

Emerging Water Insecurity in India

“Sustainability of water use at the present level is under great strain particularly in Punjab where ground water is over exploited and is getting increasingly polluted. The overall policy environment mainly with elements like free electricity for water extraction and free/subsidised water for domestic use is totally insensitive to the macro outcomes of the behaviour of water users involving huge wastages and inefficiencies. The wheat rice dominant cropping pattern which greatly contributed to the food self sufficiency of the nation has become unsustainable. This book dwells upon all these issues with insightful analysis of data and facts. The strongest point of the work is a comprehensive field survey of water use behaviour of farmers, industrial units and households. This book by Ranjit Singh Ghuman and Rajeev Sharma is a very valuable contribution to the study of water economy.”

—*Dr. S. R. Hashim*

*Ex-Member Secretary, Planning Commission,
Government of India; Director, IEG, New Delhi; and
Ex-Chairman, National Commission for Integrated Water
Resources Development Plan, Government of India.*

“The water security in this book has been viewed in the form of sustainable use of water and maintenance of its fair quality. The emergence of water scarcity in an agriculturally advanced region have been analysed in a development process based on private profiteering sans social concerns. Apathy of public policy through free power for agriculture and lack of rain water harvesting has been brought out and lessons from development experience have been made through empirical analysis. The book will be very useful reading for all those concerned with sustainable development and having stake in the water sector.”

—*Dr. Sucha Singh Gill*

*Professor of Economics and former Director General
Centre for Research in Rural and Industrial Development
Chandigarh, India*

“Punjab represents a classic case of overexploitation of water resources driven by the nexus of technology and policy. The authors demonstrate how a blessed region is heading towards dreadful future not due to any natural factors but due to absence of suitable regulation and measures essential for sustainable use of natural resource. I hope the book will awaken the society to collectively decide future course of action to save Punjab from reckless over-exploitation of water resources.”

—*Professor Ramesh Chand,*

Member, NITI Aayog, Government of India

Emerging Water Insecurity in India:

*Lessons from an Agriculturally
Advanced State*

By

Ranjit Singh Ghuman and Rajeev Sharma

Cambridge
Scholars
Publishing



Emerging Water Insecurity in India:
Lessons from an Agriculturally Advanced State

By Ranjit Singh Ghuman and Rajeev Sharma

This book first published 2018

Cambridge Scholars Publishing

Lady Stephenson Library, Newcastle upon Tyne, NE6 2PA, UK

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

Copyright © 2018 by Ranjit Singh Ghuman and Rajeev Sharma

All rights for this book reserved. No part of this book may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior permission of the copyright owner.

ISBN (10): 1-5275-1144-8

ISBN (13): 978-1-5275-1144-6

*With lots of love and affection for my grandchildren Annika, Ritwik
and Arjit who I hope do not have to face water scarcity*

Ranjit Singh Ghuman

CONTENTS

List of Tables.....	xi
List of Figures.....	xvii
List of Appendices.....	xviii
Acknowledgements	xx
Preface	xxii
Chapter One.....	1
Global Water Scenario: An Overview	
Introduction.....	1
Global Response to Water Scarcity	5
Sector-Wise Water Requirement	7
Chapter Two	14
Development and Usage of Water Resources in India	
Water Resources in India.....	14
Irrigation and Flood Control in India.....	19
State-wise Irrigation Potential and Groundwater Resources.....	24
Rainfall and Weather in India	30
Rising Population and Increasing Urbanisation in India.....	34
Chapter Three	38
Dynamics of Water Resources in Punjab	
Water Availability in Punjab	40
Average Annual Rainfall in Punjab	49
District-wise Water Table in Punjab.....	55
Extent of Ground Water Exploitation in Punjab.....	61

Chapter Four.....	69
Green Revolution and Irrigation Pattern in Punjab: A Temporal Analysis based on Secondary Data	
Land Use Pattern in Punjab: From Diversification to Non-diversification.....	70
Cropping Pattern in Punjab.....	72
Irrigation Pattern in Punjab: Increasing Dependence on Ground Water.....	77
Holding Size-wise Area under Various Sources of Irrigation.....	83
Green Revolution and Number of Tube-wells: What a Nexus!.....	88
Water Use Efficiency in Irrigation across States.....	96
Increasing Consumption of Energy in Irrigation.....	100
Growth of Submersible and Higher BHP Motors.....	104
Green Revolution and Increasing Tractorisation.....	111
 Chapter Five.....	 114
Water Use Pattern in the Agricultural Sector in Punjab: Evidence from Primary Data	
Operational Holdings.....	114
Sources of Irrigation.....	121
Harvesting and Conservation of Water.....	128
 Chapter Six.....	 131
Water Usage in the Industrial Sector in Punjab: Evidence from Primary Data	
Small-Scale Industrial Units.....	131
Nature of Processing and Production.....	132
Employment and Working Hours in the Sampled Small-Scale Units.....	134
Sources of Water of Small-Scale Industrial Units.....	137
Consumption of Water in Small-Scale Industrial Units.....	138
Medium and Large-Scale Industries.....	140
Employment in the sampled Medium and Large-Scale Units.....	144
Source of Water Supply in Medium and Large-Scale Industrial Units.....	146

Chapter Seven.....	153
Domestic Water Usage in Punjab: Evidence from Primary Data	
Rural Water Usage Pattern.....	153
The Sources of Water in the Rural Households	156
The Pattern of Water Use in Rural Households	160
Urban Water Usage Pattern	162
Sources of Drinking Water.....	168
 Chapter Eight.....	 185
Awareness about Water Scarcity: Users Response	
Awareness Level of Water Consumers in the Agricultural Sector.....	185
Educational Attainment and Level of Awareness among	
Farmers	187
Disenchantment with Agriculture.....	189
Awareness about Organic Farming	192
Sources of Awareness: Print and Electronic Media	194
Awareness about Depleting Water Table	196
Awareness in the Industrial Sector.....	199
Small-Scale Industrial Units.....	199
Awareness Level among the Medium and Large-Scale Industrial	
Units	204
Domestic Sector.....	209
Awareness about Water Conservation and Rain Water Harvesting	
among Rural Households.....	209
Respondents' Perception about Quality of Water.....	212
Urban Sector.....	214
Perceptions regarding Need to Save Water	214
 Chapter Nine.....	 221
Water Governance and Policy Response	
Constitutional Status of Water in India and Some Initiatives	
at the National Level	223
Policy Response by Government of Punjab.....	226
Resource Conservation Technologies and Innovations.....	230
Micro-Irrigation in Punjab: The Ground Reality	231
Diversification and Free Electricity to Farm Sector: An Antithesis	
to Judicious Use of Water	235

Chapter Ten	239
Summary and Policy Recommendations	
Summary	239
Indian Water Scenario	241
Water Availability and Usage in Punjab	242
Validation by Primary Data.....	246
Policy Response by the Punjab Government.....	250
Recommendations.....	253
Appendices	257
References	290

LIST OF TABLES

1.1 Global projection for irrigation water withdrawals (cubic kilometres) .	8
1.2 Water withdrawal by sectors, around 2010	9
1.3 Country-wise comparison of total water withdrawal by sectors (2003–2011).....	11
2.1 Estimates of water resources in India (billion cubic metres).....	14
2.2 Future water requirement for various sectors in India (bcm).....	16
2.3 Plan-wise expenditure on irrigation and flood control in India: 1951–2012	20
2.4 Plan-wise proliferation of schemes in major and medium sector in India.....	22
2.5 Plan-wise irrigation potential created and utilised in India.....	24
2.6 State-wise ultimate irrigation potential created in India ('000 hectares).....	25
2.7 State-wise percentage share of ultimate irrigation potential created in India	26
2.8 State-wise status of ground water resources in India (2013)	28
2.9 Rainfall and weather details in India: 1951 to 2012	30
2.10 Season-wise distribution of rainfall in India: 1992–1993 to 2014– 2025	32
2.11 Growth of population in India: 1951 to 2011	35
2.12 Proportion of population using improved water supplies	37
3.1 Details of culture-able command area (CCA) of canal system in Punjab	41
3.2 Ground water resource potential of Punjab State 33	42
3.3 Assessment of dynamic ground water resources in various districts of Punjab	45
3.4 District-wise gross ground water draft as percentage of net ground water availability.....	47
3.5 Net annual ground water availability for irrigation development in Punjab	49
3.6 District-wise annual average rainfall in Punjab: 1970–2015	50
3.7 District-wise trend of annual rainfall in Punjab 1975 to 2013	52
3.8 District-wise pre-monsoon (June over June) ground water level in Punjab: 1996–2016	56

3.9 District-wise post-monsoon (October over October) ground water level in Punjab: 1996–2016	58
3.10 District-wise annual average change in water table in 2016 over 1996	60
3.11 Extent of ground water exploitation in Punjab: 1984–2013	62
3.12 District-wise distribution in the number of over-exploited (Dark) and critical (Dark) blocks in Punjab: 1984–2011 (only sampled districts).	63
3.13 Assessment of dynamic ground water resources across the districts in Punjab	64
3.14 District-wise comparison of ground water development in some selected districts of Punjab: 1984 to 2013 (sampled districts)	66
4.1 Land use pattern in Punjab: 1960–2016 ('000 hectares).....	70
4.2 Percentage share of land under different uses in Punjab: 1960–2016	71
4.3 Shift in cropping pattern in Punjab: 1960–2016	73
4.4 Distribution of irrigated area under principal <i>rabi</i> crops in undivided Punjab: 1939–1941	76
4.5 Distribution of irrigated area under principal <i>kharif</i> crops in undivided Punjab: 1939–1941	76
4.6 Net sown area under irrigation in Punjab through canals and tube-wells: 1960–2015 ('000 hectares).....	78
4.7 Share of power subsidy to agricultural sector in Punjab: 2002–2017..	80
4.8 District-wise area under canal and tube-well irrigation in Punjab: 1995–1996 and 2010–2011.....	82
4.9 Holding size-wise area under various sources of irrigation in Punjab: 1995–1996	84
4.10 Percentage share of area under different sources of irrigation in Punjab: 1995–1996	85
4.11 Holding size-wise area under different sources of irrigation in Punjab: 2010–2011 ('000 hectares)	86
4.12 Percentage share of area under different sources of irrigation in Punjab: 2010–2011	87
4.13 Tube-wells (diesel & electric operated), area, production and yield of rice in Punjab: 1970–1971 to 2015–2016.....	90
4.14 Correlation between no. of tube-wells and area under rice, production of rice and yield of rice in Punjab: 1970–1971 to 2014–2015	92
4.15 Trend growth rate of tube-wells, area, production and yield of rice in Punjab: 1970–1971 to 2014–2015	95
4.16 Water productivity of rice in major rice-producing states in India....	96
4.17 Water consumption in rice production in Punjab	98
4.18 District-wise consumption of electricity in agriculture in Punjab (Million Kilo Watt-mkw).....	101

4.19 Compound annual growth rate (CAGR) of electricity consumption in agriculture in Punjab: 1974–75 to 2015–16.....	102
4.20 Number of tube-wells energised/ operated in the sampled districts of Punjab (as on 31 March).....	103
4.21 Trend of mono-block tube-wells and submersible motors in agriculture in Punjab: 2009–2017	105
4.22 Distribution of submersible and mono-block electric tube-well motors in agriculture in sampled districts of Punjab in 2010.....	106
4.23 Distribution of submersible and mono-block electric tube-well motors in agriculture in sampled districts of Punjab as on 31 March 2017 ...	107
4.24 District-wise change in the number and share of submersible and mono-block electric motors in agriculture in 2017 over 2010 in sampled districts of Punjab	108
4.25 BHP-wise break-up of electric motors in agricultural sector in Punjab: 2010–2017	109
4.26 Number of tractors per 1000 hectares in rural Punjab: 1981–2010 .	112
5.1 Number & proportion of sampled farmers in various agro-climatic zones of Punjab (sampled farmers).....	115
5.2 Average area of operational holdings in different zones of Punjab (sampled farmers)	115
5.3 Percentage share of area under different crops in Punjab (sampled farmers).....	117
5.4 Percentage share of area under different crops in central plain zone (CPZ) of Punjab (sampled farmers).....	119
5.5 Percentage share of area under different crops in south-west zone (SWZ) of Punjab (sampled farmers).....	119
5.6 Percentage share of area under different crops in sub-mountainous zone (SMZ) of Punjab (sampled farmers).....	120
5.7 Main source of irrigation in sampled villages across the zones in Punjab (no. of villages).....	122
5.8 Distribution of sampled farmers according to source of irrigation across the zones in Punjab (no. of farmers)	124
5.9 Mean depth of tube-wells owned by the sampled farmers across the zones in Punjab	125
5.10 Operation of tube-well during <i>kharif</i> & rabi season (Days)	126
5.11 Methods of sowing paddy & irrigation across zones in Punjab.....	127
5.12 Rain water harvesting, conservation and efforts to save water.....	128
5.13 Farmer's perception about quality of subsoil water & advice from Agriculture Department & Punjab Agricultural University (PAU) ...	129
6.1 Classification of the sampled small-scale industries	132
6.2 Employment in the sampled small-scale industries	134

6.3 Average number of hours the unit works across small-scale sampled industries.....	136
6.4 Average depth of tube-well & horse power of motors and water delivery across sampled small-scale industries.....	137
6.5 Average number of days tube-well runs per month and capacity of water storage tanks (in litres) across sampled small-scale industries.	139
6.6 Average monthly consumption of water by sampled small-scale industries (in litres).....	140
6.7 Classification of the sampled medium & large-scale industries	141
6.8 Number and percentage of employees engaged in sampled medium & large-scale industries of Punjab	144
6.9 Average number of hours the units work across sampled industries in Punjab	145
6.10 Source of water supply across medium & large-scale industries in Punjab	146
6.11 Source of water supply across sampled medium & large-scale industries in Punjab (%).....	147
6.12 Average depth of tube-well, depth & HP of motor and water delivery across sampled industries in Punjab.....	148
6.13 Average number of days tube-well runs per month across medium & large-scale industries in Punjab	149
6.14 Average monthly consumption of water across medium & large-scale industries in Punjab (in litres)	150
6.15 Average capacity of water storage tanks in different medium & large-scale industries in Punjab (in litres)	151
6.16 Average expenditure incurred on installing tube-wells across sampled industries in Punjab.....	152
7.1 District-wise growth of rural population in Punjab: 1991 to 2011 ...	154
7.2 District-wise number of rural households by main source of drinking water in sampled districts of Punjab	157
7.3 District-wise percentage share of rural households by main source of drinking water in sampled districts of Punjab.....	158
7.4 Source of drinking water in rural households in sampled villages in Punjab	159
7.5 Source of drinking water in rural households in sampled villages in Punjab	159
7.6 Use of water in rural households in sampled villages in Punjab	161
7.7 Use of water in rural households in sampled villages in Punjab (%).	161
7.8 District-wise growth of population in urban Punjab: 1991 to 2011...	163
7.9 District-wise number of urban households by main source of drinking water in sampled districts of Punjab	164

7.10 District-wise percentage share of urban households by main source of drinking water in sampled districts of Punjab.....	165
7.11 Sampled distribution of urban respondents in Amritsar and Sangrur across locations	166
7.12 Average household size, plot size and total covered area across respondents by locations	167
7.13 Plot size possessed by urban households across various categories...	168
7.14 Sources of water during summer season across the selected urban locations in two cities of Punjab	170
7.15 Sources of water during winter season across the selected urban locations in two cities of Punjab (%)	171
7.16 Activity-wise daily average consumption of water by urban households during summer season across the selected locations in two cities of Punjab (in litres).....	173
7.17 Activity-wise average consumption of water by urban households during summer season across the selected locations in two cities of Punjab (%).....	174
7.18 Activity-wise average consumption of water by urban households during winter season across the selected locations in two cities of Punjab (in litres).....	176
7.19 Activity-wise average consumption of water by urban households during winter season across the selected locations in the districts of Punjab (%).....	179
7.20 Deficiency/surplus in consumption of water on BIS norms in Punjab (lpcd).....	182
7.21 Average duration of water supply across urban households in the selected locations of Punjab (hours)	183
7.22 Number of urban households willing to pay for improved water supply in the selected districts of Punjab (Rs. per month)	183
8.1 Educational level of the household heads (HHs) in Punjab (sampled farmers).....	188
8.2 Percentage share of willingness to continue in agriculture among the sampled farmers in Punjab	191
8.3 Awareness about organic farming and area under it (sampled farmers).....	193
8.4 Percentage share of television viewers and newspaper readers in Punjab (sampled farmers)	195
8.5 Awareness about declining water table and source of awareness across zones in Punjab	197
8.6 Awareness about higher water consumption by paddy & crop diversification	198

8.7 Reported reasons for efficient use of water by the respondents across sampled industries in Punjab.....	202
8.8 Misuse and scarcity of water and waste disposal.....	203
8.9 Perceptions of medium & large-scale industrial units on water conservation and pollution in Punjab.....	204
8.10 Reported reasons for efficient use of water by the respondents across sampled industries in Punjab (%).....	205
8.11 Some perceptions of the respondents across sampled industries in Punjab (%).....	208
8.12 Awareness about water conservation among rural households in sampled villages and rain water harvesting (%).....	209
8.13 Awareness about scarcity of water and water use efficiency among rural households in sampled villages (%).....	211
8.14 Satisfaction about quality of water and duration and timing about tap water supply in rural households in sampled villages (%).....	212
8.15 Water storage facility and use of waste water in rural households among sampled villages (%).....	213
8.16 Perceptions of urban households regarding water supply in Amritsar and Sangrur cities (%).....	215
8.17 Treatment of unsafe water across urban households in Amritsar and Sangrur cities (%).....	216
8.18 Perceptions of urban households regarding cleaning of drains in Amritsar and Sangrur (%).....	218
8.19 Periodicity of cleaning of drains in Amritsar and Sangrur of Punjab (%).....	219

LIST OF FIGURES

1.1 Global population and water withdrawal over time.....	5
---	---

LIST OF APPENDICES

Appendixes to Preface

- A.P.1 Level of development and distance from the nearby town/city of the sampled villages across the selected districts
- A.P.2 Village-level data of the sampled villages of Punjab in 2001

Appendixes to Chapter 3

- A3.1 Criterion for the classification of the development blocks in Punjab
- A3.2 Decline of water table in central Punjab

Appendixes to Chapter 4

- A4.1 Water requirement of various crops
- A4.2 Crop wise water saving and resultant yield increase with the adoption of sprinkler and drip irrigation

Appendixes to Chapter 6

- A6.1 Classification of sampled small-scale units according to economic activity and nature of processing: textile and dyeing
- A6.2 Classification of sampled small-scale units according to economic activity and nature of processing: food product and beverages
- A6.3 Classification of sampled small-scale units according to economic activity and nature of processing: manufacturing of basic metal
- A6.4 Classification of sampled small-scale units according to economic activity and nature of processing: chemical industry
- A6.5 Classification of sampled small-scale units according to economic activity and nature of processing: paper and paper products
- A6.6 Classification of sampled small-scale units according to economic activity and nature of processing: rubber & plastic products
- A6.7 Classification of sampled small-scale units according to economic activity and nature of processing: hosiery and garments
- A6.8 Classification of sampled small-scale units according to economic activity and nature of processing: leather and leather product
- A6.9 Classification of sampled small-scale units according to economic activity and nature of processing: hotel & restaurants
- A6.10 Classification of sampled small-scale units according to economic activity and nature of processing: cold storage

- A6.11 Economic activity and nature of processing in sampled medium and large-scale textile units
- A6.12 Economic activity and nature of processing in sampled food product and beverage units (medium and large units)
- A6.13 Economic activity and nature of processing in sampled basic metal units (medium and large units)
- A6.14 Economic activity and nature of processing in sampled motor vehicle manufacturing units (medium and large units)
- A6.15 Economic activity and nature of processing in sampled chemical units
- A6.16 Economic activity and nature of processing in sampled manufacturing paper units (medium and large units)
- A6.17 Economic activity and nature of processing in sampled rubber and rubber product units (medium and large units)
- A6.18 Economic activity and nature of processing in sampled metal product units (medium and large units)
- A6.19 Economic activity and nature of processing in sampled hosiery units (medium and large units)
- A6.20 Economic activity and nature of processing in sampled leather product units 209

Appendixes to Chapter 9

- A9.1 Potential of water conservation technologies for water saving and cost reduction in Punjab agriculture (farm level estimates)
- A9.2 Potential of water conservation technologies for water saving and cost reduction in Punjab agriculture
- A9.3 Reasons for drip irrigation in Hoshiarpur and Fatehgarh Sahib Districts (as reported by respondents)
- A9.4 Reasons for sprinkler irrigation in Hoshiarpur and Fatehgarh Sahib Districts (As reported by respondents)
- A9.5 Area under drip irrigation in Hoshiarpur and Fatehgarh Sahib Districts (sampled farmers)
- A9.6 Area under sprinkler irrigation in Hoshiarpur and Fatehgarh Sahib Districts (sampled farmers)
- A9.7 Respondents responses with respect to drip irrigation system in Hoshiarpur and Fatehgarh Sahib Districts
- A9.8 Respondents responses with respect to sprinkler irrigation system in Hoshiarpur and Fatehgarh Sahib Districts
- A9.9 District-wise number of ponds in Punjab
- A9.10 Proposed alternative crop choices for diversification in Punjab

ACKNOWLEDGEMENTS

This book is the outcome of our concern for sustainable development and the requirements of future generations—that are bound to face water insecurity—for fresh water. A sizeable portion of the book is based on the improved and extended version of the major research project on ‘Water use efficiency in Punjab: The question of sustainability’ commissioned and funded by the Indian Council of Social Science Research (ICSSR), New Delhi. We gratefully acknowledge the financial support and cooperation given by the ICSSR.

We express our gratitude to Professor S.S. Johl, Dr. G. S. Kalkat, Mr. Rashpal Malhotra and Professor H.S. Shergill as their concern and views regarding agriculture and irrigation have been a great source of inspiration to work in this area. Our special thanks to Professor Sucha Singh Gill with whom we always have vigorous dialogues about Punjab’s decelerating growth, agrarian crisis and depleting water table. Our frequent discussions with him inspired us to undertake research on water concerns of Punjab.

We are also thankful to Dr. Dipinder Singh, IAS, for sharing his deep understanding about the rural economy of Punjab which has been very useful in articulating our views. Mr. H. S. Bedi from the Punjab State Electricity Regulatory Commission deserves our thanks for providing us with relevant data and for sparing his time to discuss the issues from time to time. We would be failing in our duty if we did not acknowledge the contribution of Mr. Sarbjit Singh Dhaliwal, a senior journalist who has always been worried about the deteriorating social, economic and political health of Punjab.

Our thanks are also due to our colleagues and friends from Punjabi University, Patiala and Punjab Agricultural University, Ludhiana, whose research work has been very useful for this study. We would like to make a special mention of Professors M.S. Sidhu, P. S. Rangi, A.S. Joshi, R.S. Sidhu, Sukhpal Singh, V.K. Arora and Kamal Vatta. The authors are also thankful to Dr. Rajesh Sharma, Professor of English at the Punjabi University, Patiala.

The formal and informal support of all our colleagues at CRRID, Chandigarh, is also thankfully acknowledged. Professors Sukhpal Singh, Satish Verma, Dr. Krishan Chand, Dr. Sukhwinder Singh, Dr. Jatinder Singh, Dr. Kulwant Nehra and Dr. Vikash deserve a special mention.

An enormous amount of secondary and primary data has been utilised in this study. Here we wish to express our thanks to various central and state agencies, especially the Central Ground Water Board and the Water Resources and Environment Directorate, Punjab. We are also obliged to all the respondents from agriculture, industry and households for happily giving us the relevant information and data which have been very useful for reaching meaningful findings. All the field investigators also deserve our appreciation for collecting the secondary and primary data and other relevant information.

Last, but not the least, the authors gratefully acknowledge the unconditional support and cooperation extended by their respective better halves throughout this trying period despite facing an unpardonable neglect.

**Ranjit Singh Ghuman
Rajeev Sharma**

PREFACE

Human demand for water, mainly originating out of its requirement for food, energy, and industry, is continuously rising and resulting in an ever-increasing gap between its demand and supply. The increasing world population and modern-day development paradigm are raising the demand for food, energy and industrial produce which, in turn, is leading to an ever-rising demand for fresh water which is not only limited in supply but also has alternative and competing usages. The major portion of demand for water comes from agriculture and subsoil water is becoming very handy as it is the most reliable source of irrigation. It is essential for stabilising and increasing the incomes and livelihoods of farmers and agricultural labourers. However, in most of the countries, water availability for agriculture is not only limited but also uncertain. It has also been estimated that by 2050, the number of countries with water scarcity will be greater than fifty and India will be on that list. About 2 billion people will be living under conditions of high water stress by 2050. This necessitates efficient management and governance of water. The global community is responding to the emerging scarcity and insecurity of water through various international agencies.

After independence in 1947, ground water emerged as the most preferred source of irrigation and for other uses in India. Irrigation accounts for 92 percent of total ground water use. About 55 percent of irrigation requirements, nearly 85 percent of domestic and other water requirements in rural areas and 50 percent of requirements in urban areas and of industries are met through ground water

The aggregate scenario of net water availability and the net draft seems to be quite comfortable. And there is quite a high scope for ground water development in the case of a large number of states in India. This is also an indicator that in many of the states, groundwater for irrigation and other purpose can be further developed as the ground water development level is substantially below 100 percent. However, the wide geographical and regional variations in the water resources and very high proportion of rain-fed agriculture in the country do not support such a scenario. The rising needs for water coming from the rapidly increasing population and

consequent developmental needs would further lead to higher demand for water.

The Indian Punjab is located between North latitudes 29° 32' and 32° 28' and East longitudes 73 ° 50' and 77 ° 00'. It is surrounded by Himachal Pradesh in the northeast, Jammu and Kashmir in the North and Haryana and Rajasthan in the south and southwest, respectively. The state also shares an international border with Pakistan and a number of its districts are in the border region. At the time of independence from the British Empire in 1947, the territory was divided into India (Hindustan) and Pakistan and Punjab was the worst victim of partition. A very large proportion of undivided Punjab went to Pakistan and a smaller part of Punjab remained in India. The undivided Punjab was known as the food basket of the undivided country and that was mainly because of the canal-irrigated agriculture in that part of Punjab which went to Pakistan after partition.

The state lies in the Punjab basin of the great Indo-Gangetic Plain and has three perennial rivers (Sutlej, Beas, Ravi and one ephemeral river Ghaggar). It has a vast network of canals. With the advent of the green revolution and emerging predominance of wheat-paddy crop rotation, demand for ground water registered a phenomenal increase as agriculture is the largest consumer of water. It led to over-exploitation of ground water resources, and the water table consequently suffered a serious depletion.

Out of a total population of 27.74 million of Punjab, 17.34 million people live in rural areas and the remaining 10.40 million people are in urban areas. About 76 percent of people are literate. Out of the total 9.90 million workers, 1.94 million are cultivators, 1.59 million agricultural labourers and the remaining 6.37 million are engaged in the non-farm sector. For administrative purposes the entire state is divided into 22 districts and 149 development blocks. The state has three major agro-climatic zones, namely, central, south-west and sub-mountain. *Mjaha*, *Doaba* and *Malwa* are its three cultural zones.

With 1.53 percent of the total geographical area of India, the state has come to be known as the food bowl of India. The total geographical area of the state is 50,362 sq. km. out of which 48,265 sq. km. is rural and 2,097 sq. km. is urban. The state is mainly a flat alluvial plain. The area occupied by the mountains (Himalayan Foothills) in the northeast is about 1,243 sq. km. Approximately 83 percent of the total area is under cultivation. With 100 percent irrigation intensity, nearly all the arable land

is under double cropping. The success story of the green revolution of Punjab helped India to become a food sufficient from a food deficient country.

In fact, optimality and rationality are the two fundamental assumptions of economics and use efficiency of resources is closely connected with the happening or non-happening of these two assumptions. Human behaviour, however, is not always governed by rationality and optimality. As such, people do not always make rational choices. It is equally applicable to their behaviour towards the consumption of natural resources despite the fact that such resources are non-renewable. Unfortunately, the greed and market-driven growth model has always been at loggerheads with these fundamental assumptions of economics as far as the use of natural resources is concerned. Nevertheless, it is assumed that every economic agent is rational and uses the resources in an optimum and rational manner. Of course, this is true as far as profit is concerned but it has put a serious question mark over the question of sustainable use of resources, especially natural resources.

Punjab is no exception to this. To provide the much-needed food security to the country, the state of Punjab has used its subsoil water in such a manner that optimality and rationality have been put on the back burner. Since the mid-1970s, Punjab has been virtually exporting its subsoil water to other states of India in the form of rice. It has been contributing between 25 percent and 45 percent of its rice and between 40 percent and 75 percent of its wheat to the central pool of the country for more than four decades. And in the process, its water table has gone down drastically. The excessive use of chemical fertilisers and pesticides has not only contaminated its subsoil water but also damaged the soil health beyond repair. As a result, poisons have entered into the whole food and fodder chain and have started adversely affecting both human and animal health, along with the flora-fauna and the environment. Such a scenario has brought to the fore the issue of sustainability of the present water use pattern.

In order to examine the main objectives of the study and validate and cross-check the secondary data, we undertook a field survey of the pattern of water use in agricultural, industrial and household sectors of Punjab. In the case of agriculture, the primary data pertain to 300 cultivators belonging to 30 villages located in 10 blocks of 10 districts of Punjab. The list of the villages and districts is given in appendix A.P.1. The basic village-level data of all the 30 sampled villages is given in appendix A.P.2.

The blocks were selected out of the list prepared by the Economic and Statistical Organisation of the Punjab according to their level of development in descending order. Out of all the 22 districts, 10 districts were selected in such a manner that they represent the three main agro-climatic zones as well as all three of the cultural zones of Punjab. Besides, these districts represent the main cropping patterns, wheat-paddy and wheat-cotton, prevalent in the state.

From each of the sampled districts, we selected one block from each district in such a manner that they represent various levels of development. The sampling of 30 villages also represents the relative level of development. In the sample, 10 villages are less developed, 10 are moderately developed and 10 are highly developed. For collecting primary data, we have selected seven districts (Gurdaspur, Amritsar, Ferozepur, Jalandhar, Ludhiana, Patiala and Sangrur) from the central plain zone (CPZ); three districts (Bathinda, Mansa and Muktsar) from the south-west zone (CWZ) and one district (Hoshiarpur) from the sub-mountain zone (SMZ). Thus, in all there are 21 villages from CPZ, six villages from SWZ and three villages from SMZ. The CPZ and SMZ are mainly the wheat-paddy zones whereas the SWZ is a cotton-wheat zone as well as a wheat-paddy zone as the area under paddy in the SWZ is quite substantial. The study can thus be claimed to be a representative one.

In the case of the industrial sector, we have randomly selected 50 small-scale industrial units, covering ten major industries, located in six districts of Punjab. In the case of medium and large industries, we have sampled 100 industrial units, covering ten industries, located in eight districts of Punjab. Care has been taken to include all the major water-consuming industries, both in the small-scale sector and in the medium and large-scale sector.

In the household sector, we have studied the water use pattern in 300 rural households and 200 urban households. The rural households belong to 30 villages in 10 districts and include both agricultural and non-agricultural households. The urban households belong to two cities namely, Amritsar and Sangrur. The primary data from all the sectors have been collected with the help of specially designed and pre-tested questionnaires.

It has been found that the prevailing water use pattern is not sustainable in view of the depleting water table and deteriorating quality of available water balance especially in Punjab. The water users (agriculture, industry and households) in Punjab are not observing water use efficiency and,

hence, are ignorant about the wastage of water resources mainly because of their low level of awareness. The ever-depleting water table due to continuous over-exploitation of ground water is a threat to the sustainability of the existing cropping pattern in Punjab. There is almost no rain water/surface water harvesting in Punjab. Free electricity in the agricultural sector and the paddy crop have led to an irrational use of ground water. The free supply of water for domestic use to a large number of rural and urban households and/or very low charges from other households is not only a serious drag on the state exchequer but it also results in an injudicious use of water. The public policy response to the water crisis and demand-supply management is too weak and casual. However, the book offers a number of lessons emerging from the experience of Punjab, an agriculturally advanced state of India.

This book is the outcome of our concern about the fast-depleting water table, shrinking water balance and near absence of a public policy response. The main objectives of the study were to examine the water consumption pattern in Punjab across all sectors and among all sections of water users, namely, agriculture, industry and rural and urban domestic consumption. In view of the limited quantity of fresh water and poor quality, water use efficiency has also been studied, though to a limited extent. An effort has also been made to identify more efficient ways and means to use this scarce natural resource in an optimum manner.

Besides Punjab, we have also discussed the global and Indian water scenario in the first and second chapters, respectively. The rest of the chapters dwell on the pattern of water use in Punjab across all sectors and users. Chapters 3 and 4 are based on secondary data and discuss the development of water resources and irrigation patterns in Punjab. Chapters 5 to 7 dwell on primary data pertaining to the pattern of water use in agricultural, industrial and household sectors. Chapter 8 is also based on primary data and discusses the level of awareness and sensitivity about water usage in each sector. Policy response and water management is the subject matter of chapter 9. The last chapter gives the summary and policy recommendations.

CHAPTER ONE

GLOBAL WATER SCENARIO: AN OVERVIEW

‘Water is the Driving Force of Our Nature’

—*Leonardo da vinci*

‘Pavan Guru, Pani Pita, Mata Dhart Mahat’

(Air is teacher, water is father and earth is mother)

—*Guru Nanak Dev, founder of the Sikh Religion*

1.1 Introduction

Though water has been the essential life supporting system ever since the inception of life on the planet Earth, it has become a rather more critical input in modern-day life. The issues of water use efficiency and sustainability of livelihood and life on earth are thus, closely interdependent. However, in the mad pursuit of material wealth, modern man is using this scarce resource in a reckless manner. In the name of growth and development, we are even consuming the water meant for our future generations and are putting the very sustainability of water and development at risk.

Out of the total available water at the global level 97.5 percent is salt water. Thus, global fresh water reserves are only 2.5 percent. The further breakdown of fresh water reserves is: glaciers—68.70 percent, groundwater—30.10 percent and others—1.2 percent. Thus, ground and surface water amount to only 0.76 percent of the total water resources on the planet Earth. Fresh and renewable water is not only limited in supply but has numerous alternative and competing usages. It is in this context that Lionel Robbins’ scarcity definition of economics has become all the more relevant in the case of water. In view of the ever-increasing demand for water the global groundwater extraction rate has at least tripled over the past 50 years and continues to increase at an annual rate of 1 to 2 percent (UN, 2012). Despite this, about 92 percent of rain water is lost due

to surface run off and evaporation etc. More than one billion people in the world who are living in developing countries are water stressed (UN, 2015).

Human demand for water mainly originates from their requirements for food, energy, and industry. Significantly, all these requirements have been on the rise, especially since the advent of the Industrial Revolution. The continuously increasing world population and modern-day development paradigm are raising the demand for food and other agricultural produce which, in turn, is leading to an ever-increasing demand for water. The world demand for water in agriculture and domestic sectors is expected to increase 1.5 times in 2030 as compared to 2010 and in the industrial sector it is expected to double. This, along with the impact of climate change, has led to serious uncertainties about the amount of water required to meet demand for food, energy and other human uses. It is significant to note that the right to adequate food was recognised by the UN General Assembly as long ago as 1966 in the International Covenant on Economic, Social and Cultural Rights (ICESCR).

Most of the demand for water comes from agriculture. Agricultural water withdrawal accounts for 44 percent of total water withdrawal in OECD countries that rely heavily on irrigated agriculture. In the BRIC countries (Brazil, Russia, India and China), agriculture accounts for 74 percent of water withdrawals, but this ranges from 20 percent in Russia to 87 percent in India. In less developed countries LDCs, the figure is more than 90 percent. However, in most of the countries water availability for agriculture is not only limited but also uncertain.

According to Food and Agricultural Organisation FAO (2009), out of 311 million hectares of land under irrigation in the world, 281 million hectares (about 84%) are actually being irrigated. This corresponds to only 16 percent of all the cultivated land that contributes nearly 44 percent of the total global crop production. This means 84 percent of the arable land is still not under assured irrigation but 56 percent of the global demand for food is being met by this land. This implies that the world has the potential to take care of food and other needs for agricultural produce coming from the increasing population and the industrial sector provided we can bring the additional area under irrigation. Certainly, that would require additional water for irrigation. At the global level irrigation is by far the largest user of water. It used about 252 billion cubic metres (bcm) of surface and ground water withdrawals in 2013 which is equivalent to 6.5 percent of the global renewable fresh water resources flows (HLPE, 2015).

Just imagine, if we were to bring all the arable land under cultivation, what amount of water would we need? Would the world be able to meet the huge demand for water from the agriculture sector? But to feed the ever-increasing population, the world will have to increase food production and, hence, bring a matching area under irrigation. Certainly, that would put an enormous additional burden on the already stressed water resources. At the same time, reliable irrigation is also essential to increase and stabilise incomes and provide livelihoods for a large number of marginal and small farmers and agricultural labourers.

Besides agriculture, approximately 20 percent of the world's freshwater withdrawals are used by industry, although this varies across regions and countries. The domestic water use is about 10 percent (UN, 2012). Significantly, global water demand has been projected to increase by 55 percent by 2050, mainly due to the growing demand for water from manufacturing, energy and domestic usages (UN, 2017).

It has also been estimated that by 2050, the number of countries with water scarcity will be more than 50 and India will be on that list. About 2 billion people will be living under conditions of high water stress by 2050 (UNEP, 2001). Two-thirds of the world's population are currently living in areas that experience water scarcity for at least one month a year (UN, 2017). About 40 percent of the global population living in river basins may experience severe water shortage especially in North and South Africa and South and Central Asia. It is estimated that manufacturing, thermal electricity and domestic demand will rise by 400 percent, 140 percent and 130 percent, respectively, by 2050. In such a scenario, there is little scope for increasing irrigation water use (HLPE, 2015).

In view of the ever-increasing pressure on water and the emerging scarcity, it is often said that a future world war may be fought over water. Let us hope that sanity prevails, and water is used, harnessed, conserved and managed in an efficient, judicious and sustainable manner and the above prophecy does not come true. Besides, there is an urgent need to reduce; recycle and reuse the water in every usage of water across the globe. Sustainable development also depends on the extent and manner in which we use our water and other natural resources, especially those which are non-renewable. The judicious use of fresh water is, thus, a compulsion and not a choice. In this context the nexus between water, land, energy and food is rather a bigger challenge.

The poor people living in slums and illegal settlements have little access to improved sources of water as compared to others who live in planned and formal settlements (WHO, 2017). In fact, access to safe drinking water and improved sanitation continues to be a serious challenge in most of the developing countries (Bain et al., 2014). As a consequence, 80 percent of illnesses are linked to unsafe drinking water and unhygienic sanitation conditions (UN, 2003). Approximately, 50 percent of hospital beds are occupied by patients suffering from water-related diseases.

As a matter of fact, the poor are subject to multi-pronged vulnerability and risk and do not have adequate access to improved drinking water and they often face food insecurity. Their water and food insecurity are not simply because of the shortage of water and food but mainly because of unaffordability. In the absence of adequate access to water, even their livelihood is at risk. Such people are often victims of macro-economic policies and the market-driven development model in which without adequate earnings and purchasing power they cannot afford, even to purchase the basic necessities of life. Significantly, 83 percent of the world population, living in the low-income countries, is below the poverty line (head count ratio) and 48 percent of people in the lower middle-income countries are earning \$2.50 PPP daily (World Bank, 2014). In order to manage the macro-economic risks, the world would have to build stronger institutions for better policy outcomes. “The increasing complexity of macro-economic management necessitates continuous strengthening of institutional capacity” (WDR, 2014: 243). The occurrence of natural hazards (droughts, earth quakes, floods and storms) has increased from 2,561 during 1993–2002 to 3,132 during 2003–12 (World Bank, 2014a).

Increasing urbanisation also puts a lot of pressure on water resources. A significant proportion of the population is still without safe drinking water, electricity and improved sanitation facilities. Between 2009 and 2050, the world population is expected to increase by 2.3 billion, from 6.8 to 9.1 billion (UNDESA, 2011). The rising proportion of the urban population would also lead to a higher and higher demand for water. Out of the total world population of 7,346.7 million in 2015, 54 percent were living in urban areas. About 11 percent of urban people did not have access to improved drinking water and 36 percent were without access to improved sanitation (World Bank, 2017). There is a positive and high correlation between size of the population on the one hand and demand for agricultural and industrial produce, energy and water use in other activities. Most of the demand for water is, thus, an indirect demand.