more than recycled water used for irrigation. When adequately treated for a given use, recycled water is safe. But, about 10% of irrigated land globally uses untreated or partially treated wastewater, according to a paper cited in the review.

That presents clear risks for human health and for the environment. Pathogens can be transported in undertreated wastewater, as can metals, pharmaceuticals, and endocrine-disrupting chemicals. Disease organisms can move from reused water to food. Metals and salts from the water can build up in soil, changing soil properties such as pH and affecting plant growth.

But other compounds in the water are actually nutritious for soils, replacing or diminishing the need for fertilizers. One study highlighted by the researchers found that in Hyderabad, India, farmers believed the partially treated wastewater contained nutrients that were beneficial to their crops. However, growers also changed which crops they grew because of increasing soil salinity.

9.7 <u>Water Use Efficiency Through Micro Irrigation in Punjab</u>

The backbone for the success of water use efficiency initiatives through micro irrigation is, first and foremost, effective training and awareness generation amongst small and marginal farmers in potential states.

According to the FICCI-Grant Thornton Strategy Paper, 2016, agriculture accounts for approximately seventy per cent of global freshwater withdrawals and ninety per cent of its consumptive use. There is considerable strain on water resources due to non-judicious conveyance and application in agricultural practices. A United Nations (UN) study further indicates that nearly 3.4 billion people would be living in water scarce countries by the year 2025. Without doubt, agriculture is a sector wherein ‘water scarcity’ has very critical relevance, specially, in context of the ongoing climate change vulnerabilities.

In India, food grain production has largely been possible through irrigated agriculture. But over fifty per cent of cultivated land that produces more than eighty per cent of nutri-cereals, pulses, oilseeds, fruits and vegetables is monsoon dependent. Such land in ‘rainfed’ regions also face vagaries of aberrant monsoons, soil degradation, nutrient deficiencies and more importantly declining ground water table. We are a food secure nation notwithstanding. However, a mammoth challenge for the future is increasing agricultural productivity, first and foremost, by prudent and efficient use of water resources. The Doubling Farmers Income Committee (DFI) Report of Government of India, 2018 correctly observes that to achieve doubling farmers income the need of the hour is to ensure scientific and egalitarian application of water to achieve the right crop result and also avoid wastage.

Therefore, to address end to end solutions for water management in agriculture, Government of India has launched a comprehensive flagship programme called, ‘’Pradhan Mantri Krishi Sinchai Yojana.” More specifically, the ‘Per Drop More Crop’ component of the scheme focuses on micro irrigation systems (sprinkler, drip, pivots, rain-guns etc.) that promote precision farming by making water available in a targeted manner to the root zone of crops. There is an area ceiling of five hectare on subsidy support and subsidy can be topped by state governments.

To supplement the above programme, the Government has also approved an initial corpus of Rs. 5000 crores for setting up a dedicated "Micro Irrigation Fund" with National Bank of Agricultural and Rural Development (NABARD). The latter aims to extend loans to state governments to undertake special and innovative projects in micro irrigation.

Unlike flood irrigation in command areas, where water is lost in conveyance, micro irrigation not only leads to water saving but also aids soil heath management and prevents water logging. As per DFI Report, 2018, micro irrigation delivers water savings upto 40 per cent over conventional flood irrigation, crop and income enhancement to the extent of approximately 47 per cent and 48 per cent respectively.

The Task Force on Micro Irrigation, 2004 had estimated a potential of 69.5 million hectare under micro irrigation. As per the DFI Report, 2018, out of the 6.4 million hectares of net cultivated area under irrigation in the country, the coverage of micro irrigation by the end of 2016-17 stood at approximately 9.5 million hectares. It is proposed to add an extent of 10 million hectares over five year's period of 2017-18 to 2021-22, the Report adds. Such coverage is to include propagation of micro irrigation in water guzzling crops like sugarcane, rice, banana, cotton etc. Geographically, the states with the largest areas under micro irrigation include Rajasthan, Maharashtra, Andhra Pradesh, Karnataka, Gujarat and Haryana. These six states cover 81 per cent of the total area under micro irrigation.

Experts opine that a key operational and implementation issue in states is improving the efficiency of the entire process from application, installation till subsidy payment for micro irrigation equipment. Information technology-based initiatives in the states of Gujarat, Andhra Pradesh and Maharashtra have enabled real time monitoring of transactions for small and marginal farmers including geo tagging of installed equipment.

Another critical issue is convergence of micro irrigation with creation of water harvesting storage structures (ponds, tanks, check dams, injection wells etc.) and related afforestation/in-situ moisture conservation schemes in over exploited/critical underground water zones to recharge aquifers. Haryana government has identified 36 ‘over exploited/critical’ community blocks to propagate micro irrigation systems along with creation of water harvesting structures under Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) and Integrated Watershed Development Programme (IWDP). It has further innovated to offer special incentive through uniform subsidy at 85 per cent for all category of farmers in the state.

Similarly, Narmada (Sinchor) Rajasthan, Mission Kakatiya and Micro Irrigation Scheme, Gujarat are integrated micro irrigation projects run by the Government of Rajasthan, Government of Telangana and the Gujarat Green Revolution Company Ltd respectively. The key feature common to all three projects is participatory management and necessary crop alignment by active involvement of marginal farmers through water users’ associations and Gram Panchayats.

Yet another area of future concern is strengthening multi stakeholder institutional support to propagate micro irrigation through public private partnerships. Niti Aayog has recently issued a draft concept note on “Micro Irrigation Through Public Private Partnership”. Therein, it has highlighted the dire need for involving the private sector in implementation and maintenance of integrated micro irrigation networks to ensure water efficiency at the farm level and achieve economy of scale. The aim is to channelize investment into micro irrigation for both social and environmental impacts coupled with rational returns.

In this context, Kaladera village in Jaipur District of Rajasthan is the location of a Public-Private Community Partnership that includes the Department of Horticulture, Government of Rajasthan, The Krishi Vigyan Kendra (KVK) Takdera and Coca Cola/Hindustan Coco Cola Beverages Pvt. Ltd. Herein, sustainable water management practices using drip irrigation for vegetables are being propagated amongst five hundred farmers. Similarly, Pepsico Ltd in partnership with Government of Maharashtra has propagated drip irrigation for potato cultivation spread over nineteen hundred acres involving over two thousand farmers.

The backbone for the success of water use efficiency initiatives through micro irrigation is, first and foremost, effective training and awareness generation amongst small and marginal farmers in potential states. Equally critical is crop alignment and diversification backed by “Green Water” techniques such as land levelling, field bunding, mulching, zero tillage etc that help in conserving water and increasing yield. In both measures, Krishi Vigyan Kendras (KVKs), as focal points, have to ensure effective demonstrations to farmers especially in over exploited and critical community blocks. In this backdrop, the mission mode “Jal Shakti Abhiyaan” through the Jal Shakti Scheme launched in 225 districts for enhancing conservation in water scarce areas is a momentous step in the right direction.

Flood irrigation delivers only 35-40 per cent water use efficiency, as opposed to micro irrigation which has up to 90 per cent efficiency. Whilst the coverage of drip (2.13 per cent) and sprinkler (3.30 per cent) methods of irrigation is meagre compared to its total potential in India, this presents an exciting opportunity for wide scale investment in micro irrigation as a key solution to solving India's water crisis.

Research highlights that the slow spread of micro irrigation is not mainly due to economic reasons, but due to a lack of awareness among the farmers about the real economic and revenue-related benefits of it. By adopting micro-irrigation, farmers experience an increase in productivity – by being able to control, quite precisely, water application at the plant roots, crop yield is increased, resulting in an increase in profits. Additionally, farmers who adopt micro irrigation experience a reduced cost of cultivation. There are cost savings to be made by reducing the use of seeds via line seeding vs broad seeding and reducing the need for weed control. There are also significant time and labour savings to be made, as the micro irrigation system is permanently fixed, requiring less expenditure on labour for weeding and watering crops.

While the Government of India has been implementing a centrally sponsored scheme on micro irrigation with the objective to enhance water use efficiency in the agriculture sector by promoting drip and sprinkler irrigation technologies, in many areas (for example, Punjab) the Government provides farmers with free or subsidised power to pump water, which does not promote the judicious use of water among farmers. In these areas, it is difficult to incentivise farmers to convert to more efficient methods of irrigation (i.e. micro irrigation).

9.8 Reduction of water intensive crops

Additionally, according to experts at the Central Water Commission, India's cropping pattern highlights the rampant cultivation of water intensive crops such as sugarcane, paddy, cotton and banana, across water stressed regions of India.

Crop	Water Requirement (mm)	Crop	Water Requirement (mm)
Rice	900-2500	Chillies	500
Wheat	450-650	Sunflower	350-500
Sorghum	450-650	Castor	500
Maize	500-800	Bean	300-500
Sugarcane	1500-2500	Cabbage	380-500
Groundnut	500-700	Pea	350-500
Cotton	700-1300	Banana	1200-2200
Soybean	450-700	Citrus	900-1200
Tobacco	400-600	Pineapple	700-1000
Tomato	600-800	Gingelly	350-400
Potato	500-700	Ragi	400-450
Onion	350-550	Grape	500-1200

***Highlighted in Red – Crops with very high requirement of water*

Table 9: Water requirement for different crops

Maharashtra is one of the worst water stressed states of India, but government data suggests that Maharashtra is also the largest state with sugarcane cultivation in the tropical region. Similarly, sugarcane and paddy are commonly cultivated in highly water stressed regions of the Cauvery basin, which spreads over the conflicting states of Karnataka and Tamil Nadu.

As agriculture is the largest consumer of freshwater in India, the shift from water intensive crops, to less water intensive crops such as pulses, millets, vegetables, legumes, oilseeds, and medicinal plants, can spare large quantities of freshwater in India, with minimal cost, for the benefit of farmers.

At a time when farmers protesting at Delhi borders are demanding to make Minimum Support Price (MSP) a legal provision, the draft National Water Policy 2020 has blamed the government's procurement policy — for wheat and rice — for the skewed pattern of demand for these water-intensive crops, which has aggravated the water crisis in the country.

The policy has held that crop diversification without endangering national food security is the "single most important step" in resolving India's water crisis. In India, water consumption for irrigation accounts for 80-90 per cent. Of this, 80 per cent water is consumed by just three crops — rice, wheat and sugarcane. The draft policy has recommended diversifying the crop procurement process in a calibrated manner to include nutri-cereals like millet, jowar and bajra, pulses and oil seeds, in line with the local agro-economy.

It was during the 70s that states like Punjab, one of the biggest beneficiaries of the Green Revolution, increased the acreage of water-intensive crops like wheat and rice, in a bid to make India self-sufficient.

To encourage farmers to move away from growing rice and wheat, the National Water Policy 2020 has recommended shifting the irrigation water fee from crop/acreage/season to volumetric basis. Volumetric basis means that the farmers will be charged based on the volume of water they use. Currently, farmers pay a fixed amount, regardless of how much they consume. This will pinch the farmers as they will have to pay more. It will push farmers to diversify to crops other than the water-intensive rice and wheat. Among others, the draft policy has also recommended bridging the water silos — between ground and surface water, irrigation and drinking water.

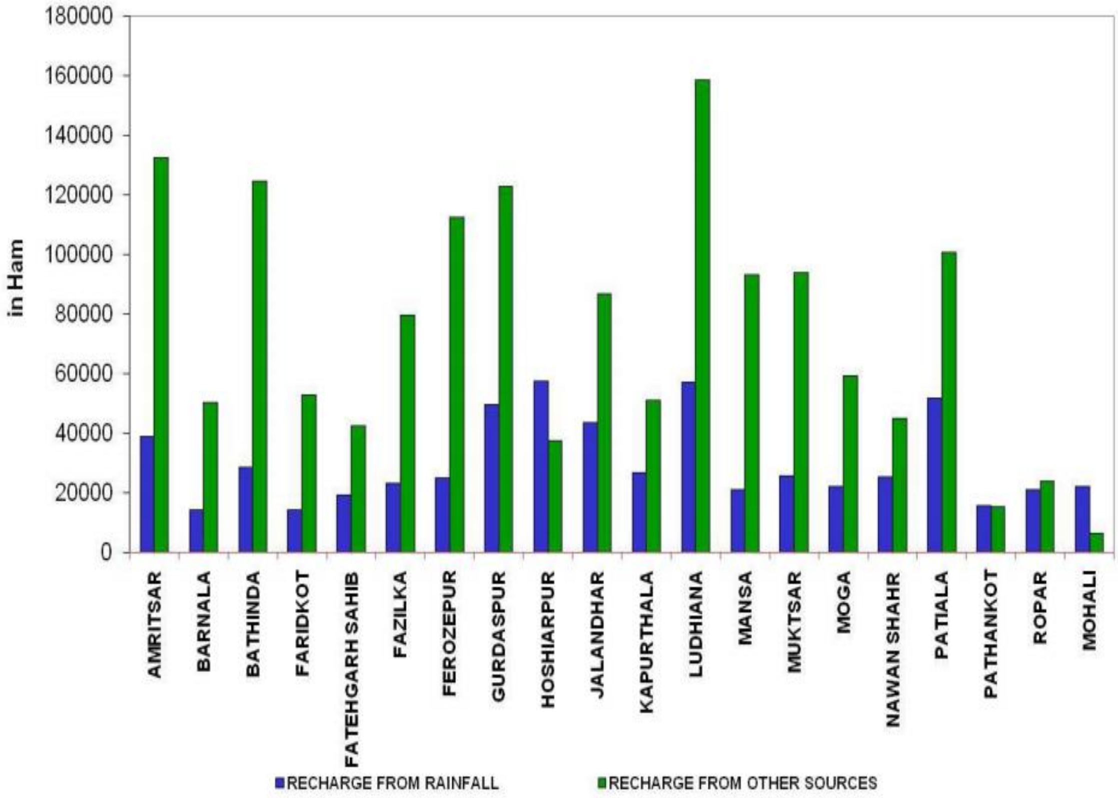
As the discussion around Punjab’s massive groundwater crisis becomes more urgent, there is an increasingly stronger accent on diversification of crops, and a move away from water-guzzling paddy. To conserve the resource, the Punjab government brought a law in 2009 to mandatorily delay transplantation of paddy beyond June 10, when the most severe phase of evapotranspiration is over. This law has been blamed for creating the bad air crisis of North India — especially Delhi — by delaying harvesting to end-October and early November, when atmospheric and wind conditions cause particulate matter and gases from burning paddy stubble to hang close to the surface.

The area under non-basmati paddy must be cut by at least 12 lakh hectares, and maize, basmati, and cotton must be grown on this land — besides increasing the area under agro-forestry and vegetables. Non-basmati paddy is currently grown on 23-26 lakh hectares. Agricultural scientists strongly feel that along with developing more high-yield and good varieties of maize for which there is a demand in the market, the government must stop free power for paddy in order to disincentivise its cultivation and check the overexploitation of underground aquifers. A large number of tube wells (more than 14 lakh in 2015-16) running on free power pump out virtually endless amounts of water across the state.

The government does not need to make any policy for diversification if it gets a market for low water-consuming crops, and a good price for such crops. Farmers will themselves go for such crops without the government’s efforts.

9.9 <u>Increasing water harvesting</u>

Water harvesting, the capture and storage of rainwater for use during dry periods, is a technology proven to increase food security in drought prone areas. Erosion control and groundwater recharge are additional advantages of water harvesting techniques, which contribute to agricultural development and resource conservation. The vast majority of poor farmers live in parts of the world where rainfall is limited or very irregular. Often, large amounts of rainfall are received but in a very short span of time, leaving the rest of the year dry.



Graph 6: District-wise recharge from Rainfall and other sources, Punjab (CGWB 2018)

There are many types of water harvesting structures. At the farm level, one of the most effective systems is the farm pond. A farm pond is a dug-out pond constructed in or near the farm. Rainwater is collected in the pond and stored for future uses such as irrigating crops, recharging groundwater, aquaculture and providing drinking water for farm animals.

9.10 <u>Watershed development</u>

A watershed is an area of land and water bounded by a drainage divide, within which the surface runoff collects and flows out of the watershed through a single outlet into a lager river or lake. Watershed technology is used in rainfed areas.

Watershed management involves the effective conservation of soil and water resources for sustainable production. It involves the management of land surface and vegetation so as to conserve the soil and water for immediate and long-term benefits to the farmers, community and society as a whole.

The development of watersheds is an important programme to make best use of rainwater for agricultural production while improving soil conservation and biodiversity. Fortunately, the Government of India has given top priority for watershed development to provide assured water supply of agriculture in rain fed areas. It is estimated that over 63 per cent of the cultivated lands in the rain fed areas need to be brought under watershed development to conserve soil and water, which in turn would improve the crop yields as well as ground water table.

9.11 <u>Happy Seeder as Resource Conservation Technique</u>

Declining water table in the Punjab State demands for development of new technologies and agronomic practices in order to enhance the water use efficiency for cultivation of different crops. Wheat being major cereal Rabi crop grown in more than 80 per cent of the cultivable area and require 4-5 irrigations. The first irrigation is generally applied at 20-25 days after sowing and subsequent irrigations are applied at 30-35 days interval. The requirement of water for the wheat crop varies from 210-350mm depending upon the soil type, date and method of sowing 'rainfall etc.

Happy Seeder: A solution to agricultural fires

After harvesting paddy, wheat crop is needed to be sown in window of 15-20 days. Due to this shorter span of wheat sowing majority of the farmers in the state resort to burn paddy straw for early clearance of the fields. To tackle the issue of stubble burning a technology was required for in-situ residue management and timely sowing of the crop. Among various in-situ residue management technologies, Happy Seeder technology had a major breakthrough due to its rapid expansion in the past two years.

This machine combines both the function of stubble mulching and seed drilling. It consists of a rotor mounted with the gamma type blades for managing the paddy residues and a zero till drill for sowing of wheat. Happy seeder cuts the standing stubbles/loose straw coming in front of the sowing tyne and clean each tyne twice in one rotation of rotor for proper placement of seed in soil. The rotor blades push the residues as surface mulch between the seeded rows.

(n= 150)

Sr. No.	Parameters	Frequency (%)
1.	Ease of operation	84 (56.0)
2.	Environment friendly	148 (98.7)
3.	Economical	128 (85.3)
4.	Time saving	135 (90.0)
5.	Water saving	118 (65.0)
6.	Labour saving	143 (95.3)
7.	Less weedicide load	109 (72.7)
8.	Lesser lodging of crop as compared to conventional sowing	112 (74.7)
9.	Better grain and straw quality	78 (52.3)
10.	Better yield	79 (52.7)

Table 10: Distribution of respondents according to benefits availed by the respondents for sowing of wheat with happy seeder
(Source: World Irrigation Forum 2019)

The average water requirement for wheat crop under this technology was lesser i.e., 215 mm as compared 285 mm required in conventional sowing. The lesser water requirement in happy seeder can be attributed to the mulching effect provide by the loose retained in the field. It has also been observed that straw mulch act as shield against evaporation which further disconnects the capillarity of the subsoil, thereby reduces soil water evaporation, which results in improvement in soil water condition. Higher soil moisture content in Happy Seeder Sown wheat reduce the demand of irrigation thus saving about one irrigation on an average as compared to conventional method of wheat sowing.

CHAPTER - X

CONCLUSION

Rivers, canals, rainfall, and groundwater are main sources of irrigation in agricultural state of Punjab. The insufficient amount of rainfall is responsible for inadequate amount of water in rivers and canals. As a result, groundwater is being overexploited. This overexploitation of groundwater resources is a serious matter of concern. Almost all the drinking water parameter values exceed the acceptable limits in case of groundwater. The higher concentration of Uranium, Arsenic and Lead like carcinogenic chemicals in groundwater may pose health risk to the local population of this region. Though efforts are being made by the concerned authorities to combat these issues and challenges, but there is an urgent need to take effective measures massively to regulate usage of water. Water-saving measures such as drip irrigation, sprinkling system, rainwater harvesting and underground piping system should be preferred for irrigation on a large scale. The canal system requires to be revamped. The state government should constitute Water Regulatory Authority and also promote less water-consuming crops such as maize and sunflower. Role of public investment in water should be examined. Hence, there must be strong regulations or check on pumping out groundwater by farming at farm and industrial sector. There must be some penalties to the persons or industries involved, in contaminating and wastage of water. The government policies should be implemented effectively with zero tolerance.

10.1 Will There be Water Balance?

Yes, ultimately, for, if it continues to be depleted, a stage would reach when it would be uneconomical and/or even technically impossible to deplete further. But the crisis would unfold earlier; the decreasing supply of water would cause the production to decline, and that is when the ‘conflicts and sufferings’ would begin to generate the ‘suicidal tensions’.

The estimates of the available supply of water in the long run are somewhat more thoroughly monitored and therefore more precisely known; these are somewhat static but for annual variations of rainfall and seasonal flows; the latter also having been manoeuvred by the ‘political shifts’ from one region/ area to another one. However, shifting the excessive flow of canal water to areas, where the underground water is brackish and ‘not fit for use’, the recharge is the ‘net loss’ (for it cannot be pumped out for use). It also ultimately leads to other problems like waterlogging, etc. for which the public investment in drainage systems becomes necessary. This is what has happened precisely and silently over the last few decades by inter-linking the rivers and large-scale diversion of surface water supply from recharging the sweet-water zones to the brackish ones. This makes a strong case of ‘mandating to recapture the excessively recharged sweet water, due to canal water supply as per demand, from the shallow layers for reuse before it is lost to deeper layers and mixes with the unfit groundwater’. The equity considerations do demand the management of given scarce water resources in a way, that allocates more to the relatively more disadvantaged regions, but nonetheless not in the above fashion. The cost of such policies needs to be weighed against the policies and incentives to make the South West region highly concentrating on low water requiring crops like cotton.

This leaves the onus on managing the demand side of water for agriculture, where numerous possibilities do exist, but require the needed investments and incentives. The long run deficit is about 10 cms height of water (rainfall), of which about half has been resolved, though too late (read it crisis-laden situation, which compelled and/or had educated the user farmers to accept and act accordingly in one go) with the 'preservation of sub-soil water act', since 2008 in Punjab and since 2009 in Haryana. It was long overdue.

Various 'water-use-efficiency' possibilities have also been discussed earlier; more need to be researched. The evaluation of the technology-investment options like happy seeder, laser leveler, ridger/trencher, etc. from the perspective of savings in water and other benefits is needed. A 20 to 25 per cent reduction in irrigation water applied, especially in case of high ET crops like sugarcane and rice means an equivalence of 4 to 5 irrigations, which means the savings in electricity (and subsidy). Although, considered judiciously, these technologies could be economical from the farmers' point of view too, but the heavy initial investment and low use during the year makes these out of the reach of majority of the farmers, particularly the smaller ones. But the state should be more concerned with the real savings in water. It is recommended that this aspect must be considered in the state and federal budgets for providing the additional support to the agriculture sector. It might work out to be providing it totally free, though a highly subsidised system and ensuring effective utilisation would work out to be better proposition. Providing these to the majority of Primary Agricultural Co-operative Societies enabling them to work as Agricultural Service Centres at working cost to the individual farmers is still better. For substantial coverage to be effective, the amount in the annual budgets has to be large, but it would be substantially recovered indirectly through the positive impact on water balance bringing the savings of subsidy and the check on environment pollution, etc.; for instance, Rs. 250 crores worth of nitrogen fertilisers is burnt (lost) annually through rice straw burning in 80 per cent of the rice fields (PSFC, 2008) before wheat sowing by the Punjab farmers, and if the entire practice is substituted by the happy seeders, it would also be saving about 1-1.5 cms of water on some 2 million ha, which is equivalent of about 0.25 km3 of water. This is

25000 ha metres of water, i.e., 250 million cubic metres, i.e., 8825 million cubic ft, which means a flow of more than 10000 cusecs for 10 days.

Diversification of agriculture through alternative crop systems such as cotton, basmati, maize, oilseeds and pulses, fruits and vegetables, dairy etc need to be encouraged in different agro-climatic conditions with the help of effective support price, processing and export infrastructure.

Following policy prescriptions will go a long way in resolving this crisis:

• Agronomic practices such as timely transplanting of rice, furrow irrigation, avoiding excessive flooding of fields, smaller fields, sprinkler and drip irrigation wherever possible could reduce the water requirements sizably.

• Suitable water pricing especially through metered system of electricity supply is essential.

• It has been estimated that about 60 per cent of irrigation water is lost in the form of seepage losses. Therefore, lining of canals, water courses and field channels, use of underground pipeline for conveyance of irrigation water should be practiced.

• A package of measures to increase the artificial recharge to augment the groundwater reservoir has to be taken. It has been estimated that the total unutilized water works out to be 0.433 million hectare meters, out of which 0.372 million hectare meters is through rivers and the rest comes through drains, nullahs, etc. This water is a potential source which can be utilized for artificial recharge to groundwater.

• The conjunctive use of surface and groundwater will help in developing strategy of irrigation for optimal agricultural development. The studies have revealed that an integrated approach for conjunctive use of surface water and poor-quality groundwater supplemented with application of gypsum amendment and proper facilities for drainage on sodic soils could also reduce pressure on freshwater use. etc. This water is a potential source which can be utilized for artificial recharge to groundwater.

• Export-import policy must take into account the use of water resource apart from comparative economic advantage of different crops.

10.2 Summing Up: The Policy Regimen to Maintain the Water Balance

Agricultural development in Punjab started around the water management, whether it was the enthusiastic landmark of achieving the consolidation of the fragmented holdings up to mid-1960s, i.e., even prior to the high-yielding varieties era or during the era through the complementary policies of institutional credit and electricity supply (and others) that facilitated the private/farmers investments in tube wells. As of today, there are more than a million electric tube wells in Punjab, of which more than half have been replaced over time with the submersible ones in search of water from the deeper layers underground; and almost everyone is with a standby availability of a diesel engine/generator set, in case of scarce electricity supply. The area irrigated by tube wells is 3 million hectares, which is about 71 per cent of the net cultivated area of the State, and is cropped twice a year, irrigated many times throughout the year. Some concerted policy initiatives and capital investments need to be channelled judiciously, for it would be unaffordable to let the story of development end with its mismanagement that had been depleting the underground water, which had accumulated over the centuries, at the rate that the crisis showed up in a quarter century, and, which even worsened over the next quarter century.

The depletion rate of groundwater resource from the central region of Punjab, where most of the rice is grown, and supplied to the food security of the country, is 4 ± 0.5 km^3 per year for the period June 1999 - June 2005. The deficit has been of a crisis-laden, considering that the gross storage capacity of India's largest reservoir dam (Bhakra) in this region is 9.34 km^3, with live storage capacity of 6.91 km^3. Thus, effective measures need to be taken to manage the deficit, still meeting the needs of the food-security of the country and save the groundwater from "diminishing to the point at which farmers and residents of the region are forced to react. Severe shortage of potable water, reduced agricultural productivity, conflict and suffering surely would accompany the supply-limited solution".

The demand for water from the agriculture sector, which is the major claimant to produce food and fibre for the mankind, responds to a variety of factors, and can be efficiently managed to restore the water balance to a significant extent. The response to the concerted appeals by the scientists and other policy measures like limiting electricity supply hours during May to early June, delayed entry of procurement agencies, etc. yielded only little impact on delaying the transplanting of rice. But the same in response to the *'Punjab preservation of sub-soil water Act, 2009'* has been a significant landmark. There have also been some improvements in water use efficiency, through techniques like laser levelling of fields and trench/ridge planting of crops like sugarcane; and the use of happy seeders for wheat sowing, which not only saves moisture, organic matter and nitrogen fertilisers from burning, but also further acts as a mulch to save more water. This need be extended to the maximum possible coverage. The economic evaluation of such technologies, accounting for their role in restoring the water balance, the crucial long-term natural resource, and other impacts, need be considered in the fiscal budgets of the state and federal governments for providing additional support to agriculture.

10.3 Modelling water levels of north western India in response to improved irrigation use efficiency

The groundwater system of north western India provides food security to India, and the current groundwater over-exploitation crisis in this region is a pressing concern. Regional-scale transient simulations of the groundwater system have been presented for the period 2004–2028 under two different scenarios:

1. A baseline scenario in which variation in groundwater abstraction was incorporated in the model for the duration 2004 to 2017, while abstraction for 2017 to 2028 remains constant at 2017 levels, and

2. A mitigation scenario, which retains the variation in groundwater abstraction for the duration 2004 to 2017, where as a mitigation measure, the groundwater abstraction for the period 2017–2028 is reduced by 20 per cent.

The modelling reveals that, if the present level of groundwater abstraction continues at the same level until 2028, groundwater levels will decline at rates of up to 2.8 m/year in critically overexploited areas like Kurukshetra, Patiala and Sangrur districts. In contrast, a reduction in groundwater abstraction by 20 per cent has the potential to generate a significant positive impact on groundwater levels within a decade. It could retard the rate of groundwater decline by up to 67 per cent in areas that are currently overexploited. However, the magnitude of the impact varies spatially based on the current levels of abstraction and recharge. Comparison of these results to studies of other critically overexploited aquifer systems suggests that an integrated approach to agricultural water management practice, incorporating groundwater use efficiency, water-efficient cropping intensity, pattern, and rainwater harvesting for agricultural use, is strongly advised.

At the same time an appropriate 'policy for groundwater use in the urban sector' is needed, where there is uncontrolled criminal exploitation and wastage of groundwater. The utmost priority is to conserve the groundwater, whatever are the means, measures and policies necessary; and it is the key word.

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