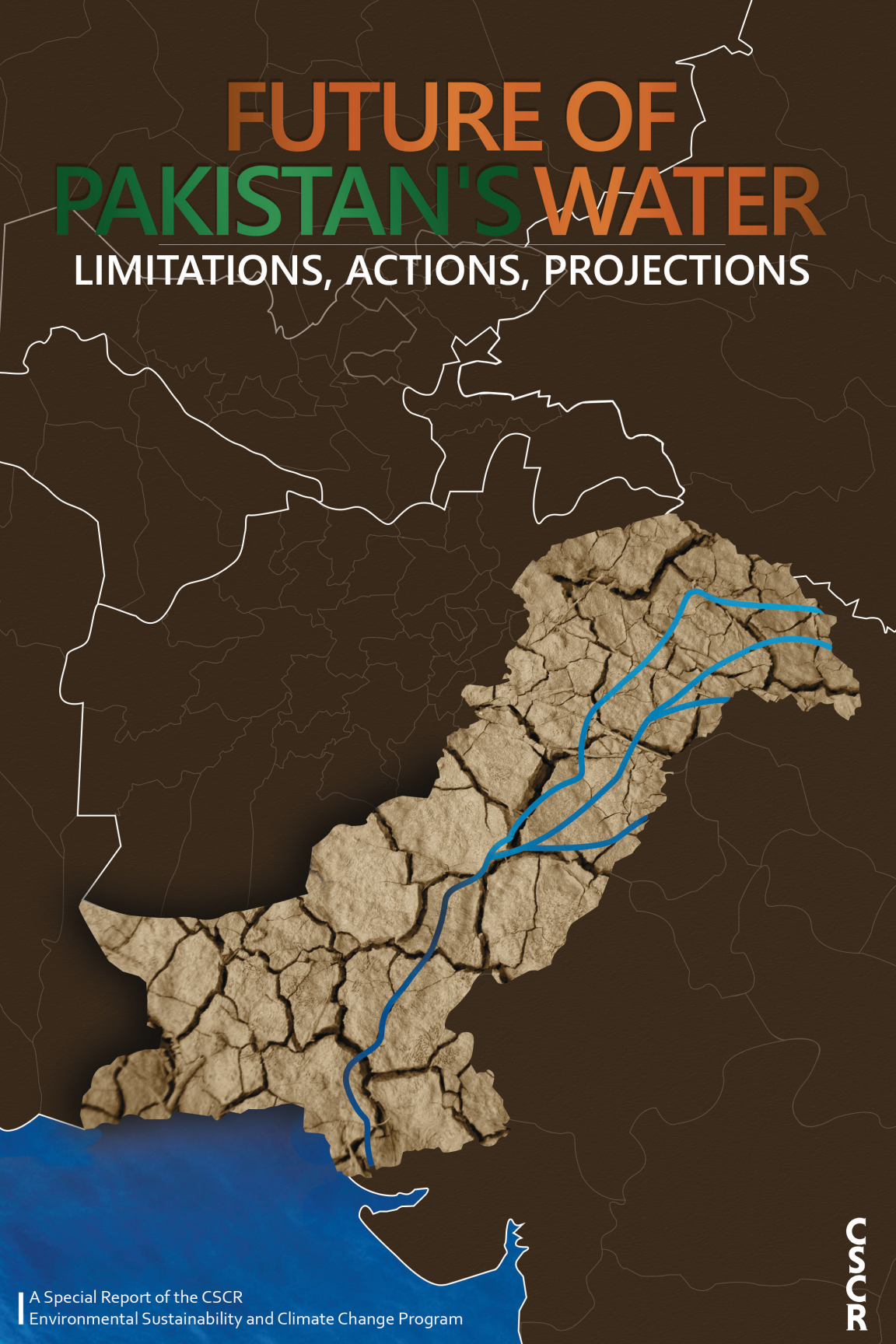
FUTURE OF PAKISTAN'S WATER

LIMITATIONS, ACTIONS, PROJECTIONS



A Special Report of the CSCR
Environmental Sustainability and Climate Change Program

CSCR

FUTURE OF PAKISTAN'S WATER

LIMITATIONS, ACTIONS, PROJECTIONS

MARCH 2020

A Special Report of the CSCR Environmental Sustainability and Climate Change Program

CSCR | CENTRE FOR STRATEGIC & CONTEMPORARY RESEARCH

About CSCR

The Centre for Strategic and Contemporary Research (CSCR) is an independent policy institute in Islamabad that projects strategic foresight rooted in academia on issues of significance for civil society stakeholders, policy makers, and state officials.

Through research, consultancy and advocacy, CSCR is playing an instrumental role in bringing a positive perceptual shift within the targeted segments to help them understand the policy choices facing Pakistan and other countries.

Established in 2014, the Centre has been working closely with various stakeholders, both institutions and individuals. Our clients and partners include currently serving representatives of the provincial governments, the media and the academia.

Our work includes primary and secondary research, centred on issues of security and governance within Pakistan and the region, and is presented through varied media. These include In-House Analyses, Commentary Videos, Policy Briefs, Perspective Papers, Monographs, In-House Research, Seminars and Conferences.

Our primary objectives are to:

Produce quality academic and policy research, drawing from primary data accrued from our on-ground presence in the concerned regions.

Engage stakeholders from the policy making elite, the academia, and the media, to apprise them of policy options on our most pressing current issues.

Highlight issues of national concern by generating debate on neglected aspects, and conveying policy options to the relevant quarters.

Bridge the disconnect between the policy maker and the ordinary citizen, conveying the concerns and compulsions of each side to the other in order to facilitate effective decision making

Help develop and promote a national narrative that reflects a positive outlook, and one which is, more importantly, based on fact and ground realities.

Centre for Strategic and Contemporary Research,
Ace Venture, 2nd Floor, near Service Rd N, E-11/2, Islamabad 46000.
+92 (051) 2712221 [Ext:100]

www.cscr.pk
CSCR_pk
CSCRpk/
company/cscrpk/

Environmental Sustainability and Climate Change Program

Director Academics
Talha Ibrahim

Project Head
Syeda Ailiya Naqvi

Project Coordinator
Zahra Khan Durrani

EDITORIAL TEAM

Chief Editor
Syeda Ailiya Naqvi

Associate Editor
Zarmina Khan

Assistant Editor
Mehrunissah Arif

Copy Editor
Afsana Afsar

Contributions

Aizah Azam
Maryam Raashed
Muhammad Saad
Sania Sabir Qureshi
Syed Ali Hadi
Tauseef Javed
Waleed Yawer

Designer
Aurangzaib Khan

CSCR does not take specific policy positions; accordingly, all views expressed herein should be understood to be solely those of the authors

Managing Editor at the Centre for Strategic and Contemporary Research
editor@cscr.pk
+92 (051) 2712221 [Ext:100]

Recommended citation:

Ailiya Naqvi et al, "Future of Pakistan's Water," *Centre for Strategic and Contemporary Research,* last modified March 2020.

Environmental Sustainability and Climate Change Program

The ongoing changes in the climate such as rise in sea level, changing weather patterns, flooding, drought etc. around the Earth are impacting global populace. To minimize the impacts of climate change, the international community needs to work together towards environmental sustainability by efficiently using limited natural resources and enhancing the recycling process. To ensure environmental sustainability necessary measures need to be implemented by focusing on environmental management and sustainable development. The key steps in environment management include conserving water and energy resources, reducing greenhouse gas emissions and protecting biodiversity. While the process of sustainable development focuses on meeting required needs for the population without minimizing resources for future generations.

The Centre for Strategic and Contemporary Research has initiated this program to conduct policy research on why environmental sustainability and climate change need to be at the fore of national policy. It also aims to research the steps Pakistan can take in this direction. As part of the program, the Centre is producing a variety of publications in the domains of climate change politics, green economy, environmental security, sustainable development, and renewable energy.

"Good effort has been made by the team while compiling this book. It includes vast information in a concise way. Every chapter of this book describing its significance in a well extended way with its worth. Each title of each chapter presenting its due connotation with the subjected material."

Muhammad Rahmatullah Khan - Water Management Expert, Food and Agriculture Organization of the United Nations, Pakistan.

"It covers all the important aspects based on available facts and figures towards future of Pakistan's water."

Abdul Salam - WASH & BCC Specialist, National Rural Support Programme.

"This book should be shared widely, especially with academia."

Abu Rehan - Senior Programme Officer, Water Governance and HA.

"The authors have rightly emphasised on the need to deal with water in its complexity, because it is affected by a multitude of factors, thus need an integrated approach to deal with water issues on sustainable basis. The book provides a ready reference to the water challenges of Pakistan and some strategies to deal with water issues at local and regional levels which can be of significant importance for policy makers, professionals from lined departments, water practitioners, researchers and students."

Dr. Ghani Akbar - Program Leader, Integrated Watershed Management Program (IWMP), Climate, Energy and Water Research Institute (CEWRI), National Agriculture Research Centre (NARC), Pakistan Agricultural Research Council Islamabad.

"With predicted increasing conflicts over water the authors have very efficiently stressed on a need for hydro-diplomacy which is an amalgamation of arguments associated with threats induced by neighbouring countries."

Dr. Umair Bin Nisar - Lecturer at Centre for Climate Research and Development, COMSATS University Islamabad.

"All important aspects have been mostly covered in the manuscript."

Mr. Muhammad Tahir Anwar - Director General, Government of Pakistan Federal Water Management Cell, Ministry of National Food Security and Research

"This book is also good for IWASRI."

Dr. Muhammad Basharat - PhD Engineering Hydrology, Addl. Chief Engineer IWASRI, WAPDA

"The authors have tried best to cover some of the important aspects of issues and prospects of the water sector including improper water management, transboundary issues, for which probable strategies and policy recommendations have been suggested."

Dr. Arshad Ashraf - Principal Scientific Officer, Climate, Energy and Water Research Institute, National Agricultural Research Centre.

"Diverse, easy to read description of water related issues covering a wide range of essential topics."

Dr. Athar Hussain - Chairman Department of Meteorology, Head Centre for Climate Research and Development, COMSATS University Islamabad

Index

List of Abberviations

ADP Asian Development Bank
AWARE Association for Water, Applied Education & Renewable Energy
BNS Bureau of National Statistics
CDA Canal and Drainage Act
CEWRI Climate, Energy and Water Research Institute
COP Conference of Parties
CPP Climate Change Policy
CPEC China Pakistan Economic Corridor
EIAR Environmental Impact Assessment Regulations
EIA Environmental Impact Assessment
EPA Pakistan Environment Protection Act
EPA Environment Protection Agency
EPPs Environment Protection Plan
EPOs Environmental Protection Orders
FFC Federal Flood Commissioner
GCISC Global Change Impact Studies Centre
GDP Gross Domestic Product
GHG Green House Gas
GLOFs Glacial Lake Outburst Floods
GYDI Global Youth Development Index
HSBC Hong Kong Shanghai Banking Corporation
IBP Indus Basin Project
IEE Initial Environmental Examination Report
IRSA Indus River System Authority
IUCN International Union for the Conservation of Nature and Natural Resources
IWT Indus Water Treaty
IWRM Integrated Water Resource Management
IWLF International Water Law Framework
IYWC International Year of Water cooperation
JICA Japan International Cooperation Agency
MDGs Millennium Development Goals
MGD Millions of Gallons per Day
NARC National Agricultural Research Centre
NCS National Conservation Strategy
NCCP National Climate Change Policy
NDRRP National Disaster Risk Reduction Policy
NDWP National Drinking Water Policy
NDWP National Drinking Water Policy
NEAP National Environmental Action Plan
NEP National Environmental Policy
NEQs National Environmental Quality Standards
NESPAK National Engineering Services Pakistan

NEAP National Environmental Action Plan
NECP National Energy Conservation Policy
NHDR National Human Development Report
NPP National Power Policy
NRP National Renewable Policy
NSDS National Sustainable Development Strategy
NSP National Sanitation Policy
NWP National Water Policy
NWV National Water Vision
NWSS National Water Sector Strategy
NUST National University of Science and Technology
PARC Pakistan Agriculture and Research Council
PBC Pakistan Business Council
PCRWR Pakistan Council of Research on Water Resources
PEPO Pakistan Environmental Protection Ordinance
PEPC Pakistan Environmental Protection Council
PID Punjab Irrigation Department
PSCST Pakistan's Standing Committee on Science and Technology
SDGs Sustainable Development Goals
SNWDP South-North Water Diversion Project
UNCED United Nations Conference on Environment and Development
UNFCCC United Nations Framework Convention on Climate Change
UNMD United National Millennium Declaration
UNDP United Nations Development Program
UNWDR United Nations Water Development Report
UNICEF United Nation
UNGA United Nations General Assembly
USAID United States Agency for International Development
WAPDA Pakistan Water and Power Development Authority
WASA Water and Sanitation Authority
WASH Water, Sanitation, and Hygiene
WAA Water Appointment Accord
WB World Bank
WEF World Economic Forum
WHO World Health Organization
WPOFA Wildlife Protection Ordinance and Forest Act
WRI World Resource Institute
WSSD World Summit on Sustainable Development
WWF World Wild Fund for Nature
YDI Youth Development Index

Overview

"The survival of every human, every region, and every society depends on having access to a share of the world's water through the global water cycle."[1]

Richard Lawford

Water scarcity, defined as the unavailability or inaccessibility of adequate fresh water for environmental and human uses, is considered to be the next probable cause of global conflict, given the important economic, social, and political roles that are attached to this natural resource. According to the United Nation's Water Development Report (2018), approximately 3.6 billion people around the world are living in areas where either water levels are extremely low or are diminishing quickly.[2] This means that water shortage is threatening the lives of almost half of the world's population, who could be facing drought like conditions in the near future. Ultimately, water will become an absolute limiting factor for overall development as well. For an agrarian economy like Pakistan, dearth of water can have serious social and economic repercussions.

Considering the aforementioned scenario, this book presents a comprehensive analysis of the water scarcity problem in Pakistan. It adheres to the definition of water scarcity as provided by the Food and Agriculture Organisation of the United Nations (UN), which expresses it in more relative and dynamic terms as "the lack of stability between water availability and its consumption" that can weaken if specific conservational actions fail to follow.[3] Pakistan's water related challenges stem from several factors such as its relations with neighbouring upper riparians whose activities upstream are threatening the flow of water downstream, lack of adequate storage options as the available water flows into the sea, limited reservoir capacity due to high rates of sedimentation, receding ground water due to excessive use of tube wells and the contamination of fresh water because of wrongful waste water disposal.

Pakistan barely receives 250 mm of annual rainfall which makes it one of the most arid states in the world.[4] According to the Water Aid Report (2016), the average water available for each person in Pakistan is about 908 m3 cubic meters which shows a decline of over 406 per cent since the 1950s.[5] Water quantities are unevenly spread across the country, where one region receives more water than the others. In this regard, this policy brief will investigate the overall concerns of the involved stakeholders, along with the future implications which the dearth of water will have for Pakistan as a whole. There is a need to stress upon the importance of water equality and right of water for all.

An on-going debate among policy makers and development practitioners about the reality of water scarcity in Pakistan has divided the overall public opinion as well. While most acknowledge this reality, some suggest that water scarcity is only an issue of inefficient management. The book in this regard, transcends the aforementioned debate and emphasises upon the need to conserve water, framing the lack of water availability as a national crisis regardless of its origins. Divided into ten chapters, it presents a comprehensive analysis of the various social, economic, political, and environmental aspects of the water problem prevailing in the country. It consolidates the existing strategies and policies supplemented by an updated assessment to guide the policy makers in formulating appropriate strategies required to tackle the issue of water scarcity in Pakistan. The following rubrics delineate the chapter wise break-up of the book.

Chapter 1 titled **The Hydrological Profile of the Indus Basin** presents a detailed overview of the hydrological aspects of the Indus Water Basin. It not only discusses the sources of water in the basin including rainfall, glaciers and ground water but also describes the Indus Water Project with special emphasis on the water related paraphernalia built on all the tributaries of the Indus. The chapter also underlines the issue of water quality and the prevalent climate in the basin as well.

Chapter 2 titled **The Landscape of Water Laws in Pakistan** presents an extensive review of the current water related policies such as the Water Apportionment Accord (1991), the National Water Policy (2018) and the National Water Vision 2025. Beginning with a detailed discussion of the evolution of the legal precedents for the sustainable use of water, the chapter concludes with a focus on building a strong regulatory framework to tackle all water related issues of the country.

Chapter 3 titled **Pakistan and the Need for Hydro Diplomacy** presents a holistic view of the transboundary water-related issues faced by Pakistan along with other domestic precedents. Recognizing the severity of the problem, it expands upon the need for cordial relations with the neighbouring countries especially India and Afghanistan. It also presents a detailed account of the intra-provincial differences over water which need to be reconciled for the preservation of water peace and quotes hydro diplomacy models such as the Blue Peace Initiative and the International Water Law Framework to reconcile all hostilities.

Chapter 4 titled **Pakistan's Water Storage Potential highlights** Pakistan's water storage capacity and potential. Despite several warnings, by various national and international agencies regarding the severity of the water problem, no concrete measures of building storage infrastructure have been taken by the government. Hence, after discussing Pakistan's current state of water dependency, the chapter provides suggestions for better storage such as building small dams etc.

Chapter 5 titled **Climate Change and Pakistan's Water Security** talks about the impacts of climate change and how it has led to the severity of the water problems in the country. The chapter reflects on the effects of various variables such as rising temperatures, increasing sea water intrusions, erratic rainfall patterns and excessive floods and droughts on the agricultural, industrial and energy sectors of the country.

Chapter 6 titled **Pakistan and the Political Economy of Water** sheds light on the economic costs of delaying the construction of water storage options and the careless use of non-renewable resources that can be seen today. The economy will continue to suffer from the damage caused by an acute shortage of water for the agricultural and industrial sectors. The chapter discusses the decentralisation of water management, the role of the private sector, agricultural and industrial losses and a futuristic scenario if such practices continue to occur.

Chapter 7 titled **Water Scarcity and Social Vulnerabilities in Pakistan** examines the relationship of water with other social variables such as health, food security, gender, migration and the upcoming generations. By doing so, it emphasises on the need for remedial measures so that the looming crisis regarding food and water insecurity in the country is not exacerbated further.

Chapter 8 titled **Unsustainable Water Management Practices in Pakistan** discusses Pakistan's inability of treating wastewater and the excessive use of non-sustainable means of obtaining fresh water which is putting further strain on the country's environment along with the economy. It urges the Pakistani government to adopt modern technological measures and infrastructure to cope with the issue of wastewater and stresses on the need for investment in research and development so that sustainable solutions to the issue of water scarcity could be found.

Chapter 9 titled **Other Riparians and Lessons for Pakistan** urges the Pakistani leadership to follow the examples of states which have championed the cause of efficient water management through the use of modern technology such as Singapore, Israel, Netherlands etc. It also presents examples of a few countries namely South Africa, India, Costa Rica and Sri Lanka have effectively tackled the issue of water scarcity though efficient water governance and user-friendly policies.

Chapter 10 tilted **Policy Recommendations** offers up-to-date solutions to the problem of water scarcity such as building more storage capacity, making water governance more efficient, engaging China and Afghanistan in water dialogue etc.

Chapter 1

The Hydrological Profile of the Indus Basin

Pakistan is the recipient of one of the world's biggest irrigation systems with river water coming primarily from the Indus, Jhelum, Chenab, Ravi, Sutlej, and Kabul rivers (average flow of 146 million acre feet annually) forming the chief sources of irrigation. Other resources such as rainwater, snow, glacial melt, and ground water form about 50-80 per cent of river flows per year.[6] Along with this, Pakistan also utilises some of its water requirement from the Kharan and Makran Coastal Basins; however, they contribute 5 cubic kilometre of surface water annually.[7] In addition, Pakistan has built three major dams - Mangla Dam, Tarbela Dam, Warsak Dam - as water reservoirs with the potential to generate electricity, along with 143 medium dams.[8]

An Overview of the Indus River Basin

The transboundary Indus River Basin has a total area of 1.12 million square kilometres. It stretches across four countries namely, Pakistan, India, China, and Afghanistan.[9] In Pakistan, the Indus River Basin stretches from the Himalayan mountains in the north to the dry alluvial plains of Sindh in the south and finally flows out into the Arabian Sea. About 65 per cent of the country's territory (around 520,000 square kilometres) is covered by the basin which includes the entire provinces of Punjab and Khyber Pakhtunkhwa, majority of Sindh along with the eastern part of Balochistan.[10]

In India, the basin covers the Indian-held Jammu and Kashmir, Himachal Pradesh, Rajasthan, Haryana and Chandigarh covering approximately 440,000 square kilometres or about 14 per cent of the total Indian territory.[11] Only eight and six per cent of the basin's total area is located in China and Afghanistan respectively.[12]

Table 1. Facts regarding the Indus River Basin

Basin	Area					
	Km²	% of Southeast Asia	Countries Inculded	Area of Country in basin (Km²)	As % of total area of the basin	As % of total area of the country
Indus	1 120 000	54	Pakistan	520 000	47	65
			India	440 000	39	14
			China	88 000	8	1
			Afghanisatan	72 000	6	11

Source: Food and Agricultural Organization

1. Climate

There is no uniformity in climate across the Indus River Basin as it varies from subtropical arid and semiarid to temperate sub-humid on the plains of Sindh and Punjab provinces to alpine in the mountainous highlands of the north. The annual precipitation ranges from 100 millimetres and 500 millimetres in the lowlands to a maximum of 2,000 millimetres on mountain slopes. Snowfall at altitudes above 2,500 meters accounts for most of the river runoff.[13] The Upper Indus River Basin is a mountainous region which limits the intrusion of the monsoon.[14] The climate in the Indus plains is arid to semi-arid with an average annual rainfall of about 230 millimetres. Due to hot climate, the evaporation rate is very high and the mean annual evaporation on the lower plain (Nawabshah) is about 204 millimetres, while on the upper plain (Sargodha) it is 1,650 millimetres.[15]

2. Water Resources

The following rubrics will delineate the sources of water in the Indus River Basin which lies within Pakistan.

a) Surface Water

The Indus river system forms a link between two large natural reservoirs, the snow and glaciers in the mountains and the groundwater contained by the alluvium in the Indus plains of the Sindh and Punjab provinces.[16] The river has two main tributaries, the Kabul on the right bank and the *Panjnad,* which is the flow resulting from the western rivers (Jhelum and Chenab) and eastern rivers (Ravi, Beas and Sutlej). This division was the outcome of the Indus Water Treaty (1960). The Indus River is the 12th largest river in the world which flows through almost 65 per cent of Pakistan's territory.[17] The country is heavily dependent on the river as its major source of

water. In the contemporary context, the river's supply is no longer able to meet the growing demand for water in its adjoining areas. The Indus river provides drinking water to millions of people, generates 45 per cent of electrical energy and fulfils the irrigation demand in Pakistan.[18] It is estimated that at least 300 million people reside in the Indus Water Basin.[19] All the rivers of the Indus system are perennial.[20] These rivers supply water to the entire Indus Basin Irrigation System through a number of smaller rivers and streams/*nullahs.*[21]

According to the latest figures given by the Indus River System Authority (IRSA), more water is available in Pakistan this year as compared to the previous year as the total rim station inflow of 104.82 million acre feet exceeded the forecasted water availability through both river inflows - 24.14 million acre feet - and stored water - 10.268 million acre feet.[22] The available surface water between 2018 and 2019 was 59.6 million acre feet for the cultivation of Kharif crops, while the consumption was increased by 11.2 per cent. The total available water for the Rabi season (2018-2019) was 24.8 million acre feet, with an increased rate of 2.5 per cent.[23]

Table 2. Surface Water Availability 2009-2019 [24]

Period	Kharif	Rabi	Total	% age increase/decrease. Over the Avg
Average System Usage	67.1	36.4	103.5	-
2009-10	67.3	25.0	92.3	-10.8
2010-11	53.4	34.6	88.0	-15
2011-12	60.4	29.4	89.8	-13.2
2012-13	57.7	31.9	89.6	-13.4
2013-14	65.5	32.5	98.0	-5.3
2014-15	69.3	33.1	102.4	-1.1
2015-16	65.5	32.9	98.4	-4.9
2016-17	71.4	29.7	101.1	-2.3
2017-18	70.0	24.2	94.2	-9
2018-19	59.6	24.8	84.4	-18.5

Owing to high consumption of water with insufficient water storage systems and reservoirs, Pakistan is now ranked amongst the world's 36 most water-stressed countries.[25] Due to a rapid increase in the country's population, its annual water availability is decreasing continuously. The per capita water availability was fixed at 5260 cubic meters per capita in 1947,[26] 1500 in 2009, 1017 in 2015 and 935 in 2018 respectively.[27] There is a need for efficient water strategies to be adopted for water conservation.

b) Western Rivers

The Indus Water Treaty suggests that Pakistan will receive an unrestricted use of the western rivers, which India is under obligation to let flow, except for restricted uses, related to domestic use, non-consumptive use, agricultural use, and generation of hydroelectric power of which the amounts are set out in the Treaty. The accumulated annual flow from China and flow generation within India results in the allocation of 170.27 cubic kilometres for Pakistan and 62.21 cubic kilometres remain available to India.

c) Eastern Rivers

The treaty also stipulates that India shall receive an unrestricted use of the eastern rivers and Pakistan shall be under an obligation to let flow the waters of any tributary which in its natural course joins the Sutlej Main or Ravi Main before these rivers have finally crossed into Pakistan. All the waters of any tributary which in its natural course joins the Sutlej Main or Ravi Main after these rivers have crossed into Pakistan shall be available for unrestricted use of Pakistan.

3. Water Reservoirs [28]

In 1959, Pakistan's Water and Power Development Authority (WAPDA), was given the responsibility to build water reservoir facilities in the form of dams, canals, and barrages so that the country could meet the significantly increasing demand of water and deal with the hazards of water logging, salinity, and floods.[29] Under the Water and Power Development Authority's construction plans, several dams such as the Rawal Dam, Tanda Dam, Hub Dam, and Khanpur Dam were completed in 1962, 1965, 1983, and 1984 respectively.[30] Both the Tarbela and Mangla dams were constructed under the joint collaboration of the WAPDA and World Bank as a part of the Indus Basin Project (IBP) once the Indus Water Treaty was signed in 1960.[31] The details of the Indus Basin Project and various major operational dams of Pakistan are discussed below:

a) The Indus Basin Project (IBP)

Under the Indus Water Treaty (1960), India was granted the waters of rivers Ravi, Beas, and Sutlej while Pakistan was allotted the Indus, Jhelum, and Chenab rivers.

Moreover, the treaty covered the construction of two multipurpose dams - Mangla and Tarbela - eight link canals and six barrages, under the IBP,[32] as a compensation of the losses faced by Pakistan due to the segregation of the rivers of the Indus Water Basin.[33] These projects will be discussed in detail in the following rubrics.

i. Tarbela Dam

The Tarbela dam is one of the major dams constructed under the Indus Basin Project in Pakistan and the second largest dam in the world in terms of reservoir capacity. Built on the Indus River in Khyber Pakhtunkhwa province, Haripur district, the dam was operationalised in 1978. It is 465 feet high with respect to the riverbed[34] and 9,000 feet long, covering a total area of 250 square kilometres.[35] The primary purpose for the creation of this dam was to meet the irrigation and electricity requirements of the Pakistani people. The dam has an installed capacity of around 3,478 megawatts along with a storage capacity of 13.69 cubic kilometres.[36] The dam has two embankments which are 220 feet and 960 feet high.[37] The embankments are further divided into two spill ways, namely, the service spillway which has a discharge capacity of 650,000 cusecs and is controlled by seven gates along with the second auxiliary spillway which has 850,000 cusecs of discharge capacity having nine gates.[38] Moreover, five large tunnels are also a part of this huge dam which are located at different outlets. The details of the spillways and their main features are shown in Table 3.

Table 3. Tarbela Dam Spillways [39]

Service Spillway	
No of Gates	7 (50 Feet wide x 61 feet high)
Discharge	650,000 Cusec
Auxilliary Spillway	
No of Gates	9 (50 Feet wide x 61 feet high)
Discharge	850,000 Cusec
Main Features	
Normal Pond Level	340.0 m above MSL
Maximum (Survival) Pond level	341.5 m above MSL
Design Flood Capacities	18,700 cumec (660,000 cusec)
Discharge Intensity (Average)	36.5 cumec (393 cusec/ft)
Survival Flood Capacities	
Gated Section	23,000 cumec (812,000 cusec)
Fuse Plug	23,200 cumec (819,000 cusec)
Combines	46,200 cumec (1,630,000 cusec)
Canal Capacity	1600 cumec (max)
Mandatory Flow down-Stream of River	28 cumec

	Standard Bays	Under Sluices	Head Regulator
No of Gates	20	8	8
Gate Size (Opening)	18.3 x 7.8m (W x H)	18.3 x 2.8m (W x H)	18.3 x 7 m (W x H)
Gate Type	Radial	Radial	Radial
Still Level	332.2m	326m	333m
Gantry Cranes(1+1)	75/1Ot		

ii. Mangla Dam

Mangla Dam is the world's 12th largest earth type dam located on the bank of River Jhelum in district Mangla, Mirpur, Pakistan.[40]

The dam has a reservoir capacity of 2.88 million acre feet.[41] The dam's construction began in 1962 and the government took charge in February 1967.[42] The project was originally executed by WAPDA and was completed in 2009.[43] It is an earth-filled dam with a maximum altitude of 380 feet above the surface of water.[44] The main edges of the dam have a gross capacity of 5.35 million acre feet whilst the maximum active storage is 4.81 million acre feet.[45] The chief motive behind the construction of the project was to strengthen the irrigation system and to generate 1,000 megawatts of electricity from 10 subunits each with a production capacity of 100 megawatts.[46] The dam was also built to utilise monsoon flows and to prevent accidental floods. The resettlement work of this project is expected to start by June 2021.[47] The details of the two spillways of the dam are listed in the table below.

Table 4. Details of Mangla Dam Spillways [48]

Desceiption	Main Spillway		Emergency Spillways	
	Before Raising	After Raising	Before Raising	After Raising
Type	Submerged Orifice		Weir	
Max discharge	870000 cfs	945300 cfs	230000 cfs	230000 cfs
Types of gates	Radial Type	Radial Type	Free Fall	Free Fall
No of Gates	09	09	Nil	Nil
No of Chutes	02	02	Nil	Nil
Still Level	1080 ft SPD	1092 ft SPD	1208 ft SPD	1243 ft SPD

iii. Indus River Canals

The Indus Basin project also comprised of eight canals including the Tirimu Sindhani, Sindhani Mailsi, Mailsi Bahawal, Rasul Qadirabad, Qadirabad Baloki, Baloki Sulemanki, Chashma Sulemanki, and Taunsa Panjnad. The total length of these canals is 389 miles with 400 main structures and a discharge capacity between 4,100-21,700 cusecs. They were completed within five years starting from 1965 and ending in 1970. [49]

b) Major Operational Dams in Pakistan

Other than the Indus Basin Project (IBP), Pakistan currently has six major operational dams including the third biggest dam (Warsak). Besides this, several other dams are also under construction such as the Dasu Hydropower Project, Keyal Khwar Hydropower Project, Kurram Tangi Dam along with various rehabilitation projects such as that of the Warsak and Mangla Dams. Moreover, a few other projects such as the Bunji, Diamer Bhasha, Harpo, Mohmand, and Tarbela fifth extension are still in the pipeline. [50]

i. Warsak Dam

The increased demand for electricity compelled Pakistan to build water reservoirs other than Tarbela and Mangla dams. Completed in two phases, the Warsak hydroelectric project under the Colombo Plan was initiated by Pakistan in collaboration with the Canadian government in 1960. Approximately 250 feet high with a four square miles reservoir, the dam covers a total area of 460 feet on River Kabul, some 30 kilometres from Peshawar. The total cost of the dam was around Rs394.98 million with its water being used for irrigation purposes since the completion of the first phase in 1960. It also started producing hydroelectricity with an installed capacity of 243 megawatts and a live water storage capacity of 25,300 acre feet. The second phase of the dam concluded the commissioning of two supplementary power units with an installed capacity of 41.48 megawatts in 1981. It is a gravity filled dam with both service and controlled spillways. [51]

To use stored rainwater, the dam has two concrete lined irrigation tunnels:

i. Right Bank Irrigation Tunnel
ii. The Left Bank Irrigation Conduit

Table 5. Major Operational Dams in Pakistan [52]

Dam	Location	Year	Technical Specifications	Cost/Objectives
Mirani Dam	Dasht River, Balochistan	2002-2006	4th largest in Pakistan Hight :127ft Length:3,350ft Flood storage upto : 588,690 cubic hectometers.	Rs. 5,267.90 million
Khanpur Dam	KPK, Dist. Khanpur	1983	Height: 167 ft water storage: 110,000 acre-ft	Rs. 1,352 million /Drinking and daily usage
Satpara Dam	Skardu, Gilgit-Baltistan	2013	earth-filled Dam Height:128 Ft, Length: 560 Ft Gross Storage Capacity: 0.093 MAF Live Storage Capacity: 0.053 MAF Power Generation 17.3 MW Power production 17.36 MW Drinking water: 3.1 MGD	Rs. 14,450.138 Million/ Hydroelectricity and Water Supply source
Hub Dam	Sindh, Dist. Lasbela	1963-1981	Height:154¢ Length: 15,640¢ live storage: 656,000 AF water supply: 100 MGD (Million gallon per day) Reservior — Level: Full: 339.0¢ Max: 346¢ Dead Storage: 276.25¢ Reservior — Capacity: Gross: 6, 87,276 AF Live: 6, 45,470 AF Dead41,806 AF Spillway: Type:Un-gated Concrete Ogee Length :6,020¢ Elevation: 339.3¢ Max. Outflow Capacity: 458,000 cfs	Rs. 1191.806 million/ water supply and irrigation
Darawat Dam Project	Sindh, Jamshoro Dist.	2010-2014	Type: Concrete Gravity Height: 151 ft Annual storage Capacity: 121,600 AFLive Storage Capacity: 89,200 AF	As per 2019, Rs. 2,366.00 Million.

The right bank irrigation tunnel is 17,000 feet high, having a diameter of 10 feet with a storage capacity of 800 cusecs with two 44.20 and 27.26 miles long canals, irrigating an area of 108,000 acres respectively. Whereas, on its left bank the reservoir has a 600 feet long circular steel pipe irrigation conduit which is three feet long. The conduit is further linked with four sub tunnels (10,414 feet long) irrigating an area of 11,000 acres. [53]

Table 6: Specification of Warsak Dam[54]

Spillway	Intake Gates	Power Tunnel	Pen Stock
Nine overflow gates each having size- 40 x40ft and discharge capacity of 60,000 cosecs Length : 440 ft.	Two gates with 39ft x16ft (HxW)	365ft long Concrete lined power tunnel with 39ft diameter.	Six penstocks of 18ft diameter.
Specification of Warsak Dam			

4. Major Sources of Rainfall in Pakistan

The two major sources of rainfall in Pakistan are monsoon and western depressions. According to an estimate, Pakistan receives around two thirds of water annually from rainfall in summer with the remaining in winter.[55] The normal (1961- 2010) rainfall for the period July to September is 137.5 millimetres.[56] Rainfall during the post-monsoon season (October-December) in 2018 was about 26.4 millimetres, whereas, the actual recorded rate post monsoon rainfall was 15.6 millimetres, showing a decline of 40.9 per cent. Similarly, in the start of this year, the average rainfall during the first three months was 74.3 millimetres out of the total recorded rainfall of 107.2 millimetres.[57] A large portion of rainwater is consumed for irrigation purposes whilst the remaining is wasted due to a lack of storage capacity and delayed construction of dams.[58] At present, Pakistan has 13 major areas of potential hill torrents, which if not managed effectively can adversely affect all water related paraphernalia.[59]

5. Glaciers as a Source of Water

Pakistan is blessed with 7,253 known glaciers which provide about three to four meters of snowfall, especially in the upper Indus region which is around 22,500 square kilometres.[60] The southern Hindukush glaciers provide 80 per cent water to the Kabul River and the glaciers in Indian occupied and Azad Kashmir provide 75 per cent water to River Chenab and 50 per cent water to River Jhelum. About 340 million acre feet of the total water in the Indus River comes from glacial melt, whereas, about 300 million acre feet of glacial melt feeds the Kabul and Jhelum rivers.

6. Ground Water

Pakistan has the fourth largest groundwater aquifer and it is the third largest groundwater user in the world and fourth-largest groundwater withdrawing country contributing to nine per cent of the global groundwater extraction and making the Indus Basin aquifer the second most "overstressed" groundwater basin in the world.[61] Pakistan's ground water level is falling a meter every year mainly due to groundwater extraction for drinking and agriculture purposes.[62] The annual consumption of ground water in Pakistan for irrigation purposes is about 60 per cent.[63] Ground water is majorly pumped out from the agricultural areas of Sindh and Punjab, some from Khyber Pakhtunkhwa and other limited areas of Balochistan. An increase in the number of tube wells since the past 30 years, extracting about 42 million acre feet of water annually has reduced the volume of ground water to a large extent.[64] The issues and challenges to groundwater in Pakistan include falling water tables, virtual water trade, no water metering and pricing, evapotranspiration, population growth rate and increasing water demand, less recharging of the aquifers, unchecked drilling and gaps in governance.

7. Water Quality

Water, an essential ingredient for life, is facing serious quality issues in Pakistan. Due to rapid population growth, wrongful sewerage disposal and rampant industrialisation, the water quality of Pakistan is deteriorating. Such deterioration in water quality along with the contamination of lakes, rivers and groundwater aquifers has resulted in increased water borne diseases. Studies have showed that around 40 per cent of all reported diseases in Pakistan are attributed to poor water quality.[65] On the global water quality index, Pakistan ranks 80th out of 122 nations. Moreover, it was found that almost all areas of Pakistan lack the supply of clean drinking water. The major contaminants present in water include microbes and metals such as arsenic and lead as well as high salinity due to the over extraction of water and low water tables.[66]

Not only surface water but the rampant use of pesticides and nitrogenous fertilisers is also seriously affecting the quality of groundwater. Almost all shallow freshwater is now polluted with agricultural pollutants and sewage. Soil salinity and sodicity also constrain farmers and affect the overall agricultural production. Poor quality of groundwater further adds to the aforesaid problems.[67] In fresh groundwater areas, excessive pumping by tube wells is further reducing the quality of groundwater.[68] Given the bleak scenario regarding the quality of water in Pakistan, there is a need for water treatment measures to be put in place so that the issue of water quality and its possible health impacts could be overcome.

Chapter 2

The Landscape of Water Laws in Pakistan

Pakistan's water laws are an amalgamation of informal rules, legislative enactments, customary practices and formal manuals of procedure which have come down from the Indus, Aryan, Arab and British civilisations. The major chunk of Pakistan's water related legislative enactments were introduced by the British based on their experience of early irrigation development in Spain, Italy and France, which were then modified to suit the needs of the subcontinent. The major focus of the legal water framework in Pakistan is to encourage the development, delivery and use of water in a sustainable manner to all stakeholders. This chapter sketches a detailed picture of the landscape of water laws in Pakistan to understand how the government has drawn specific legal precedents for the sustainable use of water.

In 1873, the British introduced the Canal and Drainage Act which empowered the provincial government to use and control the water of all rivers and streams flowing in natural channels, all lakes, sub-soil water and other natural collections of still water.[69] After independence, the Pakistan WAPDA was passed in 1958 which provided for the unified and coordinated development of the water and power resources of Pakistan giving birth to the WAPDA for the implementation of its major clauses.[70] WAPDA, a semiautonomous body, oversees the water and power sector. The power wing of WAPDA looks after hydropower generation, while the water wing follows a proactive approach and deals with all water related areas. It also has a research wing that produces scientific information related to the water and power challenges faced by Pakistan.[71]

In 1964, the Pakistan Council of Research on Water Resources (PCRWR) was established as a national research institute promoting research concerning various water related disciplines like drainage, irrigation, groundwater recharge and management, rainwater harvesting, watershed management, freshwater quality control, water conservation and the promotion of water technologies.[72] PCRWR is headquartered in Islamabad with various regional offices and research centres throughout the country.[73] In addition, the West Pakistan Land and Water Development Board Reclamation (Fee) Rule was introduced in 1965 which provided for the issuance of a reclamation fee which must be paid by the owner of the land irrigated by a system of intertwined canals.[74] Moreover, the Territorial Water and Maritime Zones Act (1976) demarcated the territorial waters, contiguous zones, continental shelves and exclusive economic zones of Pakistan.[75]

The idea that environmental protection endeavours require special attention and evaluation was only truly considered as an outcome of the Conference on Human Environment in Stockholm (1972).[76] As a result, Pakistan established the Ministry of Environment in 1975 which drafted its first ever consolidated law for environment protection in 1983, by the name of Pakistan Environmental Protection Ordinance (PEPO).[77] In order to implement the federal legislation, the Pakistan Environmental Protection Council (PEPC) along with the Environmental Protection Agency (EPA) was established. Later in 1987, the provincial EPA was established in Punjab followed by separate EPAs for both Sindh and KP.[78] Even though PEPO aimed at solving environmental problems and stressed upon pollution control in the country, it did not give special attention to the fragile ecosystems and the specific sectorial activities that were most damaging to the environment. The ordinance also did not give much importance to resource management and was unable to have a positive impact on the environment.[79]

In 1978, the Balochistan Groundwater Rights Administration Act was passed which was concerned with the management of groundwater rights in Balochistan along with the On-Farm Water Management and Water User's Association Ordinance (1981) for on-farm water management including water conservation, optimum utilisation of water for irrigation purposes and the formation of a water user's association in Punjab province.[80] Furthermore, the Karachi Water Management Board Ordinance was introduced in 1981 which established the Karachi Water Management Board to oversee the provision of water to Karachi.[81] The most prominent functions of the Board included supplying and distributing water to Karachi, managing and maintaining all works in connection with water supply, periodically assessing the position of water supply and recommending a new scheme or reviewing the existing scheme for levying, revising and collecting water charges and imposing penalties if the payment for the amount of water used was not received within the time fixed by the Board.[82] The ordinance was later followed by the Sindh Irrigation Water Users Associations Ordinance in 1982 which set up the irrigation water users associations, responsible for the improvement and productivity of irrigated agricultural land through better use of surface and ground water.[83]

In 1992, Pakistan participated in the Earth Summit, the United Nations Conference on Environment and Development (UNCED) in Rio, Brazil. Pakistan's attendance of the Summit accelerated the process of environmental law making in the country and in the same year, Pakistan prepared the National Conservation Strategy (NCS) which was a policy aimed at achieving "environmentally sustainable social and economic development" formulated after extensive collaboration (1983-1992) between the Government of Pakistan and the International Union for the Conservation of Nature and Natural Resources (IUCN).[84] Its implementation was based on the objectives of the effective management of natural resources, their conservation, and sustainable development. The policy was meant to be implemented during the eighth Five Year Plan (1993-1998) aimed at incorporating

the environmental impacts of all development related decision-making processes.[85]

The NCS was a broad framework divided into four main components: the strengthening of institutions, efficient communications and campaigning, the creation of supportive regulatory frameworks and economic incentives along with the implementation of these projects. Under NCS, Rs151 million were allocated for certain environmental protective measures geared towards the improvement of the 14 identified areas including the protection of water bodies, increasing irrigation efficiency, management of urban waste water, and supporting other institutions that dealt with these common resources.[86]

Over the years, water related legislation in Pakistan has gained momentum with the introduction of the Indus River System Authority Ordinance (1992) which established the Indus River System Authority (IRSA) for regulating and monitoring the distribution of water from the Indus River in accordance with the Water Accord amongst the provinces.[87] According to the Act, the authority should comprise of five members, one from each province and one from the federal government.[88] Later, the Climate, Energy and Water Research Institute (CEWRI) was established in 1991-1992 following the re-organisation of the water related research programmes being executed by the National Agricultural Research Centre (NARC), in Islamabad.[89]

In 1993, EPA introduced the National Environmental Quality Standards (NEQs) which were notified under PEPO's first official meeting, providing benchmarks for industrial and municipal effluent and air emissions, including 32 liquid and 16 gaseous parameters. The ordinance required industries and other development proponents to provide an "Environmental Impact Assessment (EIA)" to the Federal EPA before starting business operations anywhere.[90] However, it took a decade for EIA to be incorporated into the decision-making processes and it became mandatory to obtain "Environmental Clearance" from the Federal or Provincial EPA by July 1994. The NCS was one of the major commitments made by Pakistan in its national level development plans. However, the framework's impacts were unsuccessful in bringing every stakeholder to the same table.

In addition, water related legislations continued to come to the surface such as the Coastal Development Authority Act of 1994 which provided for the development, improvement and beautification of the coastal areas of the districts of Thatta and Badin along with the amended WAPDA Act of 1994, under which the authority was charged with the responsibility of preparing a comprehensive plan for the development and utilisation of the water and power resources of Pakistan on a unified and multi-purpose basis. In 1996, the revised Sindh Irrigation Act spearheaded the construction, maintenance, and regulation of canals for checking the amount of water supplied to the province of Sindh along with the Karachi Water and Sewerage Board Act which established the Karachi Water and Sewerage Board for the supply of water along with the disposal of sewerage in Karachi.[91]

In 1997, the Pakistan Environmental Protection Act (EPA) replaced PEPO, days before attending the third session of the Conference of the Parties under the aegis of the United Nations Framework Convention on Climate Change in Kyoto, Japan. Following a process that involved extensive participation of all important stakeholders, this act was put forward to bridge the gaps in the environment protection law, drafted at the federal and provincial levels.[92] The Act empowered the provincial EPAs to undertake appropriate measures for environmental protection. Prior to EPA, no law specifically catered to the availability of freshwater resources at the provincial level and although federal legislation governed resource allocation, but it had no provisions regarding either the sustainable use or the conservation of water resources. Only a few clauses catered to the issue of water pollution in the Penal Code, Islamabad Wildlife Protection Ordinance and the Forest Act.[93]

The Pakistan Environmental Protection Act regulated all sorts of pollution it defined the environment in broad terms and included detailed water related provisions. Section 2 (VI) of the Act talks about the various forms of water pollution and defines the term discharge as "spilling, leaking, pumping, depositing, seeping, releasing, flowing out, pouring, emitting, emptying or dumping."[94] The Act was substantive as it stressed upon banning hazardous waste and setting up environmental tribunals in every province along with adequate Provincial Sustainable Development Funds. The Act also reconstituted PEPO whereby their functions were enhanced, and they were both technically and logistically strengthened to meet the environmental challenges. Under section IX and X of the Act, Sustainable Development Boards were established in Punjab, Balochistan and North West Frontier Province (now Khyber Pakhtunkhwa).[95]

Moreover, several NEQs were revised in 1999 to make industrial pollution control a priority and to ensure that all existing industries complied with the quality standards. Under the Act, a system of self-monitoring and reporting was introduced in an attempt to make the industrial sector more compliant with environmental protocols where industries would voluntarily keep track of and report the level of pollution, they produce.[96] Another approach was the "Environmental Protection Plans" (EIPs) that enforced NEQs on industries which refused to comply with the aforementioned laws, through the issuance of the "Environmental Protection Orders (EPO)."[97] Through the EPOs, for the first time, industries were issued public complaints or warning notices for excessive polluting. For this reason, Environmental Protection Tribunals were established in Lahore and Karachi, to act on the EPOs and take up environmental cases. In the same year, a court order was filed against the Environmental Protection Act before the High Court of Lahore, due to its inefficiency and failure in holding polluting industries accountable for their actions.

In 2000 an "Initial Environmental Examination Report" along with the "Environmental Impact Assessment Regulations" (IEE/EIA Regulations) were issued under Section 12 of the Environmental Protection Act which stated that "no

proponent of a subproject shall commence construction or operation unless he has filed with the Federal Agency an initial environmental examination (IEE) or where the subproject is likely to cause an adverse environmental effect, an environmental impact assessment (EIA), and has obtained from the Federal Agency approval in respect thereof."[98] Prior environmental damage assessment was made mandatory especially for some specific types of irrigation projects and those related to the construction of dams and other water related paraphernalia.[99]

With the start of the new century, environmental protection adjudication stayed limited to the public space. It was observed that the mechanism that was being employed for environmental protection lacked understanding and innovation. Even though Environmental Tribunals were established, the lawyers in the country lacked understanding of the subject matter as courses on environmental law were not commonly taught. There was also a general lack of interest and awareness among the lawyers that slowed down the process further.[100] The country also saw the development of new policies related to environment protection as attempts to develop the "National Sustainable Development Strategy" (NSDS) of Pakistan.[101] In the year 2000, a mid-term review of the National Conservation Strategy (NCS) took place which concluded that it was limited to raising awareness and building institutional capacity only as opposed to the actual implementation of the provisions of the strategy.[102]

In September 2000, Pakistan became a signatory of The United Nations Millennium Declaration that aimed at combating global problems such as the provision of safe drinking water and improved sanitation and environmental protection.[103] Pakistan became one of the 77 countries that were successful in meeting the Millennium Development Goals on improved sanitation and drinking water.[104] However, inequalities between the urban and rural classes remain a challenge for the country. In 2001, the "National Environmental Action Plan" (NEAP) replaced NCS as a more efficient framework for environmental protection. The United Nations Development Program (UNDP) supported NEAP's implementation which aimed to check the quality of air and water for the efficient management of wastewater and other problems. In the same year WAPDA also introduced its Water Vision 2025 which aimed at tackling the severe water and energy crisis in Pakistan.

The following year, Pakistan participated in the World Summit on Sustainable Development (WSSD) in Johannesburg which put forth a UN commitment to implement all the set international environmental goals such as the Agenda 21, Millennium Development Goals etc. In 2007, the "Global Change Impact Studies Centre" (GCISC) was established that functioned as a public sector development project financed by the Ministry of Science & Technology along with the "National Water Quality Monitoring Program" covering 21 metropolitan cities. The National Water Sector Strategy was also introduced shortly after which set out to identify the key issues and objectives of the water sector and put forth "proposals for the planning, development and management of water resources and their use in all

water sub-sectors."[105]

The "National Sanitation Policy" (NSP) was introduced in 2006, aimed at promoting awareness about "the safe disposal of liquid and solid wastes and the promotion of health and hygiene practices" in the country.[106] The definition of sanitation in the policy covered "cleanliness, hygiene, proper collection of liquid and solid waste and their disposal according to the environmental standards."[107] Under the aegis of the Millennium Development Goals, the NSP proposed rewards for all "open defecation free" *tehsils* (sub-districts) and towns.[108] Meanwhile, the National Energy Conservation Policy, the National Renewable Energy Policy and the Clean Development Mechanism National Operational Strategy were introduced in 2006.

In 2007, WAPDA was separated into two entities: WAPDA and the Pakistan Electric Power Company (PEPCO). The former was made responsible for all aspects of water and hydropower development including irrigation, water supply, drainage, prevention of salinity and water logging, flood management, and inland navigation. The latter was made responsible for the provision of thermal power generation, its transmission, distribution, and billing.[109] This was followed by the establishment of a new ministry in 2007 by the name of the "National Disaster Management Authority" (NDMA) at the federal level that dealt with disaster management and all related activities in the country.[110] In 2009 the "National Drinking Water Policy" (NDWP) was introduced, aimed at the provision of safe water for domestic purposes including drinking, cooking, hygiene, and other uses.[111] By doing so, the policy also aimed to reduce the mortality rates caused by waterborne diseases. The "safe water" refers to the water complying with the National Drinking Water Quality Standards.[112]

Once the 18th Amendment was passed in 2010, the Ministry of Environment was dissolved, and the provincial governments were given all the environmental responsibilities such as the legislation and enforcement of all environmental regulations.[113] In the same year, the Pakistan Council of Renewable Technologies Act was established that was responsible for the "promotion, development, acquisition, propagation and dissemination of renewable energy technologies" along with the Alternative Energy Development Board Act and the National Sustainable Development Strategy (NSDS) which attempted to pave the pathway for a sustainable and resilient future for Pakistan.[114] The strategy highlighted the promotion of green investment, efficient water management, and the environmentally friendly production and consumption of resources.

Moreover, the Alternative and Renewable Energy Policy was also passed in 2011. In 2012, the Ministry of Disaster Management was renamed as the "Ministry of Climate Change" and the National Climate Change Policy was approved by the Federal Cabinet which aimed at instilling sustainable economic growth while addressing all climate change related challenges in the country.[115] The authority contributed efficient policy measures for climate related adaptation in various sectors including water and power. Moreover, the Balochistan Environmental

Protection Act and the Punjab Environmental Protection Act came to the fore in the same year after which the former Chief Justice established the "Green Benches" initiative in the Supreme Court along with all other High Courts of Pakistan.[116] In addition, the National Disaster Management Plan and the National Sustainable Development Strategy were also approved in 2012.[117]

In 2013, the Ministry of Climate Change was downgraded to a Cabinet Secretariat Division and more than 60 per cent of its annual expenditure was scraped. The GCISC that worked as a dedicated climate change centred research institute in the country for 10 years was granted the status of a national autonomous entity under the GCISC Act by the Parliament in 2013.[118] The same year saw the implementation of several legislations such as the National Disaster Risk Reduction Policy, the Framework for the Implementation of Climate Change Policy and the National Power Policy. In 2014, a critical guide-post for the "development of an effective strategy and road-map to reach the national goals and aspirations" was put forth by the name of "Pakistan 2025: One Nation, One Vision" with a specific focus on all climate and water related exigencies in the country.[119]

In 2015, the Climate Change Division was upgraded once again as a federal level focal ministry that dealt with all climate-related concerns in the country. The NDMA was placed under the Ministry of Climate Change. Despite regaining a ministry status its role remained limited to facilitation and coordination and no new budget or project was assigned under it. In 2015, the Framework for Implementation on Climate Change Policy was passed which recognised water as a crucial resource for human survival and sustainable economic growth.[120] The implementation framework consisted of an entire section on water along with a broad plan of action for securing Pakistan's waters.[121]

As the previously established NEQs (1993, 1997, 1999), still remained unenforced because of the lack of technical, financial, and human resource capacities, in 2016, these were once again re-gazetted as the "Environmental Quality Standards for Municipal and Liquid Industrial Effluents."[122] This new standard set a maximum cap on the amount of wastewater which the industries could drain into other water sources like lakes and streams. By 2018, the Climate Change Act had been passed, the Ministry for Water resources had been established and a comprehensive National Water Policy had been put forth to address Pakistan's environmental calamities.[123]

The following rubrics would provide a detailed assessment of a few landmark environmental legislations passed in the country such as the Water Apportionment Accord (1991), the National Environmental Policy (2005), the National Sanitation Policy (2006), National Drinking Water Policy (2009), National Water Policy (2018), and the National Water Vision (2025).

The Water Apportionment Accord (1991)

In 1991, The Water Apportionment Accord was signed to share the waters of the Indus River between the four provinces. The agreement was based on the existing and future water needs of the provinces. The accord allocates the following share of water to all four provinces:[124]

Province	Kharif (MAF)	Rabi (MAF)	Total (MAF)
Punjab	37.07	18.87	55.94
Sindh*	33.94	14.82	48.76
KP (a)	3.48	2.3	5.78
(b) Civil Canals	1.8	1.2	3
Balochistan	2.85	1.02	3.87
Total	77.34	37.01	114.35
**	1.8	1.2	3

* Including already sanctioned Urban and Industrial uses for Metropolitan Karachi
** Ungauged Civil Canals above the rim stations

Balance river supplies (including flood supplies and future storages) was to be distributed as below: [125]

Punjab	Sindh	Balochistan	KP	Total
37	37	12	14	100%

The main features of the Accord were as follows:[126]

- No restrictions on the provinces to undertake new projects within their agreed shares.
- No restrictions on developing irrigation uses in the Kurram/Gomal/Kohat basins so long as these do not adversely affect the existing use on these rivers.
- No restrictions on Balochistan to develop the water resources of the Indus River's right bank tributaries flowing through its areas.
- The Indus River System Authority to be established for the implementation of the Accord.
- The record of the actual average system uses for the period 1977-1982 would form the guideline for developing a future regulation pattern.
- The existing reservoirs would be operated on a priority basis for the irrigation needs of the provinces.
- The provinces would have the freedom within their allocations to modify system-wise and period-wise uses.
- All efforts would be made to avoid wastages.
- About 12 million acre feet of additional water will be allocated to the four provinces for priority irrigation development.

The National Environmental Policy (2005)

The policy addressed all environmental issues faced by Pakistan including the pollution of freshwater bodies and coastal areas. It also accounted for waste management, deforestation, loss of biodiversity and natural disasters as well as climate change. Furthermore, it provided directions for cross-sectoral issues and the underlying causes of environmental degradation under international obligations.[127]

The National Sanitation Policy (2006)

The focus of this policy was the safe disposal of sewage, away from settlements and workplaces including the creation of an open defecation free environment along with the safe disposal of liquid and solid wastes and the promotion of healthy and hygienic practices in the country.[128]

The National Drinking Water Policy (2009)

The Government of Pakistan recognised the provision of safe drinking water as a fundamental human right. In this context, the Ministry of Environment formulated the National Drinking Water Policy to provide an adequate quantity of safe drinking water to the entire population at an affordable cost and in an equitable, efficient and sustainable manner. The policy aims to improve the quality of life of the people of Pakistan by reducing the incidence of death and illness caused by water-borne diseases. It also provides specific guidelines for increasing access to safe drinking water, the protection and conservation of surface and groundwater resources, water treatment and safety, appropriate standardisation procedure, increasing community participation, public awareness, capacity development, public-private partnership, research and development, emergency preparedness, and coordinated planning and implementation of the policy itself.[129]

The National Water Policy (2018)

The National Water Policy lays down a set of principles of water security on the basis of which the provincial governments can formulate their respective plans and projects for water conservation, water development and water management. The National Water Policy is based on the concept of Integrated Water Resources Management primarily aimed at the following policy objectives:[130]

- Promoting sustainable consumption and production patterns throughout the water sector.
- The augmentation of the available water resources of the country through judicious and equitable utilisation via reservoirs, conservation, and efficient use.
- Improving the availability, reliability and quality of freshwater resources to meet critical municipal, agricultural, energy, security, and environmental needs.
- Improving urban water management by increasing system efficiency and reducing nonrevenue water through adequate investments to address drinking water demands, sewage disposal, handling of wastewater and industrial effluents.
- Promoting behavioural changes to reduce wastage of water by raising public awareness through media campaigns and incorporating water conservation lessons in syllabi/curricula at primary, secondary, and tertiary levels.
- Hydropower development to increase the share of renewable energy.
- Providing food security and expanding water availability to help adapt to climate change and other large-scale stresses.
- The treatment and possible reuse of wastewater - domestic, agricultural and industrial.
- Upgrading all water sector information systems for improved asset management and data driven decision making.
- Improving watershed management through extensive soil conversion, catchment area treatment, forest preservation, and increasing forest cover.
- Restoring and maintaining the health of the environment and water related ecosystems.
- Flood management to mitigate floods and minimise their damages.

- Drought management with emphasis on long-term vulnerability reduction.
- Security of water related infrastructure for the sustainable provision of services.
- Promoting appropriate technologies for rainwater harvesting in rural as well as urban areas.
- Regulating groundwater withdrawals for curing over-abstraction and promoting aquifer recharge.
- Adequate water pricing (*Abiana*) for the irrigation and proper operation and maintenance of the irrigation system.
- Promoting measures for long term sustainability of the irrigation system.
- Encouraging beneficiary participation and public-private partnerships.
- Capacity building of water sector institutions.
- Profitable use of flood water and the promotion of local irrigation practices.
- Exploitation of the vast potential of water generated through hill torrents.
- Protection of wetlands and Ramsar sites for the protection of flora and fauna.
- Stoppage of further sea water intrusion into Sindh (upstream from coastline) for the sustainability of coastal environment, flora and fauna, and mangrove growth including the use of skimming dug wells in coastal areas.
- Establishment of hydro-meteorological disaster risk reduction.
- Enhancing water productivity through infrastructure development and adoption of improved technologies in a sustainable manner.
- Climate change impact assessment and the adaption of sustainable water resources development and management.
- Promoting research on water resources related issues of national importance and building capacity/delineating roles and responsibilities of federal research institutions and promoting coordination among them.
- Setting major national targets for the water sector including those for water conservation, water shortage, irrigation, water treatment and drinking water. These targets can be met in consultation with the provincial governments

and reviewed periodically for inclusion in the 12th and 13th Five Year Plans.

National Water Vision 2025

In addition to the aforementioned legislative frameworks that govern the management of water in Pakistan, the government also outlined a National Water Vision which suggests certain water related targets that need to be achieved by 2025. It states that Pakistan should have adequate water available through conservation, development and good governance, for the entire population to use. It also states that the water supplies should be of good quality, equitably distributed, to meet the needs of all users through an efficient and integrated institutional and legal system that would support economic and social development with due consideration to the environment, quality of life and the economic value of resources.[131] The major objectives of the Water Vision are detailed below:

- To prevent future water shortages.
- To adapt according to the predicted climatic changes.
- To minimise the occurrence of droughts.
- To increase the capacity of multiple through the process of desilting and develop new storage paraphernalia to cater for future needs.
- To generate 16,000 megawatts of hydropower to minimise loadshedding.

Chapter 3

Pakistan and the Need for Hydro Diplomacy

Hydro diplomacy has been one of the most popular buzzwords in the current peace and conflict discourse, as water-related hazards continue to grow at an unprecedented level, affecting the lives of millions of people all around the globe. The United Nations General Assembly declared the year 2013 as the "International Year of Water Cooperation (Diplomacy)."[132] The preamble of the resolution recognises the connection of water to human security and sustainable development as follows: "Emphasizing that water is critical for sustainable development, including environmental integrity and the eradication of poverty and hunger, indispensable for human health and well-being, central to achieving the Millennium Development Goals and is a powerful incentive for cooperation and dialogue."[133]

Defining Water Diplomacy

Although around 71 per cent of the Earth's surface is water, but, only three per cent of it is fresh water, most of which is unevenly distributed and subject to great variability thereby affecting the socioeconomic development around the globe.[134] While states struggle to cope with their domestic water resources, the issue becomes more complex where freshwater resources cut across national boundaries. More than 260 major rivers in the world are shared by two or more states that cater to about 70 per cent of the total population.[135] As a result, issues regarding water security arise at both the local and regional/international levels. At the local level, equal access to the resource is the most pressing problem while at the regional or international level, the primary issue is of direct military confrontation based on ones claim on the resource.[136]

Since 2011, the term "water diplomacy" or "hydro diplomacy" has gained gradual prominence at various international forums and its definition varies from person to person.[137] Throughout this book, water diplomacy is understood as the tools used by policymakers to craft long-term and holistic policies geared towards solving water-related risks including trans-boundary water management between India and Pakistan. Currently, this aspect of diplomacy is missing from the foreign policies of various South Asian countries as talks over water are seldom held. As hydro-politics is going to shape the relations between major players of South Asia namely Pakistan, India, and Afghanistan in future, therefore, the only way possible to achieve the desired and shared benefits of water is through efficient water diplomacy.

This chapter aims at delineating the essence of hydro-politics through water diplomacy in South Asia. It highlights Pakistan's approach in resolving its transboundary water issues. After analysing the current state of water conflicts within Pakistan, this chapter presents a variety of frameworks through which these can be resolved. The chapter also highlights the various interprovincial differences over water in Pakistan and the importance of taking up a role towards hydro solidarity.

Hydro Diplomacy between India and Pakistan

Although the oft quoted Indus Water Treaty (IWT) exists between India and Pakistan which is lauded as a robust example of conflict management. However, water conflicts between India and Pakistan continue to emerge. It has been observed that both India and Pakistan have different approaches towards water management and while India is implementing a long-term plan of constructing a chain of hydro projects, Pakistan is lagging behind as its policy is devoid of a long-term vision and it therefore needs a new strategic push.[138] It appears that Pakistan only shows concern about the flow of water in its territory when India decides to build several dams on the western rivers namely Indus, Jhelum and Chenab which have been allocated to Pakistan under the Treaty. Electricity generation is one of Pakistan's top national priorities, and 95 per cent of the water in the Indus Basin is used for irrigation purposes.[139] Therefore, India's construction of several hydropower projects such as the Kishanganga and Baglihar dams have been seen not only as violations of the IWT but as threats to the country's economic development as well.[140]

1. The Indus Water Treaty

An article written by the former Chairman of the Tennessee Valley Authority in the Collier's magazine led to the culmination of an accord between India and Pakistan on the management of the transboundary rivers of the Indus Basin.[141] The intention was to not only ensure an adequate supply of water for both the countries without any chance of conflict but also to ease the overall atmosphere of hostility between the two riparians as a result of the partition. The IWT was signed between the two neighbours of South Asia in 1960 with the support of the World Bank (WB).[142] In addition to the framework provided by the treaty for irrigation and hydropower development, it has also survived numerous skirmishes, conflicts and escalations from both sides like the war of 1965, 1971 and the Kargil and Siachen conflicts.

The IWT designates the "Western Rivers" to Pakistan as per Article III which accounts for the Indus, Chenab and Jhelum rivers. The "Eastern Rivers" were delegated to India which accounts for Ravi, Beas and Sutlej which is elucidated in Article II of the said treaty.[143] India is under obligation to let flow of the western waters without interference except for the following limited use:

- Domestic Use
- Non-Consumptive Use
- Agriculture Use
- Generation of Hydroelectric Power

The aforesaid uses are regulated as well as restricted by further Annexes C, D, and E.

2. Disputes between India and Pakistan

Over the years, several water related conflicts have emerged between India and Pakistan such as the Salal Dam and Wullar Barrage disputes, and the more recent Baglihar dam and the Kishanganga dam disputes. The IWT provides a detailed dispute settlement clause which has been invoked by Pakistan on several occasions. For instance, a disagreement against the construction of the Kishanganga (330 MW) and Ratle (850 MW) hydroelectric power plants surfaced recently.[144] Pakistan claimed that the technical design features of the said projects were not in conjunction with the terms of the treaty as they tempered with the flow of water downstream.[145] Eventually, the WB was asked by Pakistan for the facilitation of a Court of Arbitration that would look into the schematics of the two projects. The Kishanganga project was approved by the Permanent Court of Arbitration, recognising the Indian right to build it while at the same time addressing the Pakistani concern of keeping the level of the reservoirs below the Dead Storage Level.

However, Pakistan objected to both the projects once again due to its suspicion that India was not adhering to the parameters set by the arbitrators. Although the WB has held several rounds of talks with both India and Pakistan. However, a decision is still pending. Regardless, the two projects were completed during the first term of Prime Minister Modi, at the time when the WB had "paused" the process of mediation. The explanation that came from the WB was that the step was taken in order to protect the treaty in the interest of both the parties. Accordingly, the Finance Minister from Pakistan wrote a letter to the WB arguing that India should halt construction. On the other hand, the Indian government tasked its inter-ministerial committee to propose projects that would enhance the storage capacity of the western rivers.

In addition, Prime Minister Modi has threatened to stop the flow of water to Pakistan on record with reference to the western tributaries.[146] All such developments in the post-treaty scenario indicate that India at any given time can back away from the Indus Water Treaty. Moreover, India is also working on other hydroelectric projects such as the Lower Kalnai (48 MW) and Pakal Dul (1500 MW) in Indian Occupied Kashmir on the River Chenab which would prove to be problematic in

future.[147]

Since the Indus Water Treaty is directly linked with the waters flowing from Kashmir, it is directly affected by the Indian action of the scrapping of Article 370 and 35-A. Water is not only a fundamental problem for Pakistan because of India's status as an upper riparian but the Kashmir issue is directly linked with it. In the wake of such a bold step, it would not be surprising to see if Prime Minister Modi bolstered by his Hindutva ideology scraps the IWT as well. The absence of a treaty regulating the flow of water coupled with the shrinking glaciers as well as changing weather patterns will perhaps push Pakistan to manage its water resources with India on war footings. The international community can play a direct role in resolving such disputes over water by pressurising India to consider the lower riparian status of Pakistan along with the anxieties that stem from it. Likewise, Pakistan can currently add value to the treaty since it is silent over the matter of climate change and ground water usage by both countries.

Hydro Diplomacy between Afghanistan and Pakistan

Presently, Pakistan and Afghanistan share nine rivers and their tributaries with an annual flow of about 18.7 million acre feet.[148] The Kabul River, a tributary of the Indus, accounts for about 16.5 million acre feet, while the Chitral River, which basically originates from Pakistan, contributes less.[149] This river is called Kunar when it enters Afghanistan. It joins the Kabul River near Jalalabad before re-entering Pakistan.[150] Efforts to build a consensus between Pakistan and Afghanistan in the wake of Pak-Afghan track II water diplomacy to date have not been very successful.[151] Although several factors have contributed to the recent water crisis, but population growth and climate change have brought about the highest depletion rate of water resources in both countries. The Indus River system gets more than 15 per cent of its water supply from the Kabul River and no water related agreement with Afghanistan exists which could help both the countries secure and regulate these flows.[152] The looming shadow of water stress has created a situation where there is a need to learn from and apply the lessons of international water negotiation frameworks and principles in the context of the Pak-Afghan region.

Both Afghanistan and Pakistan lack an institutionalised framework of cooperation over water concerning mainly the Kabul River. In order to avoid conflict over the shared water resources with Afghanistan, hydrodiplomacy can provide a pathway to work towards a robust water treaty covering all areas of water use. Several efforts have been made on the part of both the countries to reach an agreement over the water issue such as an initiative by Pakistan's Federal Flood Commissioner in 2003 for reaching a water treaty with Afghanistan. However, such efforts could seldom materialise into what was desired.[153] This failure presents a clear picture of history froth with conflict and absence of cooperation between the two countries not just on water related issues but others as well.

1. Indian Hydro Projects in Afghanistan

It is imperative to gauge India's pro-active posture with regard to hydro diplomacy in its neighbouring countries, particularly Afghanistan. India has already invested $1.5 billion in the north western region of Afghanistan for the development of hydro-projects on the Kabul river. These include the construction of 14 small and medium sized dams having a total storage capacity of 7.4 million acre feet. The WB also provided $7.079 billion for these projects.[154]

The dams that are likely to impact Pakistan's water flow are planned for the lower Kabul sub-basin, including the $442 million Sarobi project with the capacity to store 324,400 million acre feet of water and the Laghman project with a storage capacity of 233,568 million acre feet in Afghanistan.[155] Widespread Indian investment in water projects throughout Afghanistan is a sign of Indian dominance in the region which is not just confined to Pakistan. India has been involved in several water related disputes with its neighbours including one over Farakka Barrage with Bangladesh and another over Mahakali with Nepal.[156]

In light of the aforementioned scenario, it can be deduced that all South Asian countries are eagerly waiting for strong water diplomacy that can provide solutions to all water related disputes in the region. The scope of this chapter has been limited to the role of water diplomacy with reference to India and Afghanistan only, because currently, these two countries are co riparians with reference to Pakistan. Building on the need for a robust water policy, the following rubrics will provide a few pointers that will need to be considered by Pakistan for the formulation of such a policy.

China's Water Grab and its Future Implications

China is on a mission to build the World's longest and most advanced tunnel to transport water from the Yarlung Tsangpo River in Southern Tibet to the Taklamakan desert in Xinjiang. This 1000 kilometres long tunnel which goes by the name of South-North Water Diversion Project (SNWDP) has been the cause of great tension between China and its downstream riparians.[157] The tunnel has the potential to divert significant amounts of water from the Yarlung Tsangpo River called Brahmaputra River in India, which holds great importance for India.

"China is engaged in the greatest water grab in history," according to Brahma Chellaney, a geopolitical analyst from India.[158] The global conflicts over land have now moved on to water, which is no more a finite resource as it is being depleted at an unprecedented rate. China is not only constructing mega projects on its rivers but, is also financing various mega dams in other countries like Malaysia (Bakun Dam), Cambodia (Kamchay Dam), Laos (seven-dam cascade on the Nam Ou River)

and even Pakistan.[159]

All the major rivers originating from the Tibetan plateau - Yellow River, Mekong River, and the Brahmaputra River - have multiple hydrological projects being built on them by China. This chain of hydel projects is going to give China the ultimate control over water that is good for approximately 40 per cent of the global population.[160] The consequences of building these dams are going to be disastrous and what makes the situation more worrisome for the rest of the world, especially India, is the lack of transparency surrounding the data related to these dams which makes it impossible to calculate the impact which they will have on the downstream riparians.[161]

The Chinese mega hydro projects and water policies have the potential to disrupt international diplomacy as it is known to pay little heed to the environmental impacts of its economic endeavours as they take precedence over all other issues. Since the concern for the environment is secondary, it also determines how this influences China's implementation of its water policies.[162] If the current policies keep being implemented with a complete disregard for the environment, the consequences could be grave, especially for India which is already facing water scarcity. India will ultimately divert water from the rivers allocated to Pakistan under the IWT which would reduce flow downstream and thereby give rise to further conflicts in future. China's water diversion from the Brahmaputra River would also have harmful impacts for Bangladesh as it can face droughts and famine in some parts.[163]

Pakistan should include hydro diplomacy in its foreign policy to engage both China and India in water dialogue if extreme water shortages are to be avoided in future. The Pakistani government under the provisions of the IWT should ask India for any dam related or water related data on the Jhelum, Chenab and Indus Rivers as India is compelled to provide Pakistan with data related to any infrastructure which is being planned on them. With regard to China, Pakistan should welcome its assistance with any dam related projects and include water related provisions in the China Pakistan Economic Corridor (CPEC) as well. Currently, the CPEC project in Gwadar, Balochistan, which was said to bring about prosperity in the province has not borne much improvements in the living standards and the local people continue to feel deprived and uninvolved. Water is limited in most parts of the province and people have to rely on tankers for the daily provision of drinking water. In order to stop the condition from deteriorating further, serious dialogue between China and Pakistan is required to resolve the issue of water provision in Gwadar and the Balochistan province at large.[164]

Interprovincial Differences over Water in Pakistan

According to a study, the probability of conflicts within countries is far greater and riskier than the chances of conflict across borders.[165] In Pakistan, there is a long-standing debate on the issue of the distribution of available water among

the four provinces of the country. These issues need to be addressed to chalk out an appropriate strategic plan for the future. There have been several occasions when the provinces showed mutual goodwill and accommodated the other in the resolution of long-standing disputes. The construction of Kotri, Taunsa, and Gudu Barrages on the main Indus River after independence was the result of such goodwill and cooperation.

Similarly, the Water Apportionment Accord (1991) was a major breakthrough and a turning point in the history of Pakistan as it advocated national consolidation.[166] The apportionment agreed upon under the 1 991 Accord, thus, provides a total allocation of 55.94 million acre feet of water to Punjab, 48.76 million acre feet of water to Sindh, 5.78 million acre feet of water to Khyber Pakhtunkhwa (former North West Frontier Province) which was additionally entitled to three million acre feet of water through civil canals above the rim stations, and 3.87 million acre feet of water to Balochistan.[167] The Water Accord also accounted for both surplus water through flooding and future water storages in which 37 per cent of water was to go to Punjab and Sindh, 14 per cent to Khyber Pakhtunkhwa and 12 per cent to Balochistan.[168]

Even though this water accord was adopted in 1991, all provinces are still at loggerheads over the distribution of water in Pakistan. Mainly, the interpretation of Article 6 and Section 14b of the Water Apportionment Accord that deal with the construction of additional water storages and describe the mode of sharing storages among the provinces remain the bone of contentions.[169] The main contenders over the issue of the equitable distribution of water are Punjab and Sindh and their water rivalry is rooted in the lack of trust between them. Years of negligence coupled with a pugnacious attitude has placed Pakistan amongst the most water stressed countries of the world.

1. Hydro Diplomacy as a Source of Provincial Harmony

Provincial rivalry over the issue of water in Pakistan can only be resolved properly if effective long term and short term efforts are adopted to ensure the equitable distribution of water. However, before any comprehensive policies could be chalked out it is important to build trust among all provinces under the aegis of hydro solidarity for them to air out their grievances and work together for better solutions so that all water related disputes could be handled in a peaceful manner. Here the role of transformative and active listening cannot be downplayed as the need of the hour is to understand the apprehensions of the other side instead of strict adherence to one's own personal claims only. Pakistan must utilise the peace building potential of water which has the power to bring all stakeholders to the negotiation table, to tackle all water related disputes either with reference to its neighbouring countries like Afghanistan and India but to also settle all inter provincial water related conflicts within the country as well. This is the only viable approach through which Pakistan could become a water sufficient country in future.

In this regard, the government needs to reassess its foreign and domestic policies over the following four principles of effective negotiation:

- Separating the people from the problem,
- Concentrating on interests, not positions,
- Developing options that benefit both sides, and
- Insisting on using some objective criteria for evaluation.

The Need for a Robust Water Policy

Pakistan has not made adequate investments to secure water for its future use and it is high time that the government must envisage a plan to not only tackle its transboundary water issues with India through hydro diplomacy but also devise a robust system of water management domestically as well. In addition, it is also important to factor in the impacts of climate change which are creating a similar set of challenges for all South Asian countries which border the Himalayan-Hindu Kush regions and stretch from the Bay of Bengal to the Arabian Sea. Climate change is not only posing serious threats to food security and developing economies, but it is also increasing the risk of migration and extreme events, including floods, droughts and heat waves. In this regard, getting Pakistan's due share of water under the IWT is one side of the coin, the other side includes how efficiently and judiciously hydro diplomacy is used in the regional context to put into action a broad network of policies that would ensure a hydrologically secure South Asia.

Pakistan's future strategy for hydro diplomacy should be based on the following factors:

- A proactive assessment of the potential impediments,
- A careful selection of confidence building measures to address these impediments,
- A critical appraisal of the sensitivity of time for the execution of said initiatives, and
- An avoidance of provocative statements.

Transboundary water issues can only be settled between Afghanistan, India and Pakistan, through cooperation and adequate trust building. The way forward for overcoming the said hindrances in the way of water diplomacy need confidence building measures that entail the following steps:

- Establishing favourable conditions for dialogue and continuous interaction,
- Sharing of human and institutional capacities, and
- Encouraging joint ventures.

The following paragraphs will highlight the prospects of "Blue Peace" through water diplomacy within the conflictual landscape of South Asia.

'Blue Peace' through Water Diplomacy

The Blue Peace is an initiative where water experts, policy analysts, academics, the media, and political leaders from the Middle East – Syria, Iraq, Jordon, Lebanon, Israel, Palestine, and Turkey – came together in an effort to harness and manage a collaborative approach to find solutions for sustainable water management in the region. Consisting of several short, medium, and long term recommendations, the Blue Peace Initiative proposes seven principles of cooperation for establishing a council that will take steps for sustainable water management to avoid further conflicts over water and create new opportunities for regional cooperation.[170]

Water diplomacy has the potential to bring about 'Blue Peace' in South Asia by establishing an environment conducive for all the riparians to air out their grievances in the quest for finding viable solutions to multiple issues. The case study of 'Blue Peace Middle East' suggests that water can be used as a tool for cooperation as it has been used in the Middle East. This report provided interesting insights such as the fact that those countries in the Middle East which managed shared water resources through diplomacy had lesser chances of going to war with each other.[171] Blue Peace aspires "to create a link between security and development" and to "enhance regional water management, empowering the broader underpinning for peace in the region."[172] Today it is operational in several regions of the world giving rise to a shared political vision for water management supplemented by technical cooperation.

Despite the obstacles being faced by the Blue Peace agenda, its managing committee and policy advisory committee along with government officials, experts, and media leaders from Turkey, Syria, Jordan, Iraq, and Lebanon are working together to curb their water related exigencies. The Blue Peace initiative has introduced a new way of thinking about water in the Middle East, challenging the conventional pessimistic and alarmist approaches to treat water as an opportunity for peace and development. Pakistan should also glean important lessons from the Blue Peace Initiative and revaluate it in light of the domestic political climate of South Asia so that the region could become hydrologically secure.

The International Water Law Framework

International recognition of the importance of water in international relations and the need for cooperation to effectively manage international rivers has resulted in the culmination of the International Water Law Framework. The framework sets out certain principles derived from international conventions and treaties including the Helsinki Rules on the usage of water from international rivers (1966), the Convention on the "Law of Non Navigational Uses of International Watercourses" (1997) and "International Customary Law" applicable to transboundary water bodies.[173] The following Principles of the International Water Law Framework provide precautionary measures and safeguards in terms of any impending conflicts over transboundary water issues:

- Principle of equitable distribution;
- Obligation not to cause significant harm;
- Principles of notification, consultation and negotiation;
- Principles of cooperation and information exchange; and
- Emphasis on the peaceful settlement of disputes.

Pakistan could combine the above mentioned safeguards with the major tenets of the Blue Peace Initiative to come up with a framework that would be both politically viable and easy to implement. Although the Indus Water Treaty enshrines some of these provisions such as the emphasis on the peaceful settlement of disputes which has been invoked several times along with the principle of information exchange, the political climate of the region makes it almost impossible to implement them in the spirit of water diplomacy. This is where blue diplomacy can come into play. Just like it brings together multiple stakeholders in the Middle East, it can also do so in South Asia.

Water for Sustainable Development

A Conference on Water was organized jointly by the Government of Tajikistan and the United Nations in order to facilitate the implementation of the International Decade for Action "Water for Sustainable Development" (2018-2028) which was endorsed by the United Nations General Assembly resolution 71/222 on December 21, 2016.[174] The primary goal of the Conference was to undertake a comprehensive discussion of the way the action plan would be implemented at the global, regional, and national levels along with the development of practical recommendations for the implementation of sustainable development goals and targets related to water resources.

The conference also focused on the ways in which the member states along with the relevant UN agencies and other partners including the private sector could contribute in order to support the implementation of the 2030 Agenda. President Mamnoon Hussain represented Pakistan at the conference which delineated the government's seriousness about the need for an integrated water management approach.[175] The speakers at the conference urged the participants to develop appropriate tools and build institutional and human resources to mitigate the risk of absolute water scarcity which is a problem that transcends boundaries. This conference exhibited global concern over the issue of water scarcity and the presence of a large number of delegates from different countries showed the integrated efforts of the world geared towards tackling a common issue.[176] Keeping in line with the theme of the conference, Pakistan should implement the pledges that it made at the conference.

Chapter 4

Pakistan's Water Storage Potential

The significance of water and the critical effects embedded in the fear of its unavailability and obstructed access have been subject to extensive debate in the recent times. Though a major pressing issue in all of these debates has been the need to establish the threatening depletion of water resources, there are contesting strands when it comes to judging the seriousness of the issue. For some experts, the exhaustion of water resources is not as emergent as it has been implied over the years and that the entire case of water crisis in Pakistan rests in the ineffective and poor management of the available water resources. For others, water crisis is one of the most critical issues which must be treated as a distinct policy area so that the utter seriousness of the matter could be attended to.

It is important to mention here that the policymaking institutions in the country have substantially tried to tend to the seriousness of water issues and its potential threats. The said attention has been evidently manifest in the commitment of the Government of Pakistan to global initiatives such as the Millennium Development Goals (MDGs) followed by the Sustainable Development Goals (SDGs). Regardless of the pace of progress, Pakistan's engagement with issues such as environmental degradation, climate change, and water crisis in the recent past alongside the government's concerted efforts to familiarize the policy makers with the criticality of all the aforesaid issues stands commendable.

Despite contesting debates on the issue of water crisis in Pakistan, this chapter focuses on the strand that designates the water crisis as a reality thereby asking for immediate attention. It takes into account the unquestionable significance of the potential threat rooted in water related issues and discusses the available water resources that Pakistan is currently dependent upon. Whilst doing so, it ardently emphasizes the need for better and alternate storage mechanisms in the country to ensure a well-regulated system of water management in the years to come before the available resources have been completely exhausted. An added objective of the chapter is to look into the existing water storage mechanisms and their efficacy in delivering the purpose of resourceful water storage. At this juncture, it is equally important to stress that since climate change and water crisis are inherently linked to each other and because one does have substantial impact on the other, the scope of the chapter also includes attending to the triangular concoction of environment, water and climate change by proposing better storage options.

The Current State of Water Dependency

Apprehensions surrounding the unavailability or scarcity of water resources have surfaced at the world stage in the recent past. The fear of water shortage in Pakistan is further exacerbated considering the agrarian nature of the country's economy and the limited sources of fresh water that Pakistan is currently dependent upon. At present Pakistan majorly relies on rainfall, river flows through glacial melts along with other three water reservoirs: the Mangla dam, Tarbela dam, and the Chashma reservoir and its ground water aquifers, for its water needs.[177] Pakistan's massive reliance on the water supplied by the Indus Basin and its tributaries has not only added to the vulnerability of the Indus Basin as an eco-region but has also sparked episodes of trouble with neighbouring India. Excessive strain on the available water resources and a flawed structure to ensure effective water storage has widened the gap between the available resources and the growing demand. If Pakistan's water storage issues are not sorted out, statistics suggest that Pakistan will be amongst the highly water stressed countries of the world by the year 2020.[178]

In order to address the growing need for water supplemented by an ever-increasing population and rapid industrialisation, it is critical to take into account the arguments surrounding the water debate at present. Many concerns have been raised questioning the flawed measures of gauging the efficacy of stored water in the aforementioned three reservoirs and its sustainability for later usage. Moreover, the discourse on water-related issues in the recent times has markedly addressed the "Dam Debate" in trying to chalk out the nature and kinds of dams that can optimally end the country's woes.[179] Issues related to Pakistan's ability to store adequate water are deeply tied with the water paraphernalia being erected by neighbouring India in Indian Occupied Kashmir which serves as the entry points of two major rivers: Jhelum and Chenab. India's growing influence along the Line of Control and its projects like the Kishanganga and Baglihar are interfering with the amount of water which reaches Pakistan.[180] Therefore, it is important for Pakistan to both engage India in water related dialogue and simultaneously implement a comprehensive strategy on water storage which has become more critical given India's stance as an upper riparian.

Moreover, given the role played by water in the agricultural and industrial sector, Pakistan needs to establish better and more effective storage mechanisms, keeping in view, the rapid increase in its population along with the rapid rate at which its available resources are being exhausted. The current state of affairs when it comes to water management is also deeply entrenched in the recently realised impacts of climate change and environmental degradation. Pakistan must seriously realise the fact that most of its major water sources such as rainfall now come with a cost. With a change in the pattern of monsoon rainfalls driven by climate change and environmental degradation, there is unpredictability in the potential quantity of water which can be stored. A similar situation confronts Pakistan in terms of the water obtained through glacial melts which constitutes one of the major water

sources for the country. In the wake of climate change characterised by uncertain periods of heat waves (and cold waves as well), the water from the glacial melts also come with a potential threat of flash flooding spelling disaster for the adjoining settlements. As of recently, Glacial Lake Outburst Floods (GLOFs) have become a major concern in the Gilgit-Baltistan region of the country.[181]

Same is the case with erratic rainfall patterns and the amount of usable water that goes to waste given the unavailability of a proper mechanism to store it for later use. Hence, in terms of developing effective water storage mechanisms, Pakistan needs to take into account the consistent realities such as that of climate change and environmental degradation since the debate regarding the need for dams is far from implementation. Whereas, dams are necessary for water storage purposes, however it must be noted that building new dams in Pakistan constitute a long-term exercise which requires a great length of time along with a continuous flow of financial resources. In addition to the construction of dams, other feasible and pragmatic means for water storage should also be considered which would ensure better service delivery and water availability.

Suggestions for Better Storage Mechanisms in Pakistan

The following rubrics outline a few strategies that can be used to provide better storage mechanisms for water in Pakistan.

1. Utilising Glacial Waters

For a start, UNDPs initiative to tend to the GLOFs through the planning of a Risk Reduction mechanism is laudable.[182] The initiative aims to effectively use the waters of the glacial lakes before they turn into uncontrollable floods and result in the destruction of human settlements and cropland. The said project is worth $37.5 million and is supposed to conclude in 2022 with the construction of spillways, alternate drainage systems, ponds and small dams on the glacial water passage in order to avert the chances of a disaster and also to put the glacial waters to effective use.[183] For its northern strip and the waters pouring in from the glacial melts, Pakistan must initiate similar projects on its own in order to save the glacial waters to be optimally utilised whilst minimising any damaging factors.

2. Building Small Dams

The biggest concern in terms of dams in Pakistan is the issue of sustainability in water storage. At present the available dams do not have the capacity to store water beyond a period of 30 days. This inability to store water beyond a period of 30 days is based on the issue of rapid sedimentation. As the issue with sedimentation cannot be addressed out rightly, Pakistan must look towards building multiple small dams on its water passages. The small dams will act as alternate sources of water storage in times of severe water shortage. It must be understood that the construction of small dams does not undermine the need for the construction of large dams which are an immediate requirement for Pakistan. It does mean, however, that given the time and finances required for the completion of larger dams, it is viable to invest in the construction of small dams, particularly in countries like Pakistan which can cut both in half. In addition to building small dams, it is also important to expand their command areas so that the gap between the irrigation potential and the actual usage of water for irrigation could be minimised. The need to build small dams has been elaborated further in the last chapter of the book.

3. Utilising Wastewater for Industrial Purposes

The core issue that Pakistan needs to pay attention to is not just of water storage but also of devising an efficient system of water management. In this regard, Pakistan can conveniently borrow from South Korea where wastewater is stored in order for it to be used for industrial purposes.[184] Pakistan must also consider using a similar option with an engagement plan that urges the private companies to invest in and set up wastewater managing filters. Such a move shall also prove critical in terms of establishing a sense of re-using the water that can sufficiently serve the needs of the people at a given time. South Korea is effectively using its wastewater management plants and has relied upon cleansed wastewater to cover for its major water needs.[185]

Rainwater Harvesting

Rainwater harvesting (RWH) is understood as a societal adaptation to climatic fluctuations. The process limits surface run-off of rainwater by collecting and storing it in surface and sub-surface aquifers. The accumulated rainwater can be consumed for both potable and non-potable purposes, however, it is more frequently used for non-potable purposes. RWH holds the potential to play a pivotal role in combating water scarcity, mitigating the effects of flooding and limiting land degradation.

RWH is practiced across different parts of the world via different techniques including:

Recharge Shafts: Most cost-efficient technique that involves storage of rainwater in manually dug shafts in more permeable soil below the top impermeable strata, not necessarily touching the water table.

Dug Well Recharge: Involves the use of already existing, abandoned structures for recharge. Stored rainwater is passed through filter chambers to ensure silt-free water.

Subsurface Dykes/Ground Water Dams: Involves the storage of water by building subsurface barriers across the stream which retards the base flow, storing water below the ground surface.

Rooftop Recharge: Involves the storage of rainwater in vessels installed on rooftops.[186]

However, the variability of precipitation throughout the year makes RWH an unreliable source of water supply.[187] Moreover, harvesting requires stringent purification and filtration of the accumulated water, thereby rendering the process costly and labor-intensive. In Pakistan, RWH is most commonly practiced in the northern parts of Khyber Pakhtunkhwa, where the climate is humid and precipitation levels are usually high. Cities in northern Pakistan like Ayubia, Nathiagali, and Batgram primarily depend on RWH for potable water consumption with rooftop discharge being the most common technique being employed.[188]

Hill Torrent Runoffs

Hill torrent is a distinct waterway that drains rainwater from hills and mountain-tops to downward plains. The runoff, due to its downward trajectory acquires high speed and in several cases damages local settlements and infrastructures as well. Hill torrents are further classified into perennial and non-perennial hill torrents. In Pakistan, hill torrents are called *Rod Kohi* which cover about 65 per cent of the total land area.[189] In Punjab, a number of hill torrents originate from the Suleiman Range. In Khyber Pakhtunkhwa, hill torrents are usually called *Zams* which are mainly found in Dera Ismail Khan division. Some of the principle *Zams* in Khyber Pakhtunkhwa include: Gomal, Tank, Daraban, Choudhwan, and Sheikh Haider. In Balochistan, hill torrents are called *Salaiba* and are mainly located in the Eastern Suaiman Range, Khurasan Range and the Central Brahui Range.

Currently, a very small proportion of hill torrent run off is locally utilised by the populace, that too in personal capacities. Water experts suggest that an efficient management of hill torrent runoffs can potentially lead to effective water utilization in Pakistan. At the moment, spate irrigation is the second largest source of irrigation after canal water irrigation in Pakistan. This method of irrigation is considered to be both environment-friendly and energy-efficient which leads to an organic farming produce.[190] It is suggested that Balochistan has the largest potential to utilise hill torrent runoff, specifically in the Kachhi Basin and the Kirther Range.[191] Apart from Balochistan, Dera Ghazi Khan in Punjab, Hazara and Bannu in Khyber Pakhtunkhwa, and Sehwan and Pitaro in Sindh also hold the potential for spate irrigation.[192]

Research carried out by the National Engineering Services Pakistan (NESPAK) and Japan International Cooperation Agency (JICA) delineate the high potential of using hill torrents in piedmont areas, but, due to the erratic nature of floods, the utilisation of this land for various economic activities is quite low.[193] Practically, the Pakistan Agriculture and Research Council (PARC) has suggested and implemented several techniques to enable an effective management of *Rod Kohis*. Some of which include the remodeling of *Rod Kohi* conveyance irrigation, the restructuring of water

diversion and distribution structures, and the development of cost-effective water application mechanisms.[194]

Chapter 5

Climate Change and Pakistan's Water Security

Over the past few years, concerns have grown regarding the impact of climate change on Pakistan's depleting water resources. In the last two decades, although Pakistan's greenhouse gas (GHG) emissions have doubled, but, its share in the total GHG emissions is only 0.8 per cent and it is ranked 135th in the list of global emitters of GHG.[195] From 1997 to 2016, Pakistan faced 524,000 deaths in more than 11,000 extreme weather events and suffered losses amounting to around $3.16 billion.[196] On both short and long term indexes, Pakistan is repeatedly affected by extreme weather events. For example, super floods in 2010 caused the country a loss of $25.3 billion amounting to 5.4 per cent of the total Gross Domestic Product (GDP).[197] This chapter explains how variations in climate change are impacting the water resources in Pakistan thereby understanding its impact on the various sectors of the Pakistani economy as well. The chapter further highlights the future scenarios for Pakistan if such issues are not dealt with in an effective manner.

According to various studies, almost 23 per cent of the Pakistani land and nearly 50 per cent of its population is at risk due to the impacts of climate change.[198] The Asian Development Bank estimates that climate change may cost Pakistan more than two per cent of its total GDP per annum by 2050.[199] In an HSBC report issued earlier this year, Pakistan has been ranked as the second most vulnerable country to climate change.[200] The per capita annual water availability in Pakistan has drastically dropped to 935 cubic meters from 1,500 cubic meters per capita in 2009.[201] In other words, the country is on the brink of water scarcity.

Climate Change and Water Resources

Climate change is mainly impacting the water resources in Pakistan in the following ways:

1. Rising Temperatures

The annual mean temperature is expected to rise by three to five degrees centigrade by the end of this century.[202] Rise in temperature will lead to water shortage thereby causing a decline in hydropower generation and yields of wheat and rice crops. Due to extreme heat waves, the mortality rate will also increase. In the past 30 years, the number of heat waves per year has increased nearly by five folds.[203] During the last 60 years, both south western Pakistan and Northern Pakistan have seen two degrees centigrade and 0.5 degrees centigrade increases in average temperatures.[204] In April last year, 50.2 degrees centigrade was experienced in Nawabshah, the hottest temperature ever recorded anywhere in the world for that month.[205] According to the estimates of think tanks such as Germanwatch, more than 10,000 Pakistanis have died from extreme weather in the past two decades.[206]

According to the World Bank's report titled "South Asia's Hotspots: The Impact of Temperature and Precipitation Changes," Sindh, which is the country's second largest economy, has been identified as the most vulnerable hotspot which will suffer from changes in living conditions due to fluctuations in the average weather, followed by Punjab. The top hotspot districts in Sindh are identified as Hyderabad, Mirpurkhas, Sukkur, and Larkana. Punjab contributes 53.3 per cent to the national GDP and has the lowest rate of poverty among all provinces. In Punjab, Lahore, Multan, Faisalabad, Bahawalpur, Dera Ghazi Khan, and Sargodha have emerged as the main hotspot districts.[207] The report warned that long-term climate vulnerability will have implications for overall growth in the country.[208] It also stated that as the hotspots tend to have lower living standards compared to the national average, so, changes in average weather will hurt poor households and will increase poverty and inequality.[209]

2. Increasing Sea Water Intrusion in Coastal Areas

According to the Asian Development Bank, the sea-level in Pakistan has risen by 10 centimetres (four inches) in the past 100 years.[210] The sea water intrusion is continually moving towards the coastal belt of Sindh. It is reported that the rate of sea water intrusion is 80 acres per day and 38 per cent of the mangrove forests have been removed in the past 20 years. Such an intrusion is converting the fertile soil into infertile land. As a result, the overall ecosystem of the Indus River Delta has been disturbed.[211]

By 2100, the sea is expected to rise by 60 centimetres and this expected rise does not factor in land sinkage due to groundwater exploitation, the weight of buildings, etc.[212] In 2015, Pakistan's Standing Committee on Science and Technology claimed that the riverside cities of Badin and Thatta could go under water within 30 years.[213] The committee also claimed that Karachi could also disappear by 2060.[214] All these cities are facing grave threats because they are low-lying regions, thus, are more vulnerable to continued sea-level rise. Moreover, the continued erosion of the Indus delta as a result of unplanned coastal development has also made matters worse.[215]

3. Changes in Rainfall Patterns

According to the monsoon rainfall distribution analysis carried out by the Pakistan Meteorological Department in mid-2017, it was reported that over the past three decades climate change has resulted in a 100 kilometres spatial shift towards the

west with reference to the overall monsoon pattern in Pakistan.[216] Apart from a spatial shift, there is also a seasonal shift in the rainfall distribution patterns. The summer monsoon now occurs from July to August whereas the winter rains have shifted towards late February and March.[217]

According to the data collected by the Pakistan Meteorological Department, change in rainfall patterns has had a two-pronged effect. First, more rain is being experienced in shorter time periods which is causing flash flooding. Second, scanty rainfall is being experienced for longer periods of time, resulting in droughts.[218] Through a rigorous analysis of rainfall patterns, it can be concluded that the number of rainy monsoon days have shrunk. In the previous two decades, monsoon rains lasted from July to September. However, now the rains last till August and their intensity has also increased. Hence, the intensity of these rainfalls is now the leading cause of flooding in Pakistan. During the first five months of last year, Pakistan saw a 45 per cent average decrease in rainfall as compared to the average precipitation that the country normally receives from January to May.[219] Such a decrease resulted in dry conditions within the southern parts of the country which caused serious water stress mostly for the agricultural sector.

4. Excessive Floods and Droughts

Experts anticipate that storms will worsen in future thereby causing damage to the infrastructure along with massive flooding. From 2010 to 2015, the country has suffered from five massive floods which caused an economic loss amounting to $18 billion.[220] Apart from these economic losses, 38.13 million people were also affected along with 3.35 million houses that were severely damaged, and 10.43 million acres of crops that were destroyed with the topsoil being eroded in the process.[221]

On the other hand, longer spells of drought are also a consequence of climate change. Droughts in the country have occurred mainly because of extreme variation in monsoon rainfalls. Due to arid and hyper-arid climate, some regions of Pakistan remain dry throughout the year, making them vulnerable to drought. Pakistan has suffered severe droughts in its southern region like Tharparkar periodically between 1998-2002 and 2014-2017.[222] In future, droughts will intensify owing to three main factors: melting of snow and glaciers, increasing water demand and high rate of evaporation due to higher temperature and erratic monsoon patterns.

The continuation of droughts in Pakistan has been affecting the Indus Basin since the 19th century. According to the Economic Survey of Pakistan, drought has been identified as one of many factors behind the stagnant economic growth of the country.[223] In recent years, droughts have led to a rise in subnational conflicts within the country. For example, people of Quetta face a water shortage of approximately 20 million gallons per day. Similarly, 21 million Karachiites routinely get only half the UN-recommended daily water allocation.[224] Tensions will continue to rise if the expansion of irrigation canals along with their lining does not take place. The

average temperature of Pakistan is predicted to increase by two to three degree Celsius by 2045. It is also predicted that the intensity and severity of droughts will increase, along with the variability in monsoon rains.[225]

Other Impacts of Climate Change

The following rubrics delineate the widespread impacts of Climate Change on the Indus Water Basin and other entities within Pakistan.

1. The Hydrological regime of the Indus Basin

According to the short-term and long-term modelling results for the impact of climate change on the hydrological patterns of the Indus River Basin, the significant differences in water flow will not be experienced until after 2100.[226] In the near-term, the most likely change to occur is a shift in the timing of peak flow which will come earlier in the year. Such a shift can be expected to have grave implications for agricultural production in Pakistan. For example, an increase in flows into the Tarbela reservoir earlier in the year will increase the volume of water available to support irrigated agriculture throughout the basin. However, shifting peak flows could undermine the current balance between agricultural production and energy generation. As per the recent analysis, discharge due to glacial retreat, could significantly increase between week 14 and 25 of the calendar year, which coincides with the onset of the growing season.[227] Similarly, rise in temperature could lead to peak energy demand earlier in the year, potentially leading to conflicting water demands because of Pakistan's inadequate storage facilities.

2. Energy Sector

Pakistan's energy sector faces several continuous crises, which are due to power outages, cuts and rotational load shedding. The country mainly relies on oil and natural gas for power production. Pakistan's total energy mix constitutes 80 per cent energy from fossil fuels such as coal, natural gas, and oil, 2.5 per cent hydropower, 5.8 per cent nuclear power, and 10.8 per cent from other sources, which include wind, solar and biogas.[228]

Thermal power production is sensitive to the climate due to its high dependence on water resources and sensitivity to temperature changes. The thermal power plants generate electricity by converting heat into power. This process consumes large amounts of water for cooling purposes.[229] The projected increases in air temperature may affect the power plants by decreasing their efficiency and resulting in a loss of electrical output.

The hydroelectric generation capacities and water supplies could potentially be affected depending upon the expected lifespan of the newly installed dams, the progressive loss of glaciers and its potential impacts on water flows in the Indus

River in the 2100s. However, reduced availability of water supply in the Indus River Basin does not appear to be a significant threat in the near future. Run-of-the-river hydroelectric projects that generate electricity by using part of natural stream flows and natural elevation may be more sensitive to the changing flow patterns, which will be impacted by monsoon patterns, glacial and snow melt.

3. Agricultural Sector

Pakistan has an agrarian economy and about 38.5 per cent of the total labour force is associated with the agriculture sector.[230] According to the Economic Survey of Pakistan 2018-2019, the agriculture sector grew by 0.85 per cent which is much lower than the target of 3.8 per cent mainly due to insufficient availability of water. The crops sector experienced a negative growth of -4.43 per cent against the target of 3.6 per cent with a sharp decline in the growth of important crops by 6.55 per cent. Individually, sugarcane production declined by 19.4 per cent, cotton by 17.5 per cent and rice by 3.3 per cent, while the production of maize crop increased by 6.9 per cent and wheat by 0.5 per cent.[231] The agriculture sector is highly dependent on the Indus River and its tributaries from which it draws about 90 per cent of its water.

The agricultural sector in Pakistan is climate-sensitive and highly vulnerable to increasing variations in weather patterns and climate change. In other words, the impact of climate change on the agricultural sector can act as a barrier in achieving food security and alleviating poverty in the country. Several studies indicate that the production of major crops has been significantly impacted due to scanty rainfall along with a 0.5 degrees Centigrade increase in temperature across the country within the past three decades.[232] Moreover, variations in the frequency and intensity of both droughts and floods over the period of 1995-2017 has also adversely affected crop yield.[233] During 2018-2019, the total availability of water for the Kharif crops 2018 was recorded at 59.6 million acre feet and remained short by 11.2 per cent against the average system usage of 67.1 million acre feet and 14.9 per cent over Kharif 2017. During the Rabi season 2018-2019, the total water availability was recorded at 24.8 million-acre feet, showing an increase of 2.5 per cent over Rabi 2017-2018 and 1.9 per cent less than the normal availability of 36.4 million-acre feet.[234]

Cotton is the second largest cash crop in terms of area after wheat. It contributes about 0.8 per cent to the total GDP and contributes 4.5 per cent in agriculture value addition. Pakistan is the fourth largest producer of cotton in the world, which makes the crop an important source of foreign exchange and a main source of raw material for the textile sector. Cotton is climate-sensitive, and its yield has suffered multiple shocks over time due to multiple factors including climate change, excessive use of irrigation water and intensive pesticide and fertilizer application.[235] During 2018-2019, cotton production remained moderate at 9.861 million bales, a decrease of 17.5 per cent over the last year's production of 11.946 million bales, and 31.5 per cent against the target of 14.4 million bales.[236] Such

a decline in crop yield was due to unfavourable weather conditions, particularly the prolonged hot and dry weather that prevailed in the country as a consequence of climate change.[237] Lower cotton production levels will affect the Pakistani manufacturing industry by lowering production levels and increasing costs. The lower production levels in the agricultural and manufacturing sectors will slow the pace of development in Pakistan leading to greater societal strain as workers will attempt to find alternative income sources.

Projections indicate that the mean temperature in Pakistan is higher as compared to the expected global average i.e. 1.4 degrees Centigrade. It remains unclear how precipitation patterns and run-off from snow and glacier could change in the future.[238] It is generally anticipated however, that climate change will lead to changes in the patterns of seasonal water flow within the larger Indus River Basin, with a potential for higher run-off and river flows in the coming decades. By the 2100s, the aforesaid pattern would reverse as the Indus Water Basin will face an overall decrease in flows leading towards acute water shortages. Influenced by the changes in temperature and precipitation levels, the productivity of the following crops will decrease by varying percentages:[239]

- Wheat – eight to 10 per cent
- Rice – 20 per cent
- Maize – 20 per cent (by 2050)
- Cotton – eight to 24 per cent

As can be seen from the previous figures, the average yield of both food and cash crops will be affected by a two to four degrees centigrade increase in the mean temperatures.[240] The current crop varieties are not adaptive to high temperature and they reach maturity earlier than expected because of which a sharp decline in per acre yield is experienced in response to rising temperatures. According to a climate simulation model, rise in temperature with prolonged droughts will negatively impact the yield of fruit plants as well. In other words, impacts of climate change will be devastating for those communities that rely on their environments to provide basic food, water, and energy resources.[241]

Climate change is set to have different effects in different regions of the country. For example, water shortage could take a toll on about 20 to 25 per cent of cultivable land, rendering it unfit for agriculture. A projected increase of four degrees centigrade in temperature and three per cent rise in the rate of precipitation will result in Punjab and Sindh losing 13 per cent agricultural productivity by 2080.[242] However, wheat, maize, and rice production will increase in Gilgit-Baltistan due to longer and hotter summer seasons.

According to the Pakistan Business Council report, the agricultural sector of the country is severely underperforming which is partly linked to the current water crisis. The country produces 3.1 tonnes of wheat per hectare and 2.5 tonnes of cotton per hectare. The increasing water crisis and underperforming crop yields will critically affect Pakistan's overall food security. The declining domestic agricultural production will increase food prices and lower workers' incomes thereby adversely affecting the families' access to food. If agricultural production continues to decline on a larger scale, exports will also decline and Pakistan's reliance on food imports will increase.[243]

A Chain Reaction

Erratic weather patterns and climate change have emerged as the biggest environmental challenges that are affecting almost all the sectors of economy particularly water resources, energy, health, biodiversity with a major impact on agricultural productivity.[244] Climate change will produce a chain reaction whereby not just water quality, but the distribution of water will also be affected giving rise to various vector-borne diseases and health-related vulnerabilities. In future, water quality will be further impacted by climate change, higher temperatures, greater occurrence of floods, droughts, heavy rainfall patterns, and climate dependent flow rate. Rapid melting of glaciers, which are expected to increase in future, will affect the water chemistry and river runoff as well.

High temperatures along with variations in extreme events like floods and droughts are projected to affect water quality as well. Floods pollute surface and regenerate ground water resources but they also deteriorate water quality and increase urban runoff. In the absence of sufficient drinking water during floods, waterborne and other water-related diseases increase due to the rapid consumption of both polluted surface water and ground water by people. Drought affects water quality because less water is available to dilute contaminated water. If the said conditions continue, more and more people will be forced to use contaminated water resources for drinking, irrigation, etc., and the resulting impact will be disastrous.

Chapter 6

Pakistan and the Political Economy of Water

Pakistan's water facilities are in a state of disintegration and the drastic change in climate has done little to alleviate the country's predicament. The shortage of water is bound to hurt the economy and the earnings from the current fiscal year, as they stand today, are in line to reflect just that. Less earning from exports will harm consumers across the country and as the crisis deepens, so will the ability of the consumers to access even the most basic necessities. Water management in Pakistan is lacklustre and it will not be able to avert the water crisis in the face of the drastically changing weather patterns. Research into the crisis and its plausible solutions have only now begun to make their way into popular discourse bringing into focus the discrepancies prevalent in water management. This chapter will elaborate on the role of political economy in the provision and distribution of water to the rural and urban areas of the country followed by the role played by various sectors in managing water or the lack thereof. Furthermore, the chapter will delve into how water shortage is going to impact Pakistan's agricultural and industrial bases which are most dependent on water.

Decentralisation of Water Management

An ineffective taxation regime is central to Pakistan's water woes. The current taxation mechanism has not only allowed landowners in Punjab and Sindh to leverage their political influence to sustain a flat tax ratio but has also led to the depletion of groundwater by 12 metres in the previous 50 years.[245] The water tax known as "*Abiana*" is similar for all land holdings regardless of size and the types of crops being cultivated. Influential landowners seldom pay taxes proportional to the amount of water that is used. It has been estimated that the federal government has issued about Rs5.4 billion to bridge the cost offsets resulting from the disproportional payment of *Abiana*.[246] The devolution of power to the provinces as enshrined in the 18th Amendment to the Constitution has emboldened landowners to act more brazenly who are thereby monopolising the water pricing mechanisms.

The provincial governments have yet to reach an agreement on a water sharing mechanism with the federal government. According to the Federal Flood Commission's Head, Ahmad Kamal, approximately 15,000-20,000 cusecs of water out of a total of 100,000 cusecs are wasted as it flows towards the Chashma, Taunsa, and Guddu Barrages.[247] The central government has expressed its disdain over the lack of consensus between the provincial governments for not curbing the

monopolistic water management practices and ensuring effective tax regulation in their respective areas.

The tax policies in certain provinces are flawed for instance, farmers in Punjab are taxed Rs85 per acre for Kharif crops and Rs50 per acre for Rabi crops.[248] This policy is illogical as different crops require different amounts of water to grow. It should also be noted that the major provincial regulatory authorities have been reprieved of their duties to manage water as the authority has been passed on to individual districts. The policy that was laid out in August 2001 took little regard of the inability of the district level management authorities to cater to the technical requirements of the formation of an effective water channelling and sanitation network.[249] In addition, "extension measures" or the lack thereof as an integral part of either the central or provincial agendas for water reform have failed to inform small farmers of how to purposefully use water on the farmlands they own. At the end of the day, farm owners with huge swathes of land and proportional political influence end up with the most gains, manipulating an already weakened economic set up at every turn.

Role of the Private Sector

"By 2025, Pakistan should have adequate water available, through proper conservation and development. Water supplies should be of good quality, equitably distributed and meet the needs of all users through an efficient management, institutional and legal system that would ensure the sustainable utilization of the water resources and support economic and social development with due consideration to the environment, quality of life, economic value of resources, ability to pay and participation of all stakeholders."[250]

The National Water Vision, part of the National Water Sector Strategy (2001) states Pakistan's long term policy aspirations.[251] Seventeen years down the lane, it serves as an effective analogy as to where Pakistan's economic approach to its water crisis stands. For one, the report fails to mention the role of the private sector in tackling an underfunded water system. From Rs33.6 billion in 2007, funds earmarked for WAPDA initiated projects have fallen to Rs17 billion in 2017-2018.[252] Synonymous with the fall in the financial appropriation is the per capita availability which is reported to be at 2017 cubic meters precariously poised to put Pakistan at an "extremely high level of water stress" by 2030.[253]

As deduced earlier, the central and provincial governments' interactions with the private sector are limited to their dealings with large farm owners who exercise a fair amount of influence on the former. Understandably so, an underfunded water sector needs new avenues of cash inflow, variably independent of the traditional political practices. This is where the private sector comes in whose primary

contribution in the agricultural sector includes land ownership and logistical management, although, the regulation of water resources for irrigation purposes is still given to the public sector.[254]

The division of liabilities in such a manner has been at the core of the private sector's reluctance to invest in agriculture. Since 95 per cent of the country's water is fed into the agricultural sector, the latter's inability to participate in its management and taxation has kept the private sector at bay.[255] The taxing procedures enforced by the district authorities, as mentioned above, fail to recover finances for new water projects. Uncertain and uncompetitive market trends owing primarily to human resource i.e. the relationship between the regulators and large farm owners, dissuade private investors from introducing innovative techniques for correcting the current market flaws in water pricing.

Since the current pricing mechanisms are subject to political interests in addition to an inherent antitrust environment that is embedded deep within the rural mindsets, the market for water pricing and provision does not work in tandem with the supply and demand curve. Giving private investors a stronger voice in the management of water resources will require breaking the hold of the big farm owners, bringing the small owners into the picture thereby introducing them to a competitive environment. Doing so, will not only enable them to be an effective part of the agricultural sector but will be a lesson in the effective management of the irrigation of resources to ensure a steady flow of profits.[256]

Unveiling Social Realities

Unemployment is set to soar in the wake of the water crisis as the agrarian sector has the largest number of employees, hence, a dearth of water would mean that farmers would no longer be able to earn their livelihoods through the cultivation of crops. High value crops such as rice and cotton involve elaborate processing techniques for export and domestic use thereby employing more people when compared to other traditional crops. As the following figure shows, employment in the cash crop sector is important for the diversification of the agrarian sector.[257] If cotton production falls due to the unavailability of water, it has the potential to trigger large scale unemployment. While its impact on the farmers is obvious, unemployment will also grow among the textile industry workers who are engaged in processing textile goods which are the most dominant exports.

Rural areas, which require a higher percentage of water to meet the agricultural output targets, are home to farmers who are not well educated. Moreover, the government has not undertaken extensive research projects to understand the social realities in rural areas with an aim to outline education programs that would teach the farmers the need for effective conservative farming. There is a dearth of literature and research available on water demand in different areas of the country. The studies that have been carried out previously neither cover

the effect of water shortage on a sectoral level nor the impact of drastic climate change patterns on water use. It is estimated that an increase in temperature by three degrees Centigrade is bound to increase the water requirement by six per cent till 2025 and by 12–15 per cent till 2050.[258] The notion that climate change can disrupt the use of water for all sectors is a concept that is yet to be discussed at the national level.

Agricultural and Industrial Losses

Khalid Idrees Rana, Spokesman to the Indus River System Authority (IRSA), outlined the urgency of the matter in July 2018 when he declared that the amount of available water had fallen from 6.81 million acre feet last year to 0.89 million acre feet this year.[259] The inability to store water has led to a 47 per cent shortage of water needed to feed the Kharif crops, cotton being the most important one of them all.[260] Cotton sowing decreased by 40 per cent in the Kharif season relative to last year making the government's goal of 14.37 million bales of cotton highly improbable. The government, despite more water being available for agriculture, could not fulfil its target of 14.04 million cotton bales last year, achieving 11.5 million bales instead.[261]

Both cotton and textile products are Pakistan's primary exports amounting to 55 per cent of foreign exchange earned in a fiscal year with raw cotton contributing $3.5 billion to the total percentage of exports in a fiscal year.[262] Though Pakistan's focus is on an import substitution approach to curb the $8.9 billion trade debt, a decrease in the production of the primary export is only going to hurt the economy more.[263] Furthermore, rice which added $1.7 billion to Pakistan's export earnings last fiscal year is expected to miss production which was targeted to be about 7.2 million tons.[264] In addition to their importance as export commodities, their domestic consumption is bound to be adversely affected as well. Being an agrarian economy, the cultivation of enough crops is important, both for consumption and export purposes. It is estimated that about 70 per cent of the country's population is directly dependent on the agrarian sector.[265]

The industrial sector will also be adversely affected by the water crisis. Although the industrial sector requires a small percentage of water, almost negligible to the amount needed to keep the agriculture sector running, it is a burgeoning sector in Pakistan that requires meticulous planning. With the onset of CPEC and an intensifying focus on expanding the industrial sector, water will have to be treated as the most important resource to keep the engines running. Recurrent protests staged by the industry workers have brought into focus the effects of water shortages on the industrial output and local employment. The production of textiles, which amounts to about 18.1 per cent of the country's exports,[266] cannot proceed without an adequate provision of water for the "dying" stage in textile production which in turn inhibits the cutting and stitching of the cloth.[267]

Looking Ahead

Pakistan's water crisis is worsening day by day and it is set to impact both the agricultural and industrial sectors. The fact that $21 billion worth of water flows into the sea due to lack of storage does not help Pakistan's case.[268] Alternatively, the excessive extraction of groundwater has reduced reserves to a dangerous extent. Lack of awareness among the agrarian community which uses the highest percentage of water also contributes to the highest percentage of water wastage owing to mismanagement. It is estimated that by 2025 water in Pakistan will be reduced by 31 million acre feet and Pakistan being a water intensive economy will require better water storage facilities to save water for future use.[269] However, improved water storage facilities alone will not address the issue of diminishing water resources rather better storage facilities shall go in tandem with the promotion of efficient water utilisation practices to feed the ever-growing population.

Chapter 7

Water Scarcity and Social Vulnerabilities in Pakistan

The provision of clean drinking water is a basic human right. Every single individual, whether poor or rich, is entitled to this resource that is critical for human development. While water security is a global issue, the developing countries, which are characterised by widespread urbanisation, over population, and excessive political interference, are facing the greater brunt of this problem. In addition to the deleterious effects of water scarcity on the economy, this chapter will expand upon the social vulnerabilities attached to this issue. In the context of Pakistan, it can be observed that the "social adaptive capacity" to deal with the scarcity of water is largely missing.[270]

In 2015, water scarcity was described to be the number one long term global risk by the World Economic Forum because of its devastating impacts on society.[271] Moreover, the 2017 statistical report of WaterAid presented facts about the situation of water availability in the world. According to the report, 522 million out of the total 663 million people who do not have access to clean water, belong to rural areas.[272] These communities face water borne diseases, malnutrition and a struggle to grow crops and feed livestock because they either live in isolated locations or because of the lack of adequate infrastructure or resources. According to WaterAid, approximately 315,000 deaths of children under the age of five are reported every year as a result of water borne diseases.[273]

According to the United Nations Water Development Report (2018), approximately 3.6 billion people around the world are living in areas where water levels are either extremely low or are being depleted at an extremely rapid rate. This means that water shortage is threatening the lives of almost half of the world's population who could be facing drought like conditions in future. Shortage of water will have serious repercussions for Pakistan's economy along with the social wellbeing of its people.[274] A rapid increase in population and urbanization means that the demand for water is going to be alarmingly high in the face of only limited supply of water. Moreover, the already limited and unpredictable water supply that is currently available in the country is at risk because of climate change and pollution.[275]

When seen from an anthropological perspective, water scarcity is not just about the depletion of a natural resource but of a social resource as well. Since water is tied with every aspect of an individual's social life, a paucity of such a resource can halt the overall development of a community.[276] Water scarcity not only causes a decrease in economic activity, but is also the reason behind the increasing conflict between societies and competition between the rural and urban regions. A lack or inability of adaptive capacity to save water or the inability to treat wastewater poses more strain on the already scarce water available for domestic consumption. This chapter highlights the different ways in which the unavailability of water affects the social aspects of life and how water has increased the inequalities in societies.[277]

Water and Health

It becomes very difficult to disseminate Water, Sanitation, and Hygiene (WASH) education to the masses as a preventive strategy against illness from water borne diseases when every drop of that water is obtained through hard worn labour, like travelling several miles on foot in the scorching heat and manually extracting water from 200 feet deep wells.[278] For people living in drought like situations, one of the biggest challenges include deteriorating health and malnutrition as a result of unclean water consumption which has for the most part, been a result of the shortage of water and the increased competition over water for use in multiple sectors. Globally, lack of clean water and sanitation facilities result in approximately one million deaths each year. Every 90 seconds, a child dies from having been exposed to a water related disease diarrhoea being the leading cause of death.[279]

Furthermore, water pollution poses a serious threat to the people of Pakistan. Even ground water in many areas contains heavy doses of arsenic. According to various studies, water pollution in the country has increased over the years giving rise to more health-related problems. Improper disposal of industrial waste, overexploitation of ground water and excessive coal mining are the leading causes of water pollution as the presence of dangerous pesticides, heavy metals, toxic chemicals and municipal industrial waste in untreated sewage water are harmful to human health and cannot be reused.[280]

More than 60 per cent of diseases in a developing country like Pakistan are a result of contaminated drinking water and the lack of better sanitation facilities. Statistics show that about 13.6 per cent of the total deaths occur due to water borne diseases like typhoid, cholera, dysentery, and diarrhoea which are not just social causalities, but are also liabilities for the country's economic development.[281]

Livelihood and Food Security

Agriculture holds critical importance for Pakistan. Being the second largest economic sector in the country, it employs 42 per cent of the entire labour force and ensures food security for the masses. The agriculture sector is also highly dependent on water, making Pakistan the biggest consumer of water in the world. But since several years, agricultural productivity has been low owing to climate change and scanty rainfall.[282] Decreased agricultural output due to water shortage is and will

further compel the poor rural farmers to migrate to urban areas which will further increase urban unemployment.[283] Currently, Pakistan is one of the most food insecure countries in Asia.[284] The beginning of 2018 saw a 45 per cent average decrease in rainfall. The dry conditions faced by the country have caused serious water stress for the agriculture sector, especially affecting the Kharif crops.[285]

The rising food insecurity has been a burden on Pakistan's human resources. Water and food stress has been taking a toll on women's health and has been the cause of undernourishment in children. According to a report by the United Nations Children's Fund (UNICEF), approximately half of the Pakistani population is malnourished including 15 per cent children under the age of five, 44 per cent of who have stunted growth, which is much higher than the global average. These statistics have not changed much since 1965, which is alarming. There have been numerous cases of extreme and violent behaviour among individuals that continue to suffer because of poverty and hunger. With a large percentage of the Pakistani population already food and nutrient insecure, water scarcity issues will only make things worse for the already vulnerable.[286]

Increasing Inequalities and Decreasing National Harmony

In an interview for UNDP, the former Chairman of WAPDA, Shamsul Mulk, said that in the absence of an efficient water policy, policymakers have always been like absentee landlords and because of this "...water has become the property of the landlords and the poor are deprived of their share."[287] Looking at the statistics from Pakistan, about 21 million people are deprived of clean drinking water and even though the study shows that the situation has improved and about 44 million people now have access to clean water since 2000, every one in five people belonging to the lower income class still faces difficulty in obtaining clean water.[288]

In an address to a local newspaper, the Chairperson of the Pakistan Council of Research in Water Resources (PCRWR) said that only 39 per cent of the total Pakistani population has access to safe drinking water, and people living in rural areas face the brunt of the matter.[289] The issue also varies from region to region, for example Balochistan and Sindh have been facing severe droughts. According to the Quetta Water and Sanitation Authority, Quetta is currently facing a water shortage of approximately 20 million gallons a day.[290] While some areas are suffering from water shortage because of climate and topography, others are suffering because of poor governance and water management. People of Karachi face difficulty every day because of shortage of water while at the same time water worth $21 billion, that could have been used by those people, washes away into the sea every year owing to the lack of a robust conservation system in the country.

Water and Gender

Water is not only causing inequalities among the social classes but is also

contributing to the rising inequalities between the two genders as well.[291] Women, especially in the developing countries, play a crucial role in the management of water but their efforts and contributions are rarely acknowledged. This is especially the case in South Asia. A typical woman living in the rural areas of Pakistan actively participates in agricultural practices along with other activities that supplement the overall crop yield.[292] After working in the fields, she also carries out basic household chores ranging from cooking and cleaning to fetching water from very distant places. Given the numerous activities that she performs on a daily basis, it is evident that the everyday routine of these "unofficial water managers" revolves around the use of water. It is estimated that women and children in both Asia and Africa walk about six kilometres daily in search of water on top of all other duties which they perform.[293]

Children, especially young women, who accompany other older women in carrying water to their homes means that they miss school to serve the family needs. The scenario provides a much broader impact of water scarcity that traps the vulnerable, especially women, in a vicious cycle of inescapable poverty.[294] In addition, both the availability and quality of water have direct implications on the lives of women, which further impacts the livelihood of those living in the rural areas and ultimately the economic development of the country. Therefore, it is only fair to consider women's role in water management along with their tireless efforts and hardships that they face as the gender most affected by water scarcity.

Water and the Younger Generations

Upcoming generations in the world will be most affected by changes in the environment. The current dilemma in Pakistan is that it has one of the world's largest proportion of youth (between the ages of 18 and 33).[295] The absence of employment opportunities coupled with other concrete youth development policies have already resulted in a sense of general hopelessness about their future in Pakistan.[296] For a country that is composed of more than 63 per cent young people below the age of 25 and is considered the fifth youngest nation in the world, this is a very alarming situation.[297] This despondency is further going to aggravate due to growing climate variability that affects the quality and availability of water which impacts the overall social stability thereby jeopardizing any opportunities of employment for the youth in future.

The precarious future of Pakistan's youth considering rising unemployment is evident by Pakistan's performance in the Youth Development Index where it has moved from the middle category to the low category within a span of only five years (2010 to 2015). Moreover, according to the latest National Human Development Report, the country ranks 154 among 183 countries in the Global Youth Development Index.[298] This survival of the fittest culture that already exists for the young populace thrusts them into unfair competition. The fittest of society with their suitable socio-economic backgrounds are able to take advantage of the learning and skill

development opportunities while the underprivileged class which already lack opportunities for employment, stay less privileged by default. Moreover, females who are not exclusively targeted by policymakers, face an absence of basic facilities and lower economic prospects as compared to males. Everything considered, environmental stresses can lead to widespread social unrest in the near future.

Water Scarcity and Migration

As water insecurity rises, worsened by climate variability, droughts will become more frequent. According to a World Bank report which outlines how "episodes of droughts and floods have generated waves of migration and statistical spikes in violence within countries," the regions that have never had droughts are going to see a drop in their resources in the coming 35 years.[299] Within the Pakistani context, Sindh and Balochistan are already proof of the devastation that droughts bring with them. If the situation prevails it will continue to spark social conflicts and forced migration.[300]

In Pakistan a significant proportion of people live in rural areas where their livelihoods are dependent on agriculture. Loss of agricultural productivity due to climate change has severely altered livelihoods which can potentially scale up and intensify the process of urbanisation. Rural poverty is also often associated with one's access to resources and landlessness, the absence of which can trigger rural to urban migration.

As of December 2018, approximately 85 families from the lower Chitral region have moved to Rerioveer owing to the unavailability of water. For the same reason, around 200 families from Morilusht area have shifted to Chitral.[301] The whole Chitral district is one of the worst affected by climate change in the form of water scarcity even though it is home to several natural streams, and glaciers. The 40,000 acres of once cultivable land has become barren. The prevailing condition has resulted in an economic crisis for its native people who have no source of income and no money to send their children to school.[302]

Extreme weather events have had a severe impact on Pakistan's agriculture sector and therefore on food security as well which is a cause for migration. Residents of Tharparkar, a region prone to frequent droughts, have suffered problems of chronic malnutrition as a result of food insecurity and abundance of disease and death among the livestock. All of these reasons have forced the people to relocate and it is estimated that around 45 per cent of the rural population of Tharparkar has migrated to other adjoining areas.[303] In Balochistan around 70 per cent of the population has migrated from the Kulanch Ambi village in Gawadar, and other areas like Pasni, for the same reasons.[304]

Chapter 8

Unsustainable Water Management Practices in Pakistan

Water governance is a set of rules by which water is managed. Through laws and institutions, water governance determines whether water resource management is being implemented sustainably or not. Poor water governance results in the overuse and depletion of water resources thereby making the poor more vulnerable, lowering the economic growth rate and accelerating the loss of biodiversity and job opportunities for the people in general. Water is a unique resource that is difficult to manage or control because of its physical properties and the cultural and economic significance attached with it. Water management is also complicated because it involves an amalgamation of the political, legal, economic, technological and environmental spheres. In modern societies, political deliberations dominate water resource use and management.[305]

In recent years, the water scarcity issue has emerged as one of the most pressing problems faced by Pakistan. It is estimated that the country will become water scarce by 2025 if the current water trends continue.[306] One of the major contributing factors which have led to water scarcity in the country is the unsustainable management of water which results in excessive water wastage mainly in the agricultural sector which consumes about 95 per cent of Pakistan's total water.[307] On the other hand, wastewater (mainly originating from the industrial sector) is not treated which not only results in the loss of an important source of water but also leads to health hazards for both humans and the aquatic life. Pakistan needs to change the course of its depleting water resources by adopting water conservation and storage mechanisms.

Pakistan is among the top five countries which account for about 86 per cent of global wastewater fed cropland. The country only treats 1.2 per cent of its urban wastewater which is used to irrigate about 7.2 million acres of land in the country.[308] Wastewater should be treated through the use of new technological methods which will not only help in reusing those water resources but will also help in reducing the health hazards associated with wastewater. This chapter discusses the main problems associated with the issue of water depletion and proposes appropriate solutions.

Wasteful Patterns of Consumption and Production

One of the leading causes of water scarcity in Pakistan is wastage of water

resources due to the existence of inefficient water management practices. About 104 million acre feet of water reportedly goes into irrigation in Pakistan out of which 54 million acre feet could be secured if efficient irrigation practices are adopted.[309] Surface irrigation is the primary method used for agricultural purposes in Pakistan. As compared to modern irrigation techniques, surface irrigation causes high consumption of water per kilogram of crops. An inefficient water distribution system along with a substandard infrastructure also lowers the level of water productivity in the country. A linkage between the areas to be irrigated and the water supplies means that farmers have to consume water even when there is no requirement and consequently excess amount of water gets wasted. Canal leakages alone are responsible for the loss of two-thirds of irrigation water.[310]

According to field studies, close to 50 per cent of water can be saved by adopting furrow irrigation methods as compared to flood irrigation.[311] As time passes, the unsustainable nature of the irrigation system is becoming more obvious. In their book Pakistan's Water Economy Running Dry, John Briscoe and Usman Qamar have identified the Indus Basin as the most inefficient irrigation system in the world. Nearly all contemporary issues in the Indus Basin are directly or indirectly linked to inefficient irrigation which include delta erosion, soil degradation, water shortages, flash flooding, low productivity, pollution of aquifers, etc.[312] Cotton production in Pakistan is directly linked to the degradation of the Indus River Delta.[313]

The overall efficiency of the irrigation system in Pakistan is poor due to inadequate maintenance and lack of drainage facilities which causes severe waterlogging and salinity thereby threatening the agriculture sector at large. In Pakistan, the average yield for wheat is and rice is about 8740 kilogrammes per hectare and 2,810 kilogrammes per hector, respectively.[314] Apart from poor irrigation, water shortage, lack of inputs and secondary salinisation are the major factors which cause low crop yields. Water productivity in Pakistan is about the lowest in the world. For example, the water productivity for wheat is 0.5 kilograms per cubic meter in Pakistan, one kilogramme per cubic meter in India and 1.5 kilograms per cubic meter in California.[315] Similarly, maize yields in Pakistan are also very low, only 4,787 kilogrammes per hectare.[316] The water productivity of maize in Pakistan is 0.3 kilogrammes per cubic meter and 2.7 kilogrammes per cubic meter in Argentina.[317]

Globally, 2,497 litres of water are used to produce one kilogramme of rice whereas in Pakistan, twice the amount of water is used to produce the same kilogramme of rice.[318] Moreover, Pakistan's rice water productivity is 55 per cent lower than the average water productivity of one kilogramme per cubic metre for rice in other Asian countries. Pakistani farmers use 7,000 litres of water to produce one kilogramme of sugar whereas several other countries only use 1,500 litres of water to produce the same quantity of sugar.[319] As compared to Pakistan, Indian Punjab produces 30 per cent more crop with the same quantity of water which is only surpassed by California.[320]

In addition, a lack of awareness among farmers regarding high water intensive crops and new irrigation methods is another major factor behind the wastage of water. According to research, the following factors are hindering the adoption of new irrigation techniques by farmers:[321]

- Shortage of electricity,
- Lack of technical knowledge about better irrigation methods,
- Lack of financial resources for small farmers to adopt new methods,
- No area/farm size-based subsidy for small farmers,
- Problems associated with technology design and installation expertise, and
- Non-availability of the small parts of advanced irrigation systems in the local markets.

Like the agricultural sector, the industrial sector is also a large consumer of water resources. Only a small number of industries conduct environmental assessments and adhere to the national quality standards outlining the permissible limits of wastewater (these have been detailed in the second chapter of the book). Located in or around major cities, industries serve as key sources of pollution as the wastewater is discarded into natural streams and rivers. The food processing, petrochemicals, paper and pulp, refineries, sugar, tanneries, and textile industries are the major polluters. Over 80 per cent of the industrial effluent is produced by the industrial sub-sectors of paper and board, cement, fertiliser, polyester yarn, sugar, and textile. For example, tanneries generate between 50 to 60 litres of liquid waste per kilogramme of hide.[322] Although, millions of Dollars have been spent in addressing the problem; however limited success has been achieved. It will take hundreds or thousands of years to flush out pollutants like toxic metals from the contaminated aquifers.

Uncontrolled industrial water pollution continues to remain a problem as the government has both failed to provide any incentives to those who responsibly treat their wastewater and failed in penalising those who continue to pollute the water bodies. The problem continues to persist due to the lack of implementation of rules and regulations in the absence of proper monitoring and policing. The discharge of wastewater into rivers is also causing the degradation of mangrove forests across the Indus Delta thereby decreasing the fish and shrimp production.[323]

Furthermore, negligible recycling is also a major contributing factor towards the wastage of water resources. Overall, 962,335 million gallons of wastewater is produced in Pakistan which includes 674,009 million gallons (70 per cent) from municipal and 288,326 million gallons (30 per cent) from industrial use.[324] Currently,

only eight per cent of wastewater in Pakistan is treated.[325] The total wastewater discharged into the rivers is 392,511 million gallons, which comprise 316,740 million gallons (81 per cent) of municipal and 75,771 million gallons (19 per cent) of industrial effluents. In terms of sectors, 73 per cent of wastewater comes from domestic use, 16 per cent from the agricultural sector, six per cent from industries and five per cent from the commercial sector.[326]

Ground Water Extraction

Currently, per person annual availability of water is at 1,017 cubic meters in the world. In Pakistan however, it is 1,000 cubic meters per person, which indicates that the country is water scarce. According to the 2017 census the country's population is now 208 million which is expected to reach more than 395 million by 2047. With such a rapid population growth rate, the demand for water will increase exponentially. Although, Pakistan's water demand is projected to reach 274 million acre feet by 2025, however, the supply is expected to remain stagnant at 191 million acre feet, which means that the demand-supply gap will be approximately 83 million acre feet.[327]

Groundwater is considered to be a significant freshwater resource in Pakistan. The major groundwater resources are used for irrigation in several areas of the Indus Basin. An estimated 60 per cent of Pakistan's fresh water is wasted due to poor management. The remaining 40 per cent is used for domestic and industrial purposes.[328] According to the Pakistan Bureau of Statistics, approximately 56 per cent population has access to clean drinking water. However, if international standards of safe drinking water are factored in, then nearly 64 per cent population has access to clean drinking water. In the absence of fresh drinking water, people consume brackish water in several drought-affected regions, which has dire consequences.[329]

The groundwater table in the Indus Plain was 20-30 metres below the surface, before the development of irrigation systems.[330] However, water levels significantly increased due to the irrigation input into aquifers. Waterlogging with supplementary salinisation of groundwater has become a major problem in many parts of the Indus. Since 2010, there has been significant increase in groundwater extraction. Over pumping of groundwater has contributed to water shortage. Pakistan will be among those countries that will have less renewable water resources by 2030. In other words, Pakistan is ranked among those countries that are currently facing groundwater shortage.[331]

In Punjab, the water table is decreasing by three feet per year. According to the Punjab Irrigation Department, drilling has to be done 800 feet below the surface to obtain water. Intensive farming is the primary reason behind the receding water table. Farmers require large amounts of water to cultivate three or four crops per year. In fact, more than 50 per cent of agricultural irrigation in the province is done through extracted groundwater.[332] Over 11 million people of Lahore are supplied

with 1.29 million acre feet of ground water on a daily basis which is extracted through hand pumps, motor pumps and tube wells. Consequently, groundwater in Lahore has reached critical levels with the rate of extraction remaining above 2.5 to 3.0 feet per year, according to World Wildlife Fund-Pakistan (WWF-Pakistan). It is projected that the water table will recede below 230 feet in most areas of the city by 2025 if the present extraction trend continues and groundwater is not conserved.[333]

In order to stop the unbridled use of water, Punjab government's Irrigation Department has drafted the Punjab Groundwater Protection, Regulation, and Development Act 2017. Once adopted, the commercial and industrial enterprises will have to seek permission to extract groundwater. For regulating and managing municipal water, the Punjab Municipal Water Act was introduced in 2014 but remains unimplemented. Contrary to extensive use of groundwater in Punjab, Balochistan is the most water deficient province. In Quetta, ground water was depleted up to 95 feet from 2006-2013.[334]

Apart from intensive farming, other factors like increasing temperature, decreasing evaporation, and variability in rainfall since 1990s have also contributed to the rapid depletion of ground water. Consequently, the depletion of groundwater resource is having serious socio-economic effects as the rural population is migrating towards urban areas in search of better water facilitation.[335] Groundwater's contribution to the overall irrigation water supplies is estimated to have increased from just eight per cent in 1960 to more than 50 per cent in 2010. Currently, the country meets more than half of its overall irrigation water requirements and 70 per cent of its drinking water consumption from groundwater abstractions. These statistics make Pakistan the fourth largest groundwater depleting country with an estimated 65 cubic kilometres of groundwater extraction per year. In other words, the country accounts for about 6.6 per cent of the global groundwater withdrawals and irrigates about 4.6 per cent of the global groundwater-fed cropland.[336]

Pakistan's groundwater extraction rates have exceeded the annual recharge rate of 55 cubic kilometres per year due to excessive pumping. Consequently, groundwater tables are facing depletion at a rapid rate in various parts of the country.[337] With nearly 50 to 55 million acre feet pumped out and only 40 to 45 million acre feet recharged, the Indus Basin aquifer is getting drained faster than it can be replenished.[338] A National Aeronautics and Space Administration-led study has confirmed that Pakistan has the second most overstressed aquifer which is being depleted without getting recharged. The aquifer has also been placed on the World Resource Institute's water stress index.

According to the Karachi Water and Sanitation Board, Karachi needs 1,100 million gallons of water per day to meet the needs of 15 million people. However, the city is supplied with 450 to 480 million gallons of water per day. The shortfall of more than 50 per cent water demand is met by groups running illegal hydrants which supply water to residents and make huge profits.[339] In rural Sindh, those at the

head reaches of the canal are able to divert more water towards their land by the virtue of political influence which allows them to exert pressure at the Irrigation Department and consequently ignore any water laws in their areas. Contrarily, the farmers at the tail-end of the canals do not receive enough water for cultivation who therefore have to use seawater which makes their arable land unproductive.

Effect of Pollutants on Water Management

Apart from the decreasing quantity of groundwater, the contamination of the resource through industrial and municipal effluents is another major problem. A research published in Science Advances last year analysed data of nearly 1,200 groundwater samples from across the country and concluded that up to 60 million people were at risk from the deadly chemical, arsenic.[340] Although the World Health Organisation has established a level of 10 micrograms per litter as the permissible concentration of pollutants in drinking water; however, Pakistan's government has fixed that number at 50 micrograms per litre.[341] The study found that very high concentrations, above 200 micrograms per litre, are found mainly in the Southern parts of the country. The research study also warned that the regular consumption of water containing high concentrations of arsenic may lead to skin disorders, lung cancer and cardiovascular diseases.[342]

The Punjab government earlier this year launched a crackdown in all 36 districts and destroyed standing crops on thousands of acres that had been watered with untreated industrial effluent and sewage. The farmers in future will only be allowed to cultivate non-edible crops like bamboos, flowers, and indoor plants with the help of wastewater. Pakistan today is more susceptible to extreme floods, long spells of drought and increasing natural disasters due to the poor management of existing water resources, compounded by changing precipitation patterns caused by global warming and lack of investment in water storage facilities.[343]

Polluted groundwater could lead to severe diseases in children causing problems in their bones and joints thereby hampering their growth and mobility. This type of water contains arsenic, chromium and mercury which cause cancer. The unavailability of proper dumping grounds for wastewater results in all waste being absorbed by the soil which makes the groundwater more harmful. Moreover, unchecked extraction of groundwater not only causes the water level to go down but also weakens the foundations of houses.

Faisalabad has borne the brunt of groundwater pollution. Being an industrial hub, wastewater management is not at par with the increasing demand for groundwater and the authorities have done little to rectify the process. Industrial waste is directed to the Muhammada Wala dumping site wherein it is left to mix with water from rainfall in the rainy season. The result is an impure mixture, concentrated in industrial pollutants that contaminates the groundwater supply.[344]

Equally damaging to water sustainability is the impact that waste dumping has on marine life. The Worldwide Fund for Nature reports that approximately "8 million tonnes" of plastic waste is disposed of in the sea. The sea shores of Karachi, Kund Malir and Gwadar have all fallen victim to plastic disposal at a level that threatens the existence of marine life. Fishermen have reported coming across an increasing number of dead fish among other marine creatures owing to the consumption of plastic waste. It is not merely the direct dumping of waste into open waters that runs the risk of contaminating breeding areas for fishes, but contaminated groundwater runoff that finds its way into the sea which has a devastating impact on marine ecosystems.[345]

Wastewater Treatment

Wastewater consists of contaminants from both residential and commercial uses. If this water source remains untreated, the presence of chemical compounds and pathogens in wastewater can become a source of harm to both flora and fauna that can be found in or near water bodies. It can also affect human health through the contamination of crops and drinking water. Therefore, wastewater treatment is considered to be extremely important for the protection of the health of several different ecosystems. If treated properly, wastewater can prove to be a valuable resource. Flushing out toxins from wastewater through proper treatment can fill the water shortage gap by using water which would otherwise have been wasted.[346]

In the modern era, the traditional methods of wastewater treatment have proved to be challenging due to the identification of more contaminants, rapid explosion of population, increased industrial activities and shrinking fresh water sources. In this age of smart technology, there is a need to treat and manage wastewater using modern technical methods. The use of smart water treatment options will help people reuse wastewater for various purposes except for drinking.

Advanced filtration techniques such as membrane filtration, automatic variable filtration and urine separation work on the principle of refining the impure water to an extent that it could be reused. In addition, water filtration methods based on nanotechnology and microbial fuel cells are already being used in the developed part of the world to reuse wastewater. The former works by introducing living organisms to wastewater which cut down toxins while the latter makes use of electricity to achieve the same purpose. Natural Treatment Systems sift impurities from storm water bringing a previously untapped source into play whereas the Coke Oven Byproduct Wastewater Treatment separates ammonia from coke oven liquid owing to ammonia's role as a pollutant. Several other modern water purifying methods include the Automatic Variable Filtration Technology, Microbial fuel Cells, New Urban Sanitation Technology etc.[347]

The Drip Irrigation Model

Adopting a modern drip irrigation model is necessary for sustainable water management, especially for our agricultural sector. Drip irrigation or micro-irrigation is an irrigation model in which crops are supplied with fertilisers and water through a network of ultraviolet resistant tubes directly to the roots at a steady flow rate. Through this model, the water and fertilisers reach the soil that directly feeds the roots. The advantage offered by drip irrigation is that it prevents the whole soil from getting moisturised thereby minimising water leakage and evaporation. Also, it maintains optimal moisture levels for the crop to flourish and is therefore an ideal irrigation method for crops like cotton, sugarcane, mangoes, apples, bananas, strawberries, various vegetables, and floriculture.[348]

Reusing Effluent for Irrigation: A Case Study of Israel

By using the right technology, economic resources, and political determination, Israel has been able to reuse effluent to irrigate about 40 per cent of its land. Israel's largest wastewater treatment and reuse facility, Shafan Wastewater Treatment Facility, supplies approximately 140,000,000 cubic metre per year of reclaimed water to the Negev desert, located in the south of Israel for agricultural use on 50,000 acres of land.[349]

Ineffective Water Management Policies

The Canal and Drainage Act (1873) stipulates that all water resources are to be managed by the government.[350] As anachronistic as the law is, it is not in any sense binding on the water mafias that have sprouted up in water intensive cities, specifically Karachi. Water rights, according to the law, have been siphoned off in terms of the size of the landholdings. In more contemporary settings, private landowners, manipulating an almost non-existent accountability mechanism, channel water to their lands leaving the masses at large with little water to live off at first and having them travel long distances to acquire clean water for cut-throat prices. The "tanker mafia" as it has come to be known, feeds off the existing shortage of water and its exponential increase with population, marking immense profits. The officials responsible for regulating the distribution of water have not been able to stave off the influence of landowners, rendering the only available regulatory mechanism ineffective.

Chapter 9

Other Riparians and Lessons for Pakistan

In pursuit of economic development, water resources are being over exploited all over the world. The race to squeeze every bit of profit at high social and environmental costs is largely damaging the environment. Millions of people do not have access to water and cities are suffering because of ineffective water policies and obsolete water management infrastructure. But amidst the challenges being faced, there are some countries that have come to the forefront in conserving water. This chapter explores the various mechanisms governments all over the world have, or are, adopting to conserve water and reverse the impacts of water scarcity and climate change.

Singapore

In an extremely short time, Singapore has developed from a water-scarce nation to a world leader in water management. Its water supply comes from four channels and two-thirds of its land is water catchment, making it one of just a few countries in the world to harvest urban storm water on a large scale for consumption. Initially Singapore depended upon Malaysia for the supply of water; hence, the long-term security of water was an important consideration for it. Therefore, the country developed and executed plans for enhancing water security and self-sufficiency through out-of-the-box, creative thinking in all fields of water resource management.

A main reason for Singapore's success in managing its water is the parallel emphasis on supply and demand management, including wastewater and storm water management, institutional effectiveness, planning on long time horizons, and an enabling environment which includes a strong political will, effective legal and regulatory frameworks and an experienced and motivated workforce. Although, currently, 40 per cent of the water is imported from Malaysia, Singapore treats used water with reverse osmosis through which almost 30 per cent of the nation's water needs are fulfilled.[351]

Moreover, with regard to the water utility bill, those who are less privileged and conserve water are exempted from paying any water tax, while others pay high water taxes. This pricing strategy reflects the true value of how much a person is willing to pay for water with a set threshold which everyone adheres to. Singapore not only organises water conservation campaigns but also initiates water rationing

drills to educate the public on water conservation. Such policies tend to be more supported in areas with highly educated populations.[352]

Wide ranging water conservation initiatives, including education programmes, have been effective in encouraging individuals and industry to use water wisely and have seen a shortfall in the per capita domestic water consumption from 176 litres per day in 1976, to 165 litres per day in 2003, and 152 litres per day today. The target for 2030 is 140 litres per day. In addition to water conservation campaigns, the government also enacts stringent measures to ensure that water theft does not happen. A simple yet effective measure of cutting off the supply of water on some days is done to ensure that citizens realise the importance of the resource. Such measures reaffirm a sense of civic responsibility among the citizens when using water.[353]

India

Pakistan has a lot to learn from its neighbouring India in terms of capitalising the available resources whilst effectively adopting policies and models employed elsewhere globally. Although India too is majorly engaged in dealing with the dilemma of water scarcity, the means that Indian cities have adopted to rise above the existing situation are commendable. A fundamental pillar of the Indian approach in coming to terms with its water issues lies in its massive engagement with key international players, not just by means of adopting their policies but also by means of engaging them to invest in ventures which facilitate better water management in India. For instance, in order to curb non-revenue water losses, India has partnered with the governments of Vietnam and Indonesia to develop plans and projects to monitor theft, leakages and ineffective metering of available water resources. In a similar vein, India has also collaborated with the government of Denmark to facilitate effective water management strategies.[354] Under this Danish arrangement, the government of India has successfully managed to establish a wastewater management plant in Udaipur. The said plant has the capacity to treat 25 million litres of wastewater per day.[355] The amount constitutes 30 per cent of the country's total water supply.

Pakistan must look into similar options of engaging with more developed states to initiate projects which add to the sustainable usage of existing resources in Pakistan. A similar instance from India is that of the Karnataka State in Bangalore. Home to nearly 10 million people, the state of Karnataka majorly relies on lake water. Lately, the locals protested against the privatisation of lakes in their state so the policy was never implemented. It must also be noted here that India continues to progress in its water strategies driven by case specific policies i.e. it does not have a uniform policy for the entire country.

For the state of Karnataka, privatisation was not exactly a facilitating option. However, a similar policy of privatisation was endorsed by the government of India

in case of Nagpur where Nagpur Orange City Water Project was materialised with the assistance of a private investment company. Originally focused on tending to ineffective wastewater management mechanisms, the Orange City Water Project has generally improved the status of water availability for domestic use. The project has also earned significant attention globally and has been referred to as a great leap model worthy of being followed by the countries that face similar water management issues.[356]

Another remarkable revolution in the area of effective water conservation strategies is that of Ice Stupas in Ladakh, in the Jammu region of Indian administered Kashmir. Initiated by a local engineer Sonam Wangchuk, Ice Stupas are an incredible strategy to save and utilize water in the mountainous regions to reduce an absolute reliance on glacial melts. It involves vertically freezing stream water in the form of gigantic ice cones, about 30-50 metres high alongside settlements where water is needed the most.[357] The frozen water can then melt with the onset of summer, irrigating crops before the water from the glaciers reached them by June. Such a technique neither requires shading from direct sunlight, nor frequent maintenance or other locational prerequisites. Pakistan can employ a similar strategy in its northern areas, particularly Gilgit and Baltistan where the locals can create artificial glaciers using the same technique to save water that flows downstream as a result of improper storage facilities upstream. By doing so, the people of such areas can fulfil their basic water needs in all weather conditions.

Costa Rica

Costa Rica has emerged as a champion of capitalising its renewable resources in the past few years. Its efforts are globally acknowledged for ensuring the delivery of consistent electricity and for generating most of it from renewable resources at home. On March 25 2015, Costa Rica in an announcement revealed that it had produced 100 per cent of its electricity from renewable resources for a period of 75 days. In 2017, it broke its own record and produced electricity from renewable sources that lasted for 299 days.[358] The development was seen as a major ecological transformation of the electrical realm and received much appreciation. While it may be argued that Costa Rica is a small country given its geography and resources, the larger and more influential fact remains that Costa Rica has surpassed many states in its bid to become one of the most self-sufficient countries in terms of locally managed energy in the world.[359]

One of the two fundamental challenges confronting Costa Rica at present are determining an effective way to shift from a fossil fuel based energy system to the use of locally harnessed renewable energy resources and the expansion of its projects alongside an upgraded power generation facility.[360] Later, Costa Rica introduced a strategy that addressed both these challenges in a realistic and sustainable manner. The strategy endeavoured to replace all imported fossil fuels with renewables through a coordinated use of biofuels consumption. It prioritised

the construction of large renewable energy power plants and enhanced the role and participation of other actors, (primarily from the private sector) in the development of new projects incorporating at least additional 600 megawatts of capacity. Currently, a dominant share of electricity in Costa Rica comes from renewable resources, with hydropower contributing almost 80 per cent to the energy sector. This practice allows Costa Rica to attain self-sufficiency by powering itself for months at a time depending on renewables only.[361]

In addition, Costa Rica has also put in place an incentive-based system in order to attain decarbonisation. The plan is to incentivise the people for cleaner vehicles, particularly electric cars etc.[362] The simplest of means to attain carbon neutrality is to manage/monitor the usage of carbon. Such management can be ensured by a cut-off in the supply of fossil fuels. However, Costa Rica's plan to arrive at zero-net emissions is conventional in its character. Despite the support for electric cars, the issue in implementation is perhaps an economic one because Costa Rican residents complain about high priced electric vehicles. To tend to this, the Costa Rican government tried to abolish taxes on all electric vehicles to encourage their usage. However, a major impediment in the course of this facilitation was the realisation that a major chunk of taxes critical to the Costa Rican economy came from fossil fuels.[363]

Sri Lanka

Sri Lanka is a region where lengthy spells of dry weather prevail, and the country is using large water harvesting tanks to conserve rainwater and to provide support for the arid region during times of drought. The process involves the collection of rain in tanks installed below the ground which is later used for the purpose of market gardening. These tanks are specifically made to serve the purpose of effective water conservation as they help reduce evaporation and at one time can hold up to 15,000 litres of water. In addition, various efficient irrigation techniques are also being utilised. Pitcher Irrigation method for instance, in simple terms, involves the burying of an unglazed, porous pot made of clay near a seedling. When water is poured into the pot, it seeps gradually into the soil, supplying the seedling with the required amount of moisture at a steady pace. This method saves time as well as makes efficient use of water.[364]

Kenya

The introduction of sand dams provided new opportunities for Kenya to meet its water shortages. A sand dam is a steel concrete wall built across a seasonal sandy riverbed. During the rainy season when the seasonal river is formed, it carries soil made up of silt and sand particles, downstream. Sand, which is heavier, collects behind the dam, while the silt washes downstream over the wall of the dam. The dam completely fills with sand within two to four rainy seasons. 40 per cent of all that is left behind in the dam is actually water which is stored in between the sand and can be extracted and collected for use.[365]

In Kenya, the presence of sand dams has helped communities adapt to the impacts of climate change. Sand dams not only provide water for people living in dry lands, they also help recharge groundwater as they are filled with water and sand overtime. This is way these dams act as buffers and prevent the occurrence of droughts in the long term. Also, an increase in the water table helps in reversing the process of desertification and allows vegetation to grow. Sand dams can also be seen as a shortcut mechanism and a cost-effective solution for arid areas.[366]

Israel

Israel's water policy has always been a part of its "hydrological socialism." Water was extracted from the rich regions of the northern Galilee and sent to the dry southlands through a national water carrier. This way, the arid and semiarid Negev desert was transformed into an agricultural area. This system, however, had to be upgraded as it produced large amounts of waste and was generally inefficient. Under the new water management system, water supply was privatised, subsidies were reduced, and the pricing system was also revised where agricultural users paid less as compared to other users. Private corporations began to produce and price water as per demand. Moreover, reverse osmosis desalination plants were set up in 2002, which increased the supply of water by more than 30 per cent. Another major institutional transformation took place in the form of water and sewage management. These reformations helped Israel maintain a highly profitable agriculture sector.[367]

Over 75 per cent of Israel is dry land as it receives an average of 90 millimetres of precipitation annually, most of which is absorbed by the rocky soil. The modern drip irrigation system adopted by Israel along with other institutional transformations has revolutionised the water management system in the world. Israel used the technology interface in the form of micro planning. Through the modern drip irrigation, natural resources are used to maximise agricultural per unit output. Through the plastic tubing in the drip model, water (most of which is treated wastewater) is delivered directly to the roots of crops and plants even in desert areas such as Beersheba.[368]

South Africa

Cape Town was about to become the first major commercial city to declare the onset of "day zero," when the authorities would stop the flow of water to all its residents, only restricting it to the most important services.[369] Cape Town relies on the collection of rainwater in storage facilities but owing to climate change and less rainfall, the city's default water collecting mechanisms failed their purpose. About 95 per cent of the city's water is collected from surface water dams. Hence it is important that water collection be made more effective for existing mechanisms

along with new ones to support each other in cases of unsuitable climatic conditions. Groundwater supplies, recycled storm water and desalinated water are effective alternates that need to be put into place for all urban centres to meet all technological requirements.[370]

Climate change is a fixed variable around which water collecting policies need to be refurbished. The aforementioned proposal of bringing in private investment in addition to nationally designed water collecting programs will go a long way in not only improving the conditions of water storage mechanisms but also bridging the communication gap between the government and the population at large. Also, to augment the water storage effort, the public needs to be involved. The crisis in Cape Town and the warnings emanating from national policy circles in its wake can lead to hysteria and chaos. To ensure that the public understands the state of the crisis and the dire need for more efficiency when using water, the population needs to be taken into account. The establishment of research wings in collaboration with national policy circles is an important task for it creates a level of trust between the governing authorities and the public.

United States of America

El Paso, Texas is one of the many cities across the globe which is resorting to alternate methods to increase water capacity so that reliance on the traditional and more natural methods could be sidestepped. Both Pakistan and Texas find themselves in a similar predicament wherein the traditional sources of water are quickly depleting. El Paso relies on the River Grande to meet at least 50 per cent of its water requirements. However, the river is not being replenished at a rate faster than it is being consumed. Also, snowmelt has decreased by 25 per cent since the second half of the 20th century, forcing El Paso to look for alternate methods of water acquisition.[371]

Despite the presence of desalination plant which treats 27.5 million gallons of water daily, the availability of freshwater plunges to precarious levels. The Texan authorities do realise that with the River Grande not offering as much treatable water as before, the city will have to treat used water in a "closed loop" mechanism. The mechanism employs the use of electrocoagulation, driving electricity through used water to remove contaminants. The process has been cited as having a 99.9 per cent water purification rate.[372] A bacterium, among other contaminants, is removed in the initial phase of the treatment followed by the removal of sugars and salts through reverse osmosis.

El Paso's water purification venture is quite new as previously treated wastewater has seldom been channelled directly into homes. Treated water is conventionally fed into aquifers and made available for human consumption thereafter. There are lessons to be learnt for Pakistan here. Despite administrative differences and differing political trends, the principal of water treatment and

the primary reasons behind its need are not very dissimilar between Pakistan and America. El Paso receives an annual rainfall of about nine inches relative to Pakistan's 8.8 inches in the monsoon months, the most concentrated period of rain directed for irrigation purposes as well as direct human consumption. In addition, Pakistan's wastewater treatment is not all too impressive. A maximum of eight per cent of wastewater is treated throughout the country.[373] Treatment of wastewater is not merely a path to the future but is a necessity to account for massive water shortfall in the country. It is also important to mention water recycling is primarily practiced in Islamabad and Karachi at a very low scale while rural areas are missing out on the opportunity.

A few American cities have pioneered all water treatment procedures including California, Seattle, and Boston. The principle remains the same wherein wastewater is treated as a solution to water scarcity. The California State has outsourced large scale projects to private entities which can serve as a lesson for Pakistan. While in principle, Pakistan needs to consider closed loop technology to manage its wastewater. Such a technology will require infrastructure, expertise, and capital that can be obtained by the government through cooperation with the private sector.

Netherlands

Netherlands, like Pakistan, is one of the countries that is facing the most severe consequences of climate change. Since more than 50 per cent of the country is only a few feet above sea level, large portions of it remain flooded due to its proximity to the North Sea. To manage this situation, the country has adopted innovative water management policies and mechanisms thereby becoming experts in the field. The Dutch National Water Plan (2016–2021) which was formulated after a decade long process, is based on the concept of making "room for the rivers" as opposed to "fighting with the water." The Dutch follow a pre-emptive strategy where instead of responding to disasters like floods, they anticipate them and involve different sectors of the society and various stakeholders to come up with the best strategy to protect themselves. The country allows its rivers to expand when flooding takes place and uses its parks and open public spaces as "emergency reservoirs" for flood waters.[374]

The Dutch have built a flood protection system that involves the use of dikes and dams with a second level of protection through spatial planning. The system is closely knit with all other sectors of the society so that its needs could be met even in times of excessive flooding. Moreover, in water extraction and costal zones, water management is given top priority and is seen as the dominant activity, with which all other activities need to be compatible. In the rest of the regions, accommodation of water is done through spatial planning according to the requirements of the land in use, through the planning scheme.[375] By thinking and planning along the same lines Pakistan can also learn to adapt with climatic disasters and learn to collect flood

water to be used in times of need.

Lessons for Pakistan

The need for water conservation in Pakistan is now more than ever, as the nation is on the brink of a water crisis. Pakistan possesses the biggest single gravity flow irrigation network in the world capable of handling over 100 million acre feet (40 million hectares-0.30 m) of water annually to irrigate an area of about 13.2 million hectors.[376] However, economic efficiency of the water system is very low due to excessive water losses, inadequate drainage, fragmented land holdings and water logging and salinity.[377] Water logging and salinity are major impediments to the sustainability of irrigated lands and livelihoods of the farmers, especially small landholders, in the affected areas of the Indus Basin. These problems are the result of a multitude of factors, including seepage from unlined earthen canal systems, inadequate provision of surface and subsurface drainage, poor water management practices, insufficient water supplies, and use of poor quality groundwater for irrigation.[378] Overall, not only agricultural practices and domestic usage, but industrial practices have also greatly affected the usability and reusability of water.

Hence, a mixture of policies, legislations and laws must not only be formulated using various water related policies and practices that have been discussed above, but also implemented in order to use water more sustainably. Currently, Pakistan faces a grave water crisis because of which water conservation strategies need to be formulated urgently and implemented fully. This, however, is not possible without substantial government intervention along with private and public collaboration for effectively tackling the issue. There is a need to learn from the examples of Bangladesh, Singapore, India and many other such countries which are adopting innovative water conservation measures to tackle the severe water crisis. Moreover, water conservation awareness needs to be created amongst the citizens of Pakistan with the help of mass awareness campaigns initiated at all levels of society. This crisis can only be mitigated if we learn from the policies of China, Bangladesh, Singapore and other such states who have survived this catastrophe. Water is life and is an essential requirement for the sustenance of all living beings so everyone needs to play their part in order to conserve it for future generations.

Chapter 10

Policy Recommendations

At a time when Pakistan has finally come to terms with the haunting reality of water scarcity hovering over the prospects of stability in its economic, humanitarian and developmental spheres, the need to become water secure has become increasingly relevant. However, it must be reiterated that though the idea of water security is a recent one, it requires special contextualisation in order to fully cater to the multi-dimensional problems in Pakistan. It is equally important to stress that Pakistan must resort to diplomacy as it seeks external cooperation to resolve its water woes. Following are a set of recommendations crafted in the light of academic literature discussed in this book and in the view of steps taken globally to overcome the challenge of water scarcity.

- Pakistan can hope for better and effective management of its water resources once it has successfully addressed the inter-provincial grievances at home. Although, the division and management of water as devised under the Water Apportionment Accord of 1991 has played its part in dividing water amongst all the provinces of the country, however, grievances have remained. Hence, it must not be regarded as the "ultimate" document capable of resolving all water related provincial issues. Accordingly, the government needs to devise new legislation based on factors like the availability of water resources, increase in population, demand for industrial, agricultural, domestic use, administrative capacity of the area and its topographical features.

- Awareness regarding water scarcity must be raised at a national level to tend to the prevailing sense of alienation among the provinces stemming from their perceptions that are rooted in the seemingly unfair distribution and access to clean water. An added component of such an awareness campaign must be an engagement with experienced researchers and practitioners to come up with viable alternatives that can ease the state of water affairs in distant areas. An instance of such a practice is the installation of water wells in the remote village of Umerkot, Sindh, to facilitate the provision of safe and healthy drinking water. The installation was carried out as a mutual initiative by the students of National University of Science and Technology (NUST) and the Association for Water, Applied Education and Renewable Energy (AWARE).[379]

- Pakistan shares a troubled history with both its co riparians, India and

Afghanistan and it is perhaps for this reason that water conflicts between them keep coming to the fore. Pakistan must engage its closest allies for mitigation in its bid to become water secure. Even in the face of a robust domestic water management formula, the need to secure the sources of water will remain. All three rivers allocated to Pakistan through the IWT originate from outside Pakistan. Hence, Pakistan being a lower riparian, needs to engage third parties, just like it did at the time of the IWT, to resolve any water conflicts in the area. Cooperation in this regard might also prove beneficial as it can lead to the creation of a transborder water regime which in the long run will help make the region more water secure.

- India and Pakistan find themselves at an impasse when it comes to an agreement over how to manage water resources that affect both countries. Though, negotiations have failed to produce adequate results but previous examples of successful water negotiations exist in the form of IWT and the dispute over Salal Dam. For a regional narrative to be instilled that calls for robust hydro diplomacy, there needs to be sufficient trust between the two countries. The idea here is to create a water managing authority consisting of members from all countries in South Asia, not only those directly affected by the flow of water for agriculture but those in the region that depend heavily on trade with both India and Pakistan. The body can monitor the water resources and the subsequent trade flows that result.

- Furthermore, in the spirit of cooperation, India should also release the minimum environmental flows of water in the eastern rivers (Ravi, Beas and Sutlej) to recharge the aquifer underneath so that groundwater depletion could be minimised especially in the Bari Doab area which is not mentioned in IWT. India must also treat its industrial and domestic effluents before discharge especially in the Hudiara Drain so that it may neither contaminate Pakistan's groundwater nor disturb other environmental parameters.

- There is a need to recontextualise the IWT as it is silent on contemporary issues like ground water use, the number of dams which India can build on the rivers allocated to Pakistan, effect s of climate change etc. An in-depth review of the diversified status of water needs on a social, economic and developmental level will help address the burgeoning water problem in a more efficient manner. Although the IWT is a landmark agreement between India and Pakistan which has survived major wars and skirmishes between the two neighbours; however, this should not hinder the path of its evolution as issues regarding water allocation and usage have come a long way from what they were when the treaty was initially put in place.

- In order to deal with the expanding Indian influence in Afghanistan, Pakistan must realize its strengths beyond financial facilitation and must aid the country in its economic development by opening its trade and transit routes

for the Afghan businesses to flourish. On the waterfront, both Afghanistan and Pakistan should devise a water sharing formula as the Kabul River is a source of livelihood for seven million Afghans and the sole source of drinking water for millions of Pakistanis.[380] Hence, sidestepping the Kabul River's potential of being used as a tool of coercive diplomacy against Pakistan, both countries should exercise their political will on a bilateral level to ensure an equitable use of the river.

- Moreover, Pakistan must also engage China in water dialogues over its excessive dam building practice and play the role of a mediator in finding appropriate solutions to the issue of water management between India and China.

- As the pattern of rainfall has drastically shifted over the past few years, the government of Pakistan must plan a system of water storage to account for the sporadic pattern of rainfall so that the rainwater is also effectively harvested and used as per need. A westward shift in the monsoon patterns spell the need for a robust water storage policy considering Punjab's dependence on channelled water for its Kharif crops. Hence, there is a need to construct reservoirs in Punjab to both manage water variability and flow during the dry months to direct/redirect water to the crops.

- The requirement for water storage exclusively for hydropower production can be met by effectively using the higher altitude regions in the country. Hilly areas, specifically those that are not topographically uniform but rather asymmetrical can be used to guide surface runoff down onto hydroelectric production plants. Moreover, other traditional and nascent water storage techniques can be used such as the construction of *Jhalars* (rectangular wells with tiered steps), *Taanka* (cylindrical underground pit), *Johads* (small earthen dams), Water silo, ferrocement technology (for making hygienic water storage tanks) and other underground water storage systems.

- The construction of small dams can also aid the water storage process as relative to large dams they do not require high investment, long lead-time, large scale dislocation of people and face lesser logistical and communicational issues. Although a few small dams were planned in Pakistan, but no significant additions have been made since 1996 as mega water projects are sought after. A comparison between the construction of 12 small dams in the Potohar region for $35.4 million and the Diamer Basha dam estimated at $8.5 billion suggests the feasibility of constructing small dams.[381] Smaller dams can also be outsourced to private enterprises which can collaborate with national offices of international development regimes such as the USAID to aid the social development of populace and reap maximum economic benefits from the use of arable land around sites picked out for the construction of dams. Due to the transitional nature of weather

patterns, sites for smaller dams need to be meticulously researched because their use, dominantly in the rainy season needs to be weighed against the cost of construction/operation.

- In addition to smaller projects, bigger projects such as the on-going Diamer Bhasha Dam are important for they create a massive number of jobs, provide flood control, assist in river navigation, are multipurpose and can thereby play an integral role in resolving the water crisis. The dam is estimated to store 8.1 million acre feet of water with the potential to produce 4,500 megawatts of electricity.[382]

- Desalination plants are of utmost relevance to reduce the shortfall between the demand and supply of water. Although highly expensive, desalination plants can uplift impoverished communities by providing them clean drinking water which is an inalienable human right. These plants should not remain exclusive to Gwadar but under the China-Pakistan Economic Corridor (CPEC) should be installed throughout the coastline of the country. Moreover, vocational institutions focusing on water management need to be developed to cater to the need of the growing population in tandem with the evolving technology.

- Industrial effluents should be continuously monitored and properly managed before discharge in order to reduce potential damage to aquatic and human life. It is highly recommended that a country wide health risk assessment of food crops be undertaken to rule out the possibility of them being irrigated with wastewater that can result in the bioaccumulation of hazardous pollutants in these food crops that is highly injurious to health.

- The Pakistani government should also install water treatment plants throughout the country so that wastewater could be reused for agricultural and industrial purposes. In doing so, biological treatment technologies, especially anaerobic wastewater treatment along with post-treatment wetland processes could be used based on an accurate knowledge of its characteristics and its point of origin for instance from rural residential dwellings, commercial establishments or other facilities.

- As climate change is perhaps the greatest barrier to water resource management its impacts should be thoroughly considered while morphing any new water management strategies. Apart from reliance on international bodies for research on the phenomenon, Pakistan should develop its indigenous research capacities to analyse the effects of climate change within its borders. Only with ample scientific evidence can effective policies be formulated to not only mitigate but to also adapt to the effects of climate change. In this regard, a detailed study of basin-scale surface-groundwater interactions is required to inform improved resource assessment, planning,

and operations.

- Following the example of Cape Town which issued quotas for the daily domestic use of water per household which if exceeded is penalised, Pakistan should also place restrictions on the amount of water that can be used not only for domestic consumption but for agricultural and industrial use as well. Since Pakistan is ranked high among countries notorious for water theft, a survey on how much water is required for each sector whilst maintaining a decent rate of economic expansion, ought to be reflected in policy when distributing water. Efforts should be made to make the general public realise that water scarcity is and must be recognised as a reality.

- Since one of the aims of the current government is human resource development therefore, problems in these areas should be highlighted and resolved. Representatives accountable to the federal government, independent of local councils, ought to be selected to oversee the distribution of water. In the longer run, the monopoly of tribal elites and wealthy land holders need to be broken and people need to be educated about their rights along with the technical knowledge of efficient water use.

- Before the taxation system could be improved, provinces, based on a system of comparative advantage, need to be categorised on the basis of the need for agricultural and industrial water. It is proposed that a flat tax rate should not be applied to the distribution of water as it needs to correspond to the use of water in each region. Progressive taxation will also require a clear set of ownership records, the lack of which can corrupt any resource distribution process. Concealed ownership records prevent influential landowners from being duly charged of the utilised resources. Since such records have not been preserved for decades, renewed mechanisms of accountability need to be implemented under the auspices of the federal government. Moreover, the practice of water budgeting and water metering should be adopted to account for water use.

- Pakistan should be represented in all major environmental treaties and accords, and the country should open its doors for international investment in the construction of water related paraphernalia either for water storage or for electricity production. Moreover, Pakistan should also seek assistance from more water secure countries for technological transfer. For instance, wastewater treatment technology should be imported and in the long run Pakistan should develop its indigenous research capacity to produce prototypes suitable for its climate and technology. In this regard, the government should encourage the participation of youth and fund innovative water related projects so that they could be used on a larger scale. Excessive field work/research is required in the water sector along with the role of non-profit research organisations to tackle the issue.

- A check and balance for the water bureaucracy regime/institutions in the country is also essential. They should be asked to submit monthly progress reports of the projects being undertaken by them with an audit of all their finances as well.

- "Water management" should be introduced as a subject at college and university levels to cover the impacts and consequences of unsustainable water management with appropriate lessons for students so that they would be compelled to conserve water and ask others to do so as well.

Endnotes

[1] R. Quentin Grafton and Karen Hussey, eds., *Water Resources Planning and Management*, 1 edition (Cambridge: New York: Cambridge University Press, 2011).

[2] "World Water Development Report," United Nations, published March 19, 2018, https://www.unwater.org/publications/world-water-development-report-2018/.

[3] "Towards A Water and Food Secure Future: Critical Perspectives for Policy-Makers" (Food and Agriculture Organization of the United Nations and World Water Council, 2015), http://www.fao.org/3/a-i4560e.pdf.

[4] Salma S., Rehman S., and Shah M. A., "Rainfall Trends in Different Climate Zones of Pakistan," *Pakistan Journal of Meteorology* 9, no. 17 (2012): 37–47.the study was conducted across the country to assess the rainfall trend in different climate zones of\nPakistan over the past three decades. For this purpose dataset comprising 30 years for the period 1976 to 2005\nwere acquired from 30 meteorological observatories from different parts of the country. The whole data was\nanalyzed through Analysis Of Variations (ANOVA

[5] "Water Aid 2016 Report," Keystone, Online, available at https://washmatters.wateraid.org/sites/g/files/jkxoof256/files/Wateraid_2016_Partner%20survey%20report.pdf.

[6] "11th Five Year Plans Information Management, Water," *Ministry of Planning and Development*, accessed October7, 2019, https://www.pc.gov.pk/uploads/plans/Ch20-Water1.pdf.

[7] "Country Profile Pakistan," *Food and Agriculture Organization of United Nations*, accessed October 9, 2019, http://www.fao.org/nr/water/aquastat/countries_regions/Profile_segments/PAK-WR_eng.stm.

[8] Federal Flood Commission, "Annual Flood Report-2017," *Ministry of Water Resources*, last modified 2017, https://www.mowr.gov.pk/wp-content/uploads/2018/06/Annual-Flood-Report-of-FFC-2017.pdf.

[9] "Indus River Basin," *Food and Agricultural Organization*, accessed October 11, 2019, http://www.fao.org/nr/water/aquastat/basins/indus/indus-CP_eng.pdf.

[10] Ibid.

[11] Ibid.

[12] Ibid.

[13] Elizabeth Ojeh, "Hydrology of the Indus Basin (Pakistan)," *The University of Texas*, last modified November 30, 2006, https://waterinfo.net.pk/sites/default/files/knowledge/Hydrology%20of%20the%20Indus%20Basin.pdf.

[14] Hayley Fowler and David Archer, "Hydro-climatological variability in the Upper Indus Basin and implications for water resources," *IAHS-AISH Publication*, last modified 2005, https://www.staff.ncl.ac.uk/h.j.fowler/22%20131-138%20(Fowler)2.pdf.

[15] "Tarbela Dam and related aspects of the Indus River Basin in Pakistan," *World Commission on Dams,* last modified 2000, http://documents.worldbank.org/curated/en/278641468098987847/text/529140WP0Box341University0Press2006.txt.

[16] Elizabeth Ojeh, "Hydrology of the Indus Basin (Pakistan)," *The University of Texas*, last modified November 30, 2006, https://waterinfo.net.pk/sites/default/files/knowledge/Hydrology%20of%20the%20Indus%20Basin.pdf.

[17] Ibid.

[18] Ibid.

[19] Ibid.

[20] "Tarbela Dam and related aspects of the Indus River Basin in Pakistan," World Commission on Dams, last modified 2000, http://documents.worldbank.org/curated/en/278641468098987847/text/529140WP0Box341University0Press2006.txt.

[21] "Five-day training course on: Flood Mitigation," *National Disaster Management Authority-United Nations Development Programme,* last modified February 15, 2010, http://ndma.gov.pk/Documents/NIDM/NIDM%20COurses/Flood%20Mitigation%2015-19%20Feb%202010/Flood%20disaster%20risk%20situations%20in%20Pakistan.pdf.

[22] Khaleeq Kiani, "Water availability significantly higher than last year," *Dawn*, last modified October 02, 2019, https://www.dawn.com/news/1508479/water-availability-significantly-higher-than-last-year.

[23] "Pakistan Economic Survey 2018-2019," *Economic Adviser's Wing, Finance Division*, last modified 2018,

http://finance.gov.pk/survey/chapters_19/Economic_Survey_2018_19.pdf.

[24] Ibid.

[25] "Issues In Managing Water Challenges And Policy Instruments: Regional Perspectives And Case Studies," *International Monetary Fund*, last modified June, 2015,https://www.imf.org/external/pubs/ft/sdn/2015/sdn1511tn.pdf.

[26] "Per capita water availability may fall to 860 cubic metres," *The Express Tribune*, last modified June 28, 2019, https://tribune.com.pk/story/2002420/1-per-capita-water-availability-may-fall-860-cubic-metres/.

[27] Shah Meer Baloch, "Water Crisis: Why is Pakistan Running Dry?," *Deutsche Welle*, July 06, 2Deutsche Welle018, https://www.dw.com/en/water-crisis-why-is-pakistan-running-dry/a-44110280.

[28] "11th Five Year Plans Information Management, Water," *Ministry of Planning and Development*, ,accessed October7, 2019https://www.pc.gov.pk/uploads/plans/Ch20-Water1.pdf.

[29] Pakistan Bureau of Statistics, "Water and Power," in *50 Years of Pakistan*, (Karachi: Managers of Publication, June 1998) http://www.pbs.gov.pk/sites/default/files/50_years_statistics/vol1/9.pdf.

[30] Ibid.

[31] Ibid.

[32] Ibid.

[33] Ibid.

[34] "Reservoir: Tarbela Dam," *Water and Power Development Authority*, accessed October7, http://www.wapda.gov.pk/index.php/projects/hydro-power/o-m/tarbela-dam/item/31-reservior.

[35] "Tarbela Dam Project, Haripur District," *Water Technology*, accessed October7, 2019 https://www.water-technology.net/projects/tarbela-dam-project/.

[36] "Indus Delta and Kalabagh Dam," *DAWN*, June 14, 2013, accessed October 8, https://www.dawn.com/news/1018143.

[37] "Tarbela Dam Project, Haripur District," *Water Technology*, accessed October7, 2019 https://www.water-technology.net/projects/tarbela-dam-project/.

[38] "Spill Ways Tarbela Dam," *Water and Power Development Authority*, accessed October7, http://www.wapda.gov.pk/index.php/projects/hydro-power/o-m/tarbela-dam/item/301-spill-ways.

[39] "Tarbela Dam: An Engineering Marvel," *Concrete Show India*, last modified October 31, 2018, https://www.concreteshowindia.com/blog/tarbela-dam-anengineering-marvel/.

[40] Pakistan Bureau of Statistics, "Water and Power," in *50 Years of Pakistan*, (Karachi: Managers of Publication, June 1998) 128, http://www.pbs.gov.pk/sites/default/files/50_years_statistics/vol1/9.pdf.

[41] "Mangla Dam Raising Project," *Water and Power Development Authority*, accessed October7, 2019, http://www.wapda.gov.pk/index.php/projects/hydro-power/o-m/mangla/item/65-mangla-dam-raising-project.

[42] "History of Mangla Dam," *Water and Power Development Authority*, accessed October7, 2019, http://www.wapda.gov.pk/index.php/projects/hydro-power/o-m/mangla/item/66-mangla-dam-raising-project.

[43] Ibid.

[44] Pakistan Bureau of Statistics, "Water and Power," in *50 Years of Pakistan*, (Karachi: Managers of Publication, June 1998) 128, http://www.pbs.gov.pk/sites/default/files/50_years_statistics/vol1/9.pdf.

[45] Ibid.

[46] Ibid.

[47] "Mangla Dam Raising Project," *Water and Power Development Authority*, accessed October7, 2019, http://www.wapda.gov.pk/index.php/projects/hydro-power/o-m/mangla/item/65-mangla-dam-raising-project.

[48] "Power Station-Mangla Dam," *Water and Power development authority Pakistan*, accessed October 9, 2019, http://www.wapda.gov.pk/index.php/projects/hydro-power/o-m/mangla/item/64-power-station-of-mangla.

[49] Pakistan Bureau of Statistics, "Water and Power," in *50 Years of Pakistan*, (Karachi: Managers of Publication, June 1998) 128, http://www.pbs.gov.pk/sites/default/files/50_years_statistics/vol1/9.pdf.

[50] "Project Water," *Water and Power Development Authority Pakistan*, accessed October 9, 2019, http://www.wapda.gov.pk/.

[51] "Warsak," *Water and Power Development Authority Pakistan*, accessed October 9, 2019, http://www.wapda.gov.pk/index.php/projects/hydro-power/o-m/warsak/item/48-history.

[52] "Project Water," *Water and Power Development Authority Pakistan*, accessed October 9, 2019, http://www.wapda.gov.pk/.

[53] Ibid.

[54] Ibid.

[55] "Compendium on Environment Statistics of Pakistan," *Pakistan Bureau of Statistics*, pg.13, last modified 2015, http://www.pbs.gov.pk/sites/default/files/crops_and_climates/compendium_environment/compendium_environment_2015.pdf.

[56] "National Monsoon Contingency Response Directive 2019," *National Disaster Management Authority (Prime Minister's Office, Government of Pakistan*, accessed 23 November 2019.

[57] "Pakistan Economic Survey 2018-2019," *Economic Adviser's Wing, Finance Division*

Government of Pakistan, last modified 2018, http://finance.gov.pk/survey/chapters_19/Economic_Survey_2018_19.pdf.

[58] "Compendium on Environment Statistics of Pakistan," *Pakistan Bureau of Statistics*, pg. 13,last modified 2015, http://www.pbs.gov.pk/sites/default/files/crops_and_climates/compendium_environment/compendium_environment_2015.pdf.

[59] Ibid.

[60] Tim Craig, Pakistan has more glaciers than almost anywhere on Earth. But they are at risk, *The Washington Post*, Aug 12, 2016, https://www.washingtonpost.com/world/asia_pacific/pakistan-has-more-glaciers-than-almost-anywhere-on-earth-but-they-are-at-risk/2016/08/11/7a6b4cd4-4882-11e6-8dac-0c6e4accc5b1_story.html.

[61] Myra Imran, "Pakistan's ground water level falling a meter every year," The News, March 22, 2019, https://www.thenews.com.pk/print/447130-pakistan-s-ground-water-level-falling-a-meter-every-year.

[62] Ibid.

[63] "Compendium on Environment Statistics of Pakistan," *Pakistan Bureau of Statistics*, pg. 14, last modified 2015, http://www.pbs.gov.pk/sites/default/files/crops_and_climates/compendium_environment/compendium_environment_2015.pdf.

[64] Ibid.

[65] Saleem S, Ali W, Afzal MS, "Status of Drinking Water Quality and its contamination in Pakistan," Journal of Environmental Research 2, No.1 (2018): 6.

[66] Ibid.

[67] Jacob W. Kijne & Marcel Kuper, "Salinity and Sodicity in Pakistan's Punjab: A Threat to Sustainability of Irrigated Agriculture," *International Journal of Water Resources Development* 11, no. 1 (2015): 73-86.

[68] "Indus River Basin," *Food and Agricultural Organization*, accessed October 11, 2019, http://www.fao.org/nr/water/aquastat/basins/indus/indus-CP_eng.pdf.

[69] "The Canal and Drainage Act, 1873 (Act Viii Of 1873)," Punjab Laws, accessed October 30, 2019, http://punjablaws.gov.pk/laws/5.html.

[70] "The Pakistan Water and Power Development Authority Act, 1958 (W.P. Act Xxxi Of 1958)," Punjab Laws, accessed October 30, 2019, http://punjablaws.gov.pk/laws/86.html.

[71] "Introduction to WAPDA," *Water & Power Development Authority*, accessed November 4, 2019., http://www.wapda.gov.pk/index.php/introduction.

[72] "PCRWR Profile," *Pakistan Council of Research in Water Resources*, accessed November 4, 2019, http://www.pcrwr.gov.pk/.

[73] "PCRWR Profile," *Pakistan Council of Research in Water Resources*, accessed October 30, 2019, http://www.pcrwr.gov.pk/.

[74] "West Pakistan Land and Water Development Board Reclamation (Fee) Rules, 1965," *Khyber Pakhtunkhwa Code*, last modified December 9, 1965, http://kpcode.kp.gov.pk/uploads/West_Pakistan_Land_and_Water_Development_Board_Reclamation_Fee_Rules_1965.pdf.

[75] "Territorial Waters and Maritime Zones Act, 1976," *United Nations*, last modified December 22, 1976, https://www.un.org/Depts/los/LEGISLATIONANDTREATIES/PDFFILES/PAK_1976_Act.pdf.

[76] Stockholm 1972 - Declaration of the United Nations Conference on the Human Environment, *United Nations Environment Program*, http://legal.un.org/avl/ha/dunche/dunche.html.

[77] Tariq Banuri, "Implementation of the Environmental Protection Ordinance," *Sustainable Development Policy Institute*, last modified 1993, https://www.sdpi.org/publications/files/P4-Implementation%20of%20the%20Environmental.pdf.

[78] The Khyber Pakhtunkhwa Environmental Protection Act, 2014, http://www.pakp.gov.pk/2013/acts/the-khyber-pakhtunkhwa-environmental-protection-act-2014/.

[79] Tariq Banuri, "The Pakistan National Conservation Strategy: A Plan of Action for the 1990s." *Sustainable Development Policy Institute*, last modified 1993, https://www.sdpi.org/publications/files/P3-The%20Pakistan%20National%20Conservation%20Strategy.pdf.

[80] Balochistan Ground Water Rights Administration Ordinance 1978, *Conference on Environmental Law October,* accessed 12 October 2019, https://bhc.gov.pk/publications/books/environmental-law/acts-laws#lg=gl_acts-laws&slide=4.

[81] Sind Ordinance No. X Of 1981, *The Karachi Water Management Board Ordinance*, accessed 12 October 2019, http://sindhlaws.gov.pk/setup/Publications_SindhCode/PUB-15-000536.pdf.

[82] The Karachi Water Management Board Ordinance, 1981, http://sindhlaws.gov.pk/setup/Publications_SindhCode/PUB-15-000536.pdf.

[83] The Sind Irrigation Water Users Associations Ordinance (1982), accessed November 4, 2019, http://sindhlaws.gov.pk/setup/publications_SindhCode/PUB-15-000569.pdf.

[84] Tariq Banuri, "The Pakistan National Conservation Strategy: A Plan of Action for The 1990s," *Sustainable Development Policy Institute*, last modified 1993, https://www.sdpi.org/publications/files/P3-The%20Pakistan%20National%20Conservation%20Strategy.pdf.

[85] Ibid.

[86] Tariq Banuri, "The Pakistan National Conservation Strategy: A Plan of Action for the 1990s," *SDPI,* accessed 13 October 2019, https://www.sdpi.org/publications/files/P3-The%20Pakistan%20National%20Conservation%20Strategy.pdf.

[87] Indus River System Authority Act (1992), accessed November 4, 2019, http://www.na.gov.pk/uploads/documents/1334288668_263.pdf.

[88] Indus River System Authority, *Government of Pakistan,* accessed 13 October 2019, https://mowr.gov.pk/wp-content/uploads/2018/04/IRSA-Act-No.XXII-of-1992.pdf.

[89] "Climate, Energy & Water Research Institute (CEWRI)," *Pakistan Agricultural Research Council*, accessed November 4, 2019, http://www.parc.gov.pk/index.php/en/caewri-hom.

[90] Pakistan Environmental Protection Act (PEPA) (1997), accessed November 4, 2019, https://www.elaw.org/system/files/Law-PEPA-1997.pdf.

[91] The Karachi Water & Sewerage Board Act, 1996 (Sindh Act No. X Of 1996), *Provincial Assembly of Sindh*, accessed 13 October 2019,http://www.pas.gov.pk/index.php/acts/details/en/31/323.

[92] Pakistan Environmental Protection Act (PEPA) (1997), accessed November 4, 2019, https://www.elaw.org/system/files/Law-PEPA-1997.pdf.

[93] Islamabad Wildlife (Protection, Preservation, Conservation And Management) Ordinance, 1979.

[94] Pakistan Environmental Protection Act (PEPA), 1997.

[95] Ibid.

[96] Ibid.

[97] Ibid.

[98] Pakistan Environmental Protection Agency (Review Of IEE and EIA) Regulations, (2000), accessed November 4, http://extwprlegs1.fao.org/docs/pdf/pak115824.pdf.

[99] Ibid.

[100] Irum Ahsan and Saiman Amin Khawaja, "Development of Environmental Laws and Jurisprudence in Pakistan," *Asian Development Bank*, last modified November 2013, https://www.adb.org/publications/development-environmental-laws-and-jurisprudence-pakistan.

[101] "National Sustainable Development Strategy (NSDS): Pakistan's pathway to a sustainable and resilient future," *The London School of Economics and Political Science*, last modified 2010, http://www.lse.ac.uk/GranthamInstitute/law/national-sustainable-development-strategy-nsds-pakistans-pathway-to-a-sustainable-and-resilient-future/.

[102] Arthur J. Hanson, Stephen Bass, Aziz Bouzaher and Ghulam M. Samdani, "Pakistan's National Conservation Strategy: Renewing Commitment To Action," *International Union for Conservation of Nature*, last modified November 2000, https://www.iucn.org/downloads/pakistan_ncs_mid_review.pdf.

[103] "The Government of Pakistan and UNDP jointly working towards achieving the MDGs," *UNDP Pakistan*, last modified September 27, 2013, https://www.pk.undp.org/content/pakistan/en/home/presscenter/pressreleases/2013/09/27/the-government-of-pakistan-and-undp-jointly-working-towards-achieving-the-mdgs.html.

[104] "Pakistan now among 95 countries to have met sanitation MDG: UN report," *Dawn*, last modified July 3, 2015, https://www.dawn.com/news/1192126.

[105] The Ministry of Water and Power, Office of the Chief Engineering Advisor/Chairman Federal Flood Commission, *National Water Sector Strategy*, October 2002, https://www.mowr.gov.pk/wpcontent/uploads/2018/05/Pakistan-Water-Sector-Strategy-Vol-2.pdf

[106] National Sanitation Policy, *Government of Pakistan Ministry of Environment*, last modified September 2006, http://www.environment.gov.pk/images/policies/SanitationPolicy.pdf.

[107] Ibid.

[108] Ibid.

[109] About Us, WAPDA, last accessed October 12, 2019.http://wapda.gov.pk/index.php/neelum-jhelum/itemlist/category/14-about-us?start=14

[110] "About Us," National Disaster Management Authority, accessed November 5, 2019, http://www.ndma.gov.pk/ndma.php.

[111] National Drinking Water Policy 2009, *Government of Pakistan - Ministry Of Environment*, last modified September 28, 2009, https://ffc.gov.pk/wp-content/uploads/2018/12/National-Water-Policy-April-2018-FINAL_3.pdf.

[112] Ibid.

[113] Ahmad Rafay Alam, "Environment and the 18th Amendment," *The Express Tribune*, last modified March 23, 2012, https://tribune.com.pk/story/353639/environment-and-the-18th-amendment-2/.

[114] "National Sustainable Development Strategy," *The London School of Economics*, last modified 2010, http://www.lse.ac.uk/GranthamInstitute/law/national-sustainable-development-strategy-nsds-pakistans-pathway-to-a-sustainable-and-resilient-future/.

[115] Rina Saeed Khan, "National climate change policy to the rescue?," *Dawn*, last modified February 26, 2013, https://www.dawn.com/news/788838.

[116] Azam Khan, "Environmental justice: Green benches constituted all over Pakistan, AJK," *The Express Tribune,* last modified May 13, 2012, https://tribune.com.pk/story/378089/environmental-justice-green-benches-constituted-all-over-pakistan-ajk/.

[117] National Sustainable Development Strategy - Pakistan's pathway to a sustainable & resilient future

[118] "About Us," *Global Change Impact Studies Centre*, accessed November 5, 2019, http://www.gcisc.org.pk/About_us.php.

[119] Pakistan Vision 2025, accessed November 4, https://www.pc.gov.pk/uploads/vision2025/Pakistan-Vision-2025.pdf.

[120] Framework for Implementation of Climate Change Policy (2014-2030), accessed November 4,

[121] Ibid.

[122] National Environmental Quality Standards for Municipal and Liquid Industrial Effluents, accessed November 4, http://serl.pk/lawfile/23/NEQs-liquid-effluents.pdf.

[123] National Water Policy (April 2018), accessed November 4, https://ffc.gov.pk/wp-content/uploads/2018/12/National-Water-Policy-April-2018-FINAL_3.pdf.

[124] "The Water Accord (1991)," *Pakistan Water Gateway*, accessed October 30, 2019, https://waterinfo.net.pk/sites/default/files/knowledge/The%20Water%20Accord%20-%201991.pdf.

[125] "The Water Accord (1991)," *Pakistan Water Gateway*, accessed October 30, 2019, https://waterinfo.net.pk/sites/default/files/knowledge/The%20Water%20Accord%20-%201991.pdf.

[126] Ibid.

[127] "National Environmental Policy 2005," *Government of Pakistan- Ministry of Environment,* accessed 12 October 2019, https://mowr.gov.pk/wp-content/uploads/2018/05/National-Environmental-Policy-2005.pdf.

[128] National Sanitation Policy, *Government of Pakistan -Ministry of Environment*, last modified September 2006, http://www.environment.gov.pk/images/policies/SanitationPolicy.pdf.

[129] National Drinking Water Policy 2009, *Government of Pakistan - Ministry of Environment*, last modified September 28, 2009, https://ffc.gov.pk/wp-content/uploads/2018/12/National-Water-Policy-April-2018-FINAL_3.pdf.

[130] "National Water Policy 2018," *Ministry of Water Resources*, last modified April 2018, https://mowr.gov.pk/wp-content/uploads/2018/06/National-Water-policy-2018-2.pdf.

[131] "WAPDA Vision 2025." *WAPDA,* accessed 13 October 2019, https://www.pakistaneconomist.com/issue2001/issue31/i&e3.htm.

[132] UNDESA, "International Decade for Action 'Water For Life' 2005-2015," Accessed 14 October 2019, https://www.un.org/waterforlifedecade/water_cooperation_2013/iywc_and_wwd.shtml.

[133] Shafiqul Islam, *Water Diplomacy in Action: Contingent Approaches to Managing Complex Water Problems*, (London: Anthem Press, 2016).

[134] Matt Williams, "What Percent of Earth Is Water?," Phys.org, December 2014, https://phys.org/news/2014-12-percent-earth.html.

[135] Paul G. Harris, *Routledge Handbook of Global Environmental Politics*, (London: Routledge, 2013).

[136] Patricia Wouters,"Water Security: Global, Regional Challenges," *Institute for Public Policy Research*, last updated December 6, 2013, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2363787.

[137] Martina Klimes et al., "Water Diplomacy: The Intersect of Science, Policy and Practice," *Journal of Hydrology* 575 (2019): 1362–70, https://doi.org/10.1016/j.jhydrol.2019.02.049.Policy and Practice,\\uc0\\u8221{} \\i Journal of Hydrology\\i0{} 575 (August 1, 2019

[138] Ali Tauqeer Sheikh, "Pakistan's Water Diplomacy," *DAWN*, March 25, 2017, https://www.dawn.com/news/1322655.

[139] Brayshna Kundi, "Pakistan's Water Crisis: Why a National Water Policy Is Needed," *The Asia Foundation*, November 1, 2017, https://asiafoundation.org/2017/11/01/pakistans-water-crisis-national-water-policy-needed/.the Pakistan Council of Research in Water Resources (PCRWR

[140] Krishna Koundaniya, "Water Diplomacy-India's Position in South Asia," *Qrius*, last updated August 7, 2018, https://qrius.com/water-diplomacy-indias-position-in-south-asia/.

[141] Michael Kugelman, "Why the India-Pakistan War Over Water Is So Dangerous," *Foreign Policy*, September 30, 2016, accessed October 4, 2019, https://foreignpolicy.com/2016/09/30/why-the-india-pakistan-war-over-water-is-so-dangerous-indus-waters-treaty/.

[142] "Fact Sheet: The Indus Water Treaty 1960 and the Role of the World Bank," *World Bank*, June 11, 2018, accessed October 4, 2019, https://www.worldbank.org/en/region/sar/brief/fact-sheet-the-indus-waters-treaty-1960-and-the-world-bank.

[143] "The Indus Water Treaty 1960," *World Bank*, accessed October 4, 2019, https://siteresources.worldbank.org/INTSOUTHASIA/Resources/223497-1105737253588/IndusWatersTreaty1960.pdf.

[144] "India permitted to construct Kishanganga, Ratle projects under Indus Water Treaty: World Bank," *The Economic Times*, August 2, 2017, accessed October 4, 2019, https://economictimes.indiatimes.com/industry/energy/power/world-bank-snubs-pakistan-says-india-permitted-to-build-power-projects-under-indus-waters-treaty/articleshow/59874161.cms?from=mdr.

[145] "Indian Water Aggression in South Asia," *Center for Global & Strategic Studies*, October 15, 2018, accessed October 4, 2019, https://cgss.com.pk/paper/pdf/Indian-Water-Aggression-in-South-Asia.pdf.

[146] Ahmad Salik and Ahmad Saffee, "Indus Water Treaty: Issues and Recommendations," *Institute for Strategic Studies Islamabad*, August 29, 2017, accessed October 4, 2019, http://issi.org.pk/wp-content/uploads/2017/11/Final-Report-Indus-Water-Treaty.pdf.

[147] Malik Muhammad Ashraf, "India continues to violate Indus Water Treaty," *The Nation*, August 31, 2018, accessed October 4, 2019, https://nation.com.pk/31-Aug-2018/india-continues-to-violate-indus-water-treaty.

[148] Tasleem Malik, "Pak-Afghan Water Issue: A Case for Benefit-Sharing," *Policy Perspectives* 16, no. 1 (2019): 77–98.

[149] Khalid Mustafa, "India out to Damage Pakistan's Water Interests on Kabul River," *The News*, June 5, 2016, https://www.thenews.com.pk/print/125490-India-out-to-damage-Pakistans-water-interests-on-Kabul-river.

[150] Tasleem Malik, "Pak-Afghan Water Issue: A Case for Benefit-Sharing," *Policy Perspectives* 16, no. 1 (2019): 77–98.

[151] Khawar Shahza, "Hydro-Diplomacy between Pakistan and Afghanistan" *LEAD Pakistan*, March 2016, http://www.lead.org.pk/lead/Publications/Hydro-diplomacy%20between%20Pakistan%20and%20Afghanistan.pdf.

[152] Waleed Majidyar, "Afghanistan and Pakistan's Looming Water Conflict," The Diplomat, December 15, 2018, https://thediplomat.com/2018/12/afghanistan-and-pakistans-looming-water-conflict/.

[153] Syed Muhammad Abubakar, "Pak-Afghan Hydro Diplomacy," *The News*, July 2016, http://tns.thenews.com.pk/pak-afghan-hydro-diplomacy/.

[154] From the Newspaper, "No Integrated Approach," *DAWN,* May 23, 2011, http://www.dawn.com/news/631143.\\uc0\\u8221{} DAWN.COM, May 23, 2011, http://www.dawn.com/news/631143.}","plainCitation":"From the Newspaper, "No Integrated Approach," DAWN.COM, May 23, 2011, http://www.dawn.com/news/631143."},"citationItems":[{"id":622,"uris":["http://zotero.org/users/local/HzbnJkZQ/items/87UZGYEK"],"uri":["http://zotero.org/users/local/HzbnJkZQ/items/87UZGYEK"],"itemData":{"id":622,"type":"webpage","title":"No integrated approach","container-title":"DAWN.COM","abstract":"WATER is taking centre stage in the changing geo-strategic equation of South Asia. The latest move in this direction...","URL":"http://www.dawn.com/news/631143","language":"en","author":[{"family":"Newspaper","given":"From","dropping-particle":"the"}],"issued":{"date-parts":[["2011",5,23]]},"accessed":{"date-parts":[["2018",7,6]]}}}],"schema":"https://github.com/citation-style-language/schema/raw/master/csl-citation.json"}

[155] "Pakistan to Convey US Concerns over Kabul River Projects," *Sustainable Development Policy Institute*, May 16, 2011, https://www.sdpi.org/media/media_details53-press-2011.html.

[156] Huma Baqai, "Water-Related Issues in South Asia: Conflicts in the Making," *Pakistan Horizon* 58, no. 3 (2005): 77–88.

[157] "China has built the world's largest water-diversion project," *The Economist*, published April 5, 2018, https://www.economist.com/china/2018/04/05/china-has-built-the-worlds-largest-water-diversion-project.

[158] John Vidal, "China and India 'Water Grab' Dams Put Ecology of Himalayas in Danger," *The Guardian*, August 10, 2013, http://www.theguardian.com/global-development/2013/aug/10/china-india-water-grab-dams-himalayas-danger.

[159] "China's Global Role in Dam Building," *International Rivers*, accessed October 7, 2019, https://www.internationalrivers.org/campaigns/china-s-global-role-in-dam-building.

[160] Peter Bosshard, "China Dams the World," *World Policy Journal* 26, no. 4 (2009): 43–51.

[161] John Vidal, "China and India 'Water Grab' Dams Put Ecology of Himalayas in Danger," *The Guardian*, August 10, 2013, sec. Global development, http://www.theguardian.com/global-development/2013/aug/10/china-india-water-grab-dams-himalayas-danger.

[162] Peter H. Gleick, "China and Water," *World Water Organization*, Online, last updated August 7,2018, http://worldwater.org/wp-content/uploads/2013/07/ch05.pdf.

[163] Jessica Williams, " The international Implications of China Water Policies," *E-International Relations*, Online, last updated Feb 15, 2013, https://www.e-ir.info/2013/02/15/chinas-water-policies-and-their-international-implications/.

[164] Muhammad Akbar Notezai, "Pakistan's Bourgeoning Relationship with China," *The Diplomat,* Online, last updated, January 24, 2018 https://thediplomat.com/2018/01/pakistans-burgeoning-relationship-with-china/.

[165] L OhIsson, "Water Conflicts and Social Resource Scarcity," *Physics and Chemistry of the Earth, Part B: Hydrology, Oceans and Atmosphere* 25, no. 3 (January 1, 2000): 213–20, https://doi.org/10.1016/S1464-1909(00)00006-X.it is argued that the risk of conflicts within countries in fact is larger, and that the risk of international conflict is derived from the necessity to avoid what is defined as second-order conflicts within countries, caused not by water scarcity itself, but by the institutional change required to adapt to water scarcity. To illustrate this, the most pernicious effect of social resource scarcity, a new Social Resource Water Stress/Scarcity Index (SWSI

[166] Arif Anwar, "Pakistan's Provincial Water Disputes: A Way Forward," *DAWN*, July 28, 2016, http://www.dawn.com/news/1273760.

[167] "Apportionment of The Waters of The Indus River System Between The Provinces Of Pakistan," *Indus River System Authority*, 2011, http://pakirsa.gov.pk/WAA.aspx.

[168] Ibid.

[169] Arif A. Anwar and Muhammad Tousif Bhatti, "Pakistan's Water Apportionment Accord of 1991: 25 Years and Beyond," *Journal of Water Resources Planning and Management* 144, no. 1 (January 1, 2018).

[170] Hana Namrouqa, "Blue Peace Proposes Seven Principles of Cooperation for Sustainable Management of Region's Water Resources," *Jordan Times*, September 29, 2014, http://www.jordantimes.com/news/local/blue-peace-proposes-seven-principles-cooperation-sustainable-management-region%E2%80%99s-water.

[171] Aaron Wolf, "Conflict and Cooperation along International Waterways," *Water Policy* 1, no. 2 (April 1998): 251–65, https://doi.org/10.1016/S1366-7017(98)00019-1.

[172] "Water Management in Fragile Systems: Building Resilience to Shocks and Protracted Crises in the Middle East and Nort Africa," *Food and Agriculture Organization of the United Nations*, 2018, http://www.fao.org/3/I9730EN/i9730en.pdf.

[173] Uttam Kumar Sinha, *Riverine Neighbourhood Hydro Politics in South Asia* (New Delhi: Pentagon Press, 2016).

[174] IISD's SDG Knowledge Hub, "Event: High-Level Conference on International Decade of Water for Sustainable IISD," accessed July 10, 2018, http://sdg.iisd.org/events/high-level-conference-on-international-decade-of-water-for-sustainable-development/.

[175] Ibid.

[176] Ibid.

[177] Tariq J. Bhatti, Muhammad Nawaz Chaudry, and Ghulam Hassan, "Measured Reaction - International Waterpower," *Water Power and Dam Construction*, December 22, 2004,

[178] Tianyi Luo, Robert Young, and Paul Reig, "Aqueduct Projected Water Stress Country Rankings" (*World Resources Institute*, 2015), https://wriorg.s3.amazonaws.com/s3fs-public/aqueduct-water-stress-country-rankings-technical-note.pdf?_ga=2.113557252.261494969.1539339857-624840109.1539339857.

[179] Daanish Mustafa, "Dams: To Be or Not to Be," *Herald Magazine*, October 11, 2018, https://herald.dawn.com/news/1398688.

[180] Keith Johnson, "Are India and Pakistan on the Verge of a Water War?," *Foreign Policy*, accessed October 7, 2019, https://foreignpolicy.com/2019/02/25/are-india-and-pakistan-on-the-verge-of-a-water-war-pulwama-kasmir-ravi-indus/.

[181] "Communities Work Together to Reduce the Risk of Flash Floods in Northern Pakistan," *UNDP in Pakistan*, 2019, https://www.pk.undp.org/content/pakistan/en/home/ourwork/environmentandenergy/successstories/glof.html.

[182] Ibid.

[183] Amar Guriro, 'Rising Tide' in *Newsweek Pakistan*, August 18- September 1, 2018, 18-21.

[184] Alexander Danilenko and Aroha Bahuguna, "Korea: A Model for Development of the Water and Sanitation Sector," *World Bank Blogs*, October 26, 2016, https://blogs.worldbank.org/water/korea-model-development-water-and-sanitation-sector.

[185] Ibid.

[186] Rashid, O., F. M. Awan, Z. Ullah, and I. Hassan. "Rainwater harvesting, a measure to meet domestic water requirement; a case study Islamabad, Pakistan." In IOP Conference Series: Materials Science and Engineering, vol. 414, no. 1, p. 012018. IOP Publishing, 2018.

[187] Exall, K., and T. D. Vassos. "Integrated urban water management: water use and reuse." In Metropolitan Sustainability, pp. 319-349. Woodhead Publishing, 2012.

[188] Ibid.

[189] Zahid Khan, D. M. and Zubair Khan, "Watershed And Hill Torrent Management In Dg Khan Region, Sulaiman Range: & Ii - Water Use Efficiency Of Local Tree Species In Arid Climate," National Centre of Excellence in Geology, University of Peshawar, http://nceg.uop.edu.pk/WatershedManagementWokrshop2010/lectureslides/Session-IV/5.DMZahidKhan.pdf.

[190] Ahmad, Matlob. "Optimal Management of Water Resources in Selected Hill Torrent Command Area of Pakistan." P.hd Diss., University of Agriculture, Faisalabad, 2016.

[191] Ibid

[192] Ibid

[193] Qureshi, M. M., M. U. Rashid, M. A. Shah and M. A. Baluch. "Hill torrent management in Southern Punjab of Pakistan: Historic perspective and new trends." *Technical Journal* 21, no. 2 (2016): 2-9.

[194] Nawaz, Mohsin and Mooyoung Han. "Hill torrents management for increasing agricultural activity in Pakistan." (2008).

[195] N. Abas et al., "Review of GHG Emissions in Pakistan Compared to SAARC Countries," *Renewable and Sustainable Energy Reviews* 80 (December 1, 2017): 990–1016, https://doi.org/10.1016/j.rser.2017.04.022.

[196] Syed Muhammad Abubakar, "Pakistan 7th Most Vulnerable Country to Climate Change, Says Germanwatch," *DAWN*, November 9, 2017, https://www.dawn.com/news/1369425.

[197] Asad Hussain, "Climate change is giving us a beating but we seem to still be asleep," *Daily times*, Online, last updated October 7, 2019, https://dailytimes.com.pk/266810/climate-change-is-giving-us-a-beating-but-we-seem-to-still-be-asleep/.

[198] Qamar Uz Zaman Chaudhry, "Climate Change Profile of Pakistan" (Asian Deveopment Bank, 2017), https://www.adb.org/sites/default/files/publication/357876/climate-change-profile-pakistan.pdf.droughts, and cyclones in recent years that have\nkilled and displaced thousands, destroyed livelihoods, and damaged infrastructure.\nClimate change raises the prospect that these and other natural hazards will increase\nin frequency and severity in the coming decades—a stark reminder that Pakistan is one of the\ncountries most vulnerable to the effects of climate change.\nThis climate change country profile provides a comprehensive overview of climate change\nscience and policy in Pakistan, drawing insights from national and international literature. The\nprofile covers (i

[199] Ibid.

[200] "Fragile Planet: Scoring Climate Risks around the World," *HSBC*, accessed October 7, 2019, https://www.sustainablefinance.hsbc.com/reports/fragile-planet.

[201] Ibid.

[202] Sehrish Wasif, "Pakistan's Temperature to Rise by 3-5 Degrees: Report," *The Express Tribune*, February 5, 2018, https://tribune.com.pk/story/1627169/1-pakistans-temperature-rise-3-5-degrees-report/.

[203] Fahad Saeed and Abid Qaiyum Suleri, "Future Heatwaves in Pakistan under IPCC's AR5 Climate Change Scenario" (SDPI, November 2015), https://sdpi.org/publications/files/PB-46.pdf.

[204] Qamar Uz Zaman Chaudhry, "Climate Change Profile of Pakistan" (Asian Deveopment Bank, 2017), https://www.adb.org/sites/default/files/publication/357876/climate-change-profile-pakistan.pdf.droughts, and cyclones in recent years that have\nkilled and displaced thousands, destroyed livelihoods, and damaged infrastructure.\nClimate change raises the prospect that these and other natural hazards will increase\nin frequency and severity in the coming decades—a stark reminder that Pakistan is one of the\ncountries most vulnerable to the effects of climate change.\nThis climate change country profile provides a comprehensive overview of climate change\nscience and policy in Pakistan, drawing insights from national and international literature. The\nprofile covers (i

[205] Janjua Haroon,"Pakistani city breaks April record with day of 50C heat," *The Guardian*, last updated May 2, 2018, https://www.theguardian.com/world/2018/may/02/pakistani-city-breaks-april-record-with-day-of-50c-heat-nawabshah.

[206] David Eckstein, Marie-Lena Hutfils, and Maik Winges, "Global Climate Risk Index 2019" (Germanwatch, 2019), https://germanwatch.org/sites/germanwatch.org/files/Global%20Climate%20Risk%20Index%202019_2.pdf.

[207] Muthukumara Mani et al., "South Asia's Hotspots: The Impact of Temperature and Precipitation Changes on Living Standards" (World Bank Group, 2018), https://openknowledge.worldbank.org/bitstream/handle/10986/28723/9781464811555.pdf.

[208] Ibid.

[209] Ibid.

[210] Ruben Carlo Asuncion and Minsoo Lee, "Impacts of Sea Level Rise on Economic Growth in Developing Asia" (Asian Deveopment Bank, January 2017), https://www.adb.org/sites/default/files/publication/222066/ewp-507.pdf.

[211] Ibid.

[212] Ibid.

[213] Ibid.

[214] Ibid.

[215] Ruth Schuster, "Pakistan's Deadly Paradox: It Can't Combat Climate Change, but It has no Choice," *HAARETZ,* Online, Published July, 16, 2018, https://www.haaretz.com/science-and-health/MAGAZINE-pakistan-poster-child-for-lip-service-to-climate-change-1.6272138.

[216] S. Haider et al., "Spatio-Temporal Characteristics of an Unusual Wintertime Extratropical Weather System Causing Widespread Downpours over Pakistan," *Pakistan Journal of Meteorology* 13, no. 26 (2017): 37–50.

[217] Ibid.

[218] Furrukh Bashir and Uzma Hanif, "Climate Change Extremes and Rainfall Variability Over Pakistan" (Pakistan Meteorological Department, December 15, 2018), http://www.pmd.gov.pk/reports/Extrme_Events_Scenario_Under_2C_Pakistan.pdf.

[219] Ibid.

[220] Nadeem Ahmad, "Economic Losses from Disasters" (Leadership for Environment and Development

Pakistan, March 2015), http://www.lead.org.pk/lead/attachments/briefings/LPNB3.pdf.

[221] Ibid.

[222] "Report on Prevailing Drought Like Situation in Sindh With Particular Reference to District Tharparkar" (Government of Pakistan, National Disaster Management Authority (Prime Minister's Office), November 2018), http://www.ndma.gov.pk/Advisory/2018/Drought%20Situation%20%20Report%20of%20Sindh%20Particularly%20in%20District%20Tharparkar-2018%20(12-11-2018).pdf.

[223] "Economic Survey 2017-18: People Living below Poverty Line Plunge to 24.3pc," *Profit by Pakistan Today* (blog), April 26, 2018, https://profit.pakistantoday.com.pk/2018/04/26/pakistans-percentage-of-people-living-below-poverty-line-falls-to-24-3-percent-economic-survey-2018/.

[224] Adnan Aamir, "Quetta's Water Shortage Problem," *The News*, September 29, 2019, http://tns.thenews.com.pk/slowly-running-water/.

[225] Zahra khan Durrani, " Lessons for Pakistan from Droughts in the Past, *Centre for Strategic and Contemporary Research*, "Online published July 20, 2018, https://cscr.pk/explore/themes/energy-environment/lessons-pakistan-droughts-past/.

[226] Pervaiz Amir and Zaigham Habib, "Estimating the Impacts of Climate Change on Sectoral Water Demand in Pakistan" (Action on Climate Today (ACT), November 2015), https://cyphynets.lums.edu.pk/images/Readings_concluding.pdf.

[227] Ibid.

[228] Maryam Sarim, "Pakistan's Energy Mix," *The Express Tribune*, January 2, 2019, https://tribune.com.pk/story/1879268/6-pakistans-energy-mix/.

[229] "Making Every Drop Count: Pakistan's Growing Water Scarcity Challenge," *IISD*, September 29, 2016, https://www.iisd.org/library/making-every-drop-count-pakistan-s-growing-water-scarcity-challenge.

[230] Pakistan Economic Survey 2018-19," *Ministry of Finance (Government of Pakistan)*, Accessed 24 November 2019, http://www.finance.gov.pk/survey_1819.html.

[231] Ibid.

[232] Ali Abbas Khan, "Climate Change and Agricultural Challenges in Pakistan: The Need for Adaptation Policy," *Daily Times*, August 8, 2019, https://dailytimes.com.pk/445075/climate-change-and-agricultural-challenges-in-pakistan-the-need-for-adaptation-policy/.

[233] Ibid.

[234] Pakistan Economic Survey 2018-19," Ministry of Finance (Government of Pakistan), Accessed 24 November 2019, http://www.finance.gov.pk/survey_1819.html.

[235] Muhammad Ali Imran et al., "Impact of Climate Smart Agriculture (CSA) Practices on Cotton Production and Livelihood of Farmers in Punjab, Pakistan," *Sustainability* 10, no. 2101 (2018): 1–20, https://doi.org/0.3390/su10062101.

[236] Pakistan Economic Survey 2018-19," Ministry of Finance (Government of Pakistan), Accessed 24 November 2019, http://www.finance.gov.pk/survey_1819.html.

[237] Ibid.

[238] Qamar Uz Zaman Chaudhry, "Climate Change Profile of Pakistan" (Asian Development Bank, 2017), https://www.adb.org/sites/default/files/publication/357876/climate-change-profile-pakistan.pdf.droughts, and cyclones in recent years that have\nkilled and displaced thousands, destroyed livelihoods, and damaged infrastructure.\nClimate change raises the prospect that these and other natural hazards will increase\nin frequency and severity in the coming decades—a stark reminder that Pakistan is one of the\ncountries most vulnerable to the effects of climate change.\nThis climate change country profile provides a comprehensive overview of climate change\nscience and policy in Pakistan, drawing insights from national and international literature. The\nprofile covers (i

[239] Asjad Baig and Amjad Shahid, "Impact of Climate Change on Major Crops of Pakistan: A Forecast for 2020," *Pakistan Business Review* 15 (2014).

[240] Ibid.

[241] Sajjad Ali et al., "Climate Change and Its Impact on the Yield of Major Food Crops: Evidence from Pakistan," *Foods* 6, no. 6 (June 2017): 39, https://doi.org/10.3390/foods6060039.

[242] Ibid.

[243] Chirstopher Crellin, "Pakistan: Major Dams Hit Dead Storage Level," *Future Directions International,* online, published July 25, 2015, http://www.futuredirections.org.au/publication/pakistan-major-dams-hit-dead-storage-level/.

[244] Pakistan Economic Survey 2018-19," Ministry of Finance (Government of Pakistan), Accessed 24 November 2019, http://www.finance.gov.pk/survey_1819.html.

[245] Ahmed Faraz Khan. "Water Shortage: Management Challenges," *Dawn*, July 3, 2017,https://www.dawn.com/news/1342849.

[246] Ibid.

[247] Riazul Haq, "WAPDA blames water crisis on devolution," *The Express Tribune,* June 28, 2018,

[h]ttps://tribune.com.pk/story/1745208/1-wapda-blames-water-crisis-devolution/.

[248] State Bank of Pakistan. *Annual Report 2016-2017 (State of the Economy).* Chap 07. Water Sustainability in Pakistan – Key Issues and Challenges. Accessed October 11, 2018, http://www.sbp.org.pk/reports/annual/arFY17/Chapter-07.pdf.

[249] Ministry of Water and Power Office of the Chief Engineering Advisor/ Chairman Federal Flood Commission. *Pakistan Water Sector Strategy.* National Water Sector Strategy. Section 2.2. October 2002. Accessed October 11, 2018. http://mowr.gov.pk/wp-content/uploads/2018/05/Pakistan-Water-Sector-Strategy-Vol-2.pdf.

[250] Ibid.

[251] Gebran Bassil, "National Water Sector Strategy" (Ministry of Energy and Water, December 27, 2010), http://extwprlegs1.fao.org/docs/pdf/leb166572E.pdf.

[252] Riazul Haq, "WAPDA blames water crisis on devolution." *The Express Tribune*, June 28, 2018, https://tribune.com.pk/story/1745208/1-wapda-blames-water-crisis-devolution/.

[253] State Bank of Pakistan. *Annual Report 2016-2017 (State of the Economy).* Chap 07. Water Sustainability in Pakistan – Key Issues and Challenges. Accessed October 11, 2018, http://www.sbp.org.pk/reports/annual/arFY17/Chapter-07.pdf.

[254] Asian Development Bank. *Private Sector Assessment Pakistan.* Section 1.5.1. December 2008, Accessed October 11, 2018. https://www.adb.org/sites/default/files/institutional-document/32216/private-sector-assessment.pdf.

[255] Brayshna Kundi, "Pakistan's Water Crisis: Why a National Water Policy Is Needed," *The Asia Foundation*, November 1, 2017, https://asiafoundation.org/2017/11/01/pakistans-water-crisis-national-water-policy-needed/.the Pakistan Council of Research in Water Resources (PCRWR

[256] Adrien Couton, *Tackling the Water Crisis in Pakistan: What Entrepreneurial Approaches Can Add* (Running on Empty: Pakistan's Water Crisis). Woodrow Wilson International Center for Scholars. 2009.

[257] John Briscoe, Usman Qamar, Manuel Contijoch, Pervaiz Amir, and Don Blackmore. *Pakistan's Water Economy: Running Dry.* The World Bank. October 2005. Accessed October 16, 2018.

[258] Pervaiz Amir and Zaigham Habib, "Estimating the Impacts of Climate Change on Sectoral Water Demand in Pakistan" (Action on Climate Today (ACT), November 2015), https://cyphynets.lums.edu.pk/images/Readings_concluding.pdf.

[259] Khaleeq Kiani*, "*Water shortage intensifies, crops at risk," *Dawn*, July 3, 2018, Accessed October 12, 2018. https://www.dawn.com/news/1417595.

[260] Tahir Amin, "Water shortage to adversely affect Kharif crops*," Business Recorder*. May 19, 2018. Accessed October 12, 2018. https://fp.brecorder.com/2018/05/20180519372766/.

[261] Ibid.

[262] Directorate of Agriculture (Economics and Marketing Punjab), *Cotton production, marketing and export.* Project Agriculture Marketing Information Service. 2006. Accessed October 12, 2018. http://amis.pk/pdf/Pulications/CottonProductionMarketingAndExport.pdf.

[263] Shahbaz Rana, "Trade deficit narrows to $8.9b in first quarter," *The Express Tribune*. October 11, 2018. Accessed October 12, 2018. https://tribune.com.pk/story/1822985/2-trade-deficit-narrows-8-9b-first-quarter/.

[264] Tahir Amin, "Water shortage to adversely affect Kharif crops," *Business Recorder*, Online, published May 19, 2018. Accessed October 12, 2018. https://fp.brecorder.com/2018/05/20180519372766/.

[265] Salim Khoso, "Water Shortage; Its causes, impacts and remedial measures*," Conference Paper for the University of Toledo*. Online, published December 2013. Accessed October 12, 2018. https://www.researchgate.net/publication/259820824_WATER_SHORTAGE_ITS_CAUSES_IMPACTS_AND_REMEDIAL_MEASURES.

[266] Daniel Workman, "Pakistan's Top 10 exports- World's Top Exports," Online, published September 9, 2018, Accessed October 12, 2018. http://www.worldstopexports.com/pakistans-top-10-exports/.

[267] Bilal Hussain, "Industry threatens to go on strike over power, water shortage*," The Express Tribune*, April

22, 2018. Accessed October 12, 2018. https://tribune.com.pk/story/1691916/2-industry-threatens-strike-power-water-shortage/.

[268] Nadir Guramani, "Pakistan Dumps $21bn Worth of Water in the Sea Each Year: IRSA," *DAWN*, November 2, 2017, https://www.dawn.com/news/1367885.

[269] "Water Shortage of 31m Acre Feet Expected by 2025," *DAWN*, March 29, 2018, https://www.dawn.com/news/1398099.

[270] Leif Ohlsson and B. Appelgren, "Water and Social Resource Scarcity," *The Water Page*, 1998, http://www.thewaterpage.com/SoicalResourceScarcity.htm.

[271] Carl Ganter, "Water Crises Are a Top Global Risk," *World Economic Forum*, January 16, 2015, https://www.weforum.org/agenda/2015/01/why-world-water-crises-are-a-top-global-risk/.

[272] Rosie Stewart, "Wild Water the State of the World's Water 2017" (Water Aid, March 2017), https://washmatters.wateraid.org/sites/g/files/jkxoof256/files/Wild_Water_The_State_of_the_Worlds_Water_2017.pdf.

[273] Ibid.

[274] "World Water Development Report 2018," *UN-Water*, accessed September 27, 2018, http://www.unwater.org/publications/world-water-development-report-2018/.

[275] State Bank of Pakistan. *Water Sustainability in Pakistan – Key Issues and Challenges.* State Bank of Pakistan's Annual Report 2016-17, 2017.

[276] Ben Orlove and Steven C. Caton, "Water Sustainability: Anthropological Approaches and Prospects," *Annual Review of Anthropology* 39, no. 1 (2010): 401–15, https://doi.org/10.1146/annurev.anthro.012809.105045.\\uc0\\u8221{} \\i Annual Review of Anthropology\\i0{} 39, no. 1 (2010

[277] "Water and Social Resource Scarcity," *The Water Page*, accessed September 27, 2018, http://www.thewaterpage.com/SoicalResourceScarcity.htm.

[278] "Water in the Desert by Concern Worldwide," accessed October 5, 2018, https://concernworldwide.exposure.co/water-in-the-desert.

[279] "Effects of The Water Crisis On Health," *Water.org*, 2019, https://water.org/our-impact/water-crisis/health-crisis/.

[280] Zahid. K Soomro et al., "Drinking Water Quality Challenges in Pakistan," accessed October 5, 2018, https://www.researchgate.net/publication/265036997_DRINKING_WATER_QUALITY_CHALLENGES_IN_PAKISTAN.

[281] Shuja Ur Rehman and Saima Baig, "Water Consumption Patterns and Waterborne Diseases in Slums of Karachi," *Academic Journal of Interdisciplinary Studies*, 2017.

[282] "Chronic Agricultural Weakness," *The Express Tribune*, January 25, 2018, https://tribune.com.pk/story/1617119/6-chronic-agricultural-weakness/.

[283] UNDP, "Water Security in Pakistan: Issues and Challenges," Development Advocate Pakistan Volume 3, Issue 4 (UNDP Pakistan, 2016).

[284] "The Global Food Security Index," accessed October 8, 2018, http://foodsecurityindex.eiu.com/.

[285] "Pakistan: Drought - 2018-2019," *ReliefWeb*, 2018, https://reliefweb.int/disaster/dr-2018-000428-pak.

[286] Asjad Baig and Amjad Shahid, "Impact of Climate Changee on Major Crops of Pakistan: A Forecast for 2020," *Pakistan Business Review* 15 (2014).

[287] UNDP, "Water Security in Pakistan: Issues and Challenges," Development Advocate Pakistan Volume 3, Issue 4 (UNDP Pakistan, 2016).

[288] Sana Jamal, "21 Million in Pakistan Don't Have Access to Clean Water: Report," *Gulf News Asia*, March 22, 2018, https://gulfnews.com/world/asia/pakistan/21-million-in-pakistan-dont-have-access-to-clean-water-report-1.2192988.

[289] Ibid.

[290] "Balochistan: Experts Ring Alarm Bell on Water Scarcity in the Region," Unrepresented Nations and People Organization, March 22, 2018, https://unpo.org/article/20699.

[291] Maitreyi Bordia Das, "The Rising Tide: A New Look at Water and Gender" (World Bank Group, 2017), https://openknowledge.worldbank.org/bitstream/handle/10986/27949/W17068.pdf?sequence=4&isAllowed=y.

[292] Yasmeen Ghazala, "Contribution of Pakistani Women in Agriculture: Productivity and Constraints," *Sarhad Journal of Agriculture* 27 (2011).

[293] "Six Kilometers a Day," *USAID*, September 26, 2013, https://www.usaid.gov/global-waters/may-2011/six-kilometers-day.

[294] "Why Is the Global Water Crisis a Women's Issue and the Top Global Risk over the next Decade?," *HuffPost*, accessed October 8, 2019, https://www.huffpost.com/entry/why-the-global-water-cris_b_12450260.

[295] Asma Kundi, "Pakistan Currently Has Largest Percentage of Young People in Its History," *DAWN*, May 3, 2018, https://www.dawn.com/news/1405197.

[296] Khalid Bin Majeed, "Let's Make Space for Youth in Naya Pakistan," *The News*, August 12, 2018, https://www.thenews.com.pk/print/353988-let-s-make-space-for-youth-in-naya-pakistan.

[297] Adil Najam and Faisal Bari, "Pakistan National Human Development Report: Unleashing the Potential of a Young Pakistan" (UNDP, 2017), https://www.pk.undp.org/content/dam/pakistan/docs/HDR/NHDR_Summary%202017%20Final.pdf.

[298] Ayesha Khalid, "The Youth Development Index in South Asia: A Human Security Risk," Pakistanpolitico, July 9, 2018, http://pakistanpolitico.com/the-youth-development-index-in-south-asia-a-human-security-risk/.

[299] "High and Dry: Climate Change, Water and the Economy" (World Bank Group, 2016), https://reliefweb.int/sites/reliefweb.int/files/resources/K8517.pdf.

[300] Ibid.

[301] "85 Families Migrate to Lower Chitral due to Water Scarcity," *Pakistan Today*, December 15, 2018, https://www.pakistantoday.com.pk/2018/12/15/85-families-migrate-to-lower-chitral-due-to-water-scarcity/.

[302] Ibid

[303] Cristina Alvarez-Quinones Torres, "Drought in Tharparkar: From Seasonal to Forced Migration" (Asia Pacific, 2015), http://labos.ulg.ac.be/hugo/wp-content/uploads/sites/38/2017/11/The-State-of-Environmental-Migration-2015-65-76.pdf.

[304] Moosa Kaleem and Maqbool Ahmed, "How a Prolonged Drought Is Damaging Lives and Livelihoods in Many Parts of Pakistan," *Herald Magazine*, December 5, 2018, https://herald.dawn.com/news/1398733.

[305] J. Schmidt Jeremy and Nathanial Matthews, *Global Challenges in Water Governance: Environments, Economies, Societies*, 1st edition (New York: Palgrave Macmillan, 2017).

[306] Hafeez Tunio, "'Pakistan May Run Dry by 2025 If Govts Fail to Act in next 5 Years,'" *The Express Tribune*, March 22, 2019, https://tribune.com.pk/story/1934680/1-pakistan-may-run-dry-2025-govts-fail-act-next-5-years/.

[307] Riaz Hussain Qureshi and Muhammad Ashraf, "Water Security Issues of Agriculture in Pakistan" (Pakistan Academy of Sciences, 2019), http://www.paspk.org/wp-content/uploads/2019/06/PAS-Water-Security-Issues.pdf.

[308] Muhammad Arif Watto, "Groundwater — One of the Most Neglected Resources," *DAWN*, January 15, 2018, https://www.dawn.com/news/1382878.

[309] Hassan Abbas, "Short of Water?," *DAWN*, June 28, 2018, https://www.dawn.com/news/1416613.

[310] Ibid.

[311] "Living Waters: Conserving the Source of Life" (WWF, October 28, 2002), http://wwf.panda.org/?3692/Living-Waters-Conserving-the-source-of-.

[312] Hassan Abbas, "Irrigation Efficiency Key to Ending Indus Water Shortages," *The Third Pole*, February 14, 2017, https://www.thethirdpole.net/en/2017/02/14/irrigation-efficiency-key-to-ending-indus-water-shortages/.

[313] Ibid.

[314] Pakistan Economic Survey 2018-19," Ministry of Finance (Government of Pakistan), Accessed 24 November 2019, http://www.finance.gov.pk/survey_1819.html.

[315] Asad Qureshi, "Water Management in the Indus Basin in Pakistan: Challenges and Opportunities," Mountain Research and Development 31 (September 15, 2011): 252–60, https://doi.org/10.1659/MRD-JOURNAL-D-11-00019.1.

[316] Pakistan Economic Survey 2018-19," Ministry of Finance (Government of Pakistan), Accessed 24 November 2019, http://www.finance.gov.pk/survey_1819.html.

[317] Asad Qureshi, "Water Management in the Indus Basin in Pakistan: Challenges and Opportunities," *Mountain Research and Development* 31 (September 15, 2011): 252–60, https://doi.org/10.1659/MRD-JOURNAL-D-11-00019.1.providing water for 90% of the food production in Pakistan, which contributes 25% of the country's gross domestic product. But Pakistan could face severe food shortages intimately linked to water scarcity. It is projected that, by 2025, the shortfall of water requirements will be 32%, which will

result in a food shortage of 70 million tons. Recent estimates suggest that climate change and siltation of main reservoirs will reduce the surface water storage capacity by 30% by 2025. The per capita water storage capacity in Pakistan is only 150 m3, compared with more than 5000 m3 in the United States and Australia and 2200 m3 in China. This reduction in surface supplies and consequent decreases in groundwater abstraction will have a serious effect on irrigated agriculture. Supply-side solutions aimed at providing more water will not be available as in the past. Current low productivity in comparison with what has been achieved in other countries under virtually similar conditions points to the enormous potential that exists. To harness this potential, Pakistan needs to invest soon in increasing storage capacity, improving water-use efficiency, and managing surface-water and groundwater resources in a sustainable way to avoid problems of soil salinization and waterlogging. Building capacity between individuals and organizations, and strengthening institutions are key elements for sustaining irrigated agriculture in the Indus Basin.","DOI":"10.1659/MRD-JOURNAL-D-11-00019.1","shortTitle":"Water Management in the Indus Basin in Pakistan","journalAbbreviation":"Mountain Research and Development","author":[{"family":"Qureshi","given":"Asad"}],"issued":{"date-parts":[["2011",9,15]]}}},"schema":"https://github.com/citation-style-language/schema/raw/master/csl-citation.json"}

318 "How much water is needed to produce food and how much do we waste?," *The Guardian*, 2016, https://www.theguardian.com/news/datablog/2013/jan/10/how-much-water-food-production-waste.

319 Shakir Lakhani, "Why Kalabagh Dam Is Not the Answer to Our Water Woes," *The Express Tribune*, June 25, 2018, https://blogs.tribune.com.pk/story/68503/why-kalabagh-dam-is-not-the-answer-to-our-water-woes/.

320 Ibid.

321 Abdul Rehman et al., "Fertilizer Consumption, Water Availability and Credit Distribution: Major Factors Affecting Agricultural Productivity in Pakistan," *Journal of the Saudi Society of Agricultural Sciences* 18, no. 3 (July 1, 2019): 269–74.

322 Ghulam Hashmi et al., "Leather Industry and Environment: Pakistan Scenario," *International Journal of Applied Biology and Forensics* 1 (June 1, 2017): 20–25.

323 "Special Report: Pakistan's Waters at Risk: Water & Health Related Issues in Pakistan & Key Recommendations" (WWF, February 2007), https://reliefweb.int/report/pakistan/special-report-pakistans-waters-risk-water-health-related-issues-pakistan-key.

324 Ghulam Murtaza and Munir H. Zia, "Wastewater Production, Treatment and Use in Pakistan," *UN-Water Activity information System*, last modified 2012, https://www.ais.unwater.org/ais/pluginfile.php/232/mod_page/content/128/pakistan_murtaza_finalcountryreport2012.pdf.

325 Ibid.

326 Hassan Abbas, "World Water Day: National Policy on Sustainable Use of Wastewater Urged," Business Recorder, March 23, 2017, https://fp.brecorder.com/2017/03/20170323157264/.

327 Maimoona Raza et al., "Groundwater Status in Pakistan: A Review of Contamination, Health Risks, and Potential Needs," *Critical Reviews in Environmental Science and Technology*, December 14, 2017, 1–50, https://doi.org/10.1080/10643389.2017.1400852.

328 Brayshna Kundi, "Pakistan's Water Crisis: Why a National Water Policy Is Needed," *The Asia Foundation*, November 1, 2017, https://asiafoundation.org/2017/11/01/pakistans-water-crisis-national-water-policy-needed/.the Pakistan Council of Research in Water Resources (PCRWR

329 "64% Pakistanis Deprived of Safe Drinking Water, Says WB Report," *Pakistan Today*, March 22, 2019, https://www.pakistantoday.com.pk/2019/03/22/64-pakistanis-deprived-of-safe-drinking-water-says-wb-report/.

330 Muhammad Arif Watto and Amin William Mugera,"Groundwater Depletion in the Indus Plains of Pakistan: Imperatives, Repercussions and Management Issues," *International Journal of River Basin Management* 14, no. 4 (October 1, 2016): 447–58.the groundwater economy of Pakistan is at critical juncture now. Concomitant with massive pumping of groundwater aquifers through unrestricted expansion of tube-wells, groundwater exploitation has led to many negative environmental, economic and spatial impacts and serious threats to the sustainability of irrigated agriculture in the region. The spectacular increase in the groundwater development during the last half-century has manifested as a kind of 'silent revolution' carried out by thousands of farmers in pursuit of reliable irrigation water supplies. The groundwater revolution in the Indus Basin has been a result of a succession of factors –each of them exacerbated the groundwater crises in the subsequent periods. Massive groundwater extraction programmes were commenced to overcome waterlogging and salinity, which was blown up by large-scale surface water developments in coming years. Within this backdrop, this article attempts to identify the causes and consequences of groundwater overdrafting in Pakistan and draws attention to groundwater resource management issues. In this article, we discuss how the rigidity of the surface-water-allocation system, the Green Revolution, the Indus Water Treaty,

soaring population and the groundwater management policies have led to groundwater revolution. Major environmental impacts identified include soil salinization, salt water and sea water intrusion, land subsidence, and drying up of lakes and vegetation in different parts of the country. Various pecuniary impacts such as increasing pumping costs while decreasing land values are also very prominent. Migration and prospective social conflicts are amongst the potential spatial impacts. We have concluded that decreasing surface water supplies, unimpeded pumping of aquifers, lack of groundwater entitlements and the institutional impediments are the major problems related to the sustainable groundwater management in Pakistan.","DOI":"10.1080/15715124.2016.1204154","ISSN":"1571-5124","shortTitle":"Groundwater depletion in the Indus Plains of Pakistan","author":[{"family":"Watto","given":"Muhammad Arif"},{"family":"Mugera","given":"Amin William"}],"issued":{"date-parts":[["2016",10,1]]}}},"schema":"https://github.com/citation-style-language/schema/raw/master/csl-citation.json"}

331 Ibid.

332 Zofeen T. Ebrahim, "Is Pakistan Running out of Fresh Water?," *DAWN*, March 30, 2018, https://www.dawn.com/news/1398499.

333 Ibid.

334 Maimoona Raza et al., "Groundwater Status in Pakistan: A Review of Contamination, Health Risks, and Potential Needs," *Critical Reviews in Environmental Science and Technology*, December 14, 2017, 1–50, https://doi.org/10.1080/10643389.2017.1400852.

335 Ibid.

336 Muhammad Arif Watto, "Groundwater one of the most neglected resources," *Dawn*, last modified January 15, 2018, https://epaper.dawn.com/DetailImage.php?StoryImage=15_01_2018_604_003.

337 Muhammad Arif Watto, "Groundwater — One of the Most Neglected Resources," *DAWN*, January 15, 2018, https://www.dawn.com/news/1382878.

338 Zofeen T. Ebrahim, "Is Pakistan Running out of Fresh Water?," *DAWN*, March 30, 2018, https://www.dawn.com/news/1398499.

339 Naeem Khanzada, "Major Water Crisis Feared in Karachi," *The Express Tribune*, December 8, 2018, https://tribune.com.pk/story/1862409/1-major-water-crisis-feared-karachi/.

340 Matt McGrath, "'Alarmingly high' levels of arsenic in Pakistan's ground water," *BBC News*, last modified August 23, 2017, https://www.bbc.com/news/science-environment-41002005.

341 "Lead in Drinking-Water" (World Health Organization, 2011), https://www.who.int/water_sanitation_health/dwq/chemicals/lead.pdf.whatever their stage of development and their social and\neconomic conditions, have the right to have access to an adequate supply of safe\ndrinking water". A major WHO function to achieve such goals is the responsibility\n"to propose ... regulations, and to make recommendations with respect to international\nhealth matters ...."","URL":"https://www.who.int/water_sanitation_health/dwq/chemicals/lead.pdf","issued":{"date-parts":[["2011"]]},"accessed":{"date-parts":[["2019",10,15]]}}},"schema":"https://github.com/citation-style-language/schema/raw/master/csl-citation.json"}

342 Daniya Khalid, "How Serious Is the Risk to Pakistanis from Arsenic Contamination of Groundwater?," *DAWN*, August 29, 2017, https://www.dawn.com/news/1354507.

343 Ibid.

344 Muhammad Usman, Hafsa Yasin, Abdul Nasir, Waqas Mehmood, "A Case Study of Groundwater Contamination Due to Open Dumping of Municipal Solid Waste In Faisalabad," *Earth Sciences Pakistan*, 1(2):15-16.

345 "Plastic Products Polluting Pakistan's Coast, Say Experts," *The Express Tribune*, June 25, 2017, https://tribune.com.pk/story/1444147/plastic-products-polluting-pakistans-coast-say-experts/.

346 Rinkesh, "What Is Wastewater Treatment and Process of Wastewater Treatment," *Conserve Energy Future*, February 10, 2016, https://www.conserve-energy-future.com/process-of-wastewater-treatment.php.

347 Daniel Puyol et al., "Resource Recovery from Wastewater by Biological Technologies: Opportunities, Challenges, and Prospects," *Frontiers in Microbiology* 7 (2017), https://doi.org/10.3389/fmicb.2016.02106. changing the focus from residues treatment, such as wastewater treatment, towards resource recovery. Biotechnological processes offer an economic and versatile way to concentrate and transform resources from waste/wastewater into valuable products, which is a prerequisite for the technological development of a cradle-to-cradle bio-based economy. This review identifies emerging technologies that enable resource recovery across the wastewater treatment cycle. As such, bioenergy in the form of biohydrogen (by photo and dark fermentation processes

348 Jean-Philippe Venot, Marcel Kuper, and Margreet Zwarteveen, eds., *Drip Irrigation for Agriculture:*

Untold Stories of Efficiency, Innovation and Development, 1st ed. (London: Routledge, 2017).

[349] Rowan Jacobsen and Ensia, "Israel Proves the Desalination Era Is Here," *Scientific American*, published April 25, 2019, https://www.scientificamerican.com/article/israel-proves-the-desalination-era-is-here/.

[350] Daanish Mustafa, Majed Akhter, and Natalie Nasrallah, "Understanding Pakistan's Water-Security Nexus" (United States Institute of Peace, 2013), http://futuredirections.org.au/wp-content/uploads/2015/04/PW88_Understanding-Pakistan's-Water-Security-Nexus.pdf.

[351] "Singapore Water Story," *Singapore's National Water Agency*, 2019, https://www.pub.gov.sg.

[352] Ibid.

[353] Martin Jacobson, "Singapore Water Management," *WWF*, March 1, 2012, https://wwf.panda.org/?204587/Singapore#targetText=In%202001%20Singapore's%20Public%20Utilities,more%20integrated%20management%20of%20water.&targetText=This%20water%20is%20drinkable%2C%20and,Singapore%20has%20five%20NEWater%20plants.

[354] "Indian Wastewater Treatment Demo Project" (Danish Water Forum, 2011), https://ec.europa.eu/environment/archives/ecoinnovation2011/2nd_forum/presentations/Session%202/case%20studies/miriam_feilberg_dwf.pdf.

[355] Ibid.

[356] Aditya Gupta et al., "Need of Smart Water Systems in India" 11 (March 1, 2016): 2216–23.Bangladesh, China, and India who is still developing are likely to face water scarcity more. It was expected that till 2050, 70% of population will leave in city of India. With shrinking of water reservoir, low rainfall, etc is hard to feed and provide resources like water, electricity to such high population. Using sensor, Information and communication Technology (ICT

[357] "Ice Stupa - A Form of Artificial Glacier," *Ladakh*, 2019, http://icestupa.org/about.

[358] Miles Rote, "Costa Rica Has Run on 100% Renewable Energy for 299 Days," *Under30Experiences*, October 1, 2019, https://www.under30experiences.com/blog/costa-rica-has-run-on-100-renewable-energy-for-299-days.

[359] Mauricio Herrera-Rodríguez, "Sustainable Development in Costa Rica: A Geographic Critique," *Journal of Latin American Geography* 12, no. 2 (2013): 193–219.it identifies the contending values and attitudes, environmentalism and neoliberalism, that legitimize and shape the Costa Rican sustainable development model and its consequences. This contradictory mix, the paper concludes, has created a fragmented national geography where conservation and pollution, economic growth and poverty, tourism and slums coexist. Este artículo propone una conceptualización del desarrollo como un proceso geográfico que necesita de lugares como instrumentos para materializar visiones particulares sobre lo que debe existir. Esta conceptualización críticorealista se complementa con aportes de la geografía marxista para mapear las transformaciones geográficas desiguales asociadas al paradigma neoliberal que permea la práctica del desarrollo en Costa Rica y alrededor del mundo. El artículo identifica explícitamente los valores y actitudes en los que se fundamentan tanto el neoliberalismo como el ambientalismo, y que legitiman y forman parte fundamental del modelo costarricense de desarrollo sostenible y sus consecuencias. El texto concluye que esta mezcla contradictoria y contraproducente ha creado una geografía nacional fragmentada dónde conservación, crecimiento económico y turismo coexisten con degradación ambiental y miseria.","ISSN":"1545-2476","shortTitle":"Sustainable Development in Costa Rica","author":[{"family":"Herrera-Rodríguez","given":"Mauricio"}],"issued":{"date-parts":[["2013"]]}}},"schema":"https://github.com/citation-style-language/schema/raw/master/csl-citation.json"}

[360] Lindsay Fendt, "All That Glitters Is Not Green: Costa Rica's Renewables Conceal Dependence on Oil," *The Guardian*, January 5, 2017, sec. World news, https://www.theguardian.com/world/2017/jan/05/costa-rica-renewable-energy-oil-cars.

[361] Peter Foster-Bunch, "Can Costa Rica's Path to Carbon Neutrality Be Replicated by Other Countries?," *Resilience*, August 8, 2019, https://www.resilience.org/stories/2019-08-08/can-costa-ricas-path-to-carbon-neutrality-be-replicated-by-other-countries/.

[362] "Energy Strategy of Costa Rica: Towards a New Energy Model" (Ministry of Environment and Energy (MINAE), July 7, 2010), https://www.iea.org/media/pams/costarica/EnergyStrategyofCostaRicaTowardsaNewEnergyModel.pdf.

[363] Anthony Tipping, "The Outlook for Costa Rica's Electric Vehicle Revolution," *Global Risk Insights*, August 27, 2018, https://globalriskinsights.com/2018/08/costa-rica-electric-vehicle-revolution/.

[364] K.R. Gangadhara and Hetti Arachchige Jayasena, "Was Rainwater Harvesting in the Dry Zone of Sri Lanka a Technically Adapted Methodology by the Ancients?" (XII-International Rainwater Catchment Systems Association (IRCSA) Congress, Sri Lanka, 2005).\\uc0\\u8220{}Was Rainwater Harvesting in the Dry Zone of Sri Lanka a Technically Adapted Methodology by the Ancients?\\uc0\\u8221{} (XII-International Rainwater Catchment Systems Association (IRCSA

[365] Henry Gamage, "Land and Water Sector Development in Sri Lanka - Henry Gamage," *Ministry of Agriculture, Sri Lanka*, 2005, http://www.fao.org/3/ac623e/ac623e0k.htm.

[366] Mutuku Kioko, "Reversing the Effects of Climate Change through Sand Dams: A Case Story of Kyalimba SHG," *The Water Project*, June 2014, https://thewaterproject.org/community/interest_story/reversing-the-effects-of-climate-change-through-sand-dams-a-case-story-of-kyalimba-shg.

[367] Rowan Jacobsen and Ensia, "Israel Proves the Desalination Era Is Here," *Scientific American*, accessed April 25, 2019, https://www.scientificamerican.com/article/israel-proves-the-desalination-era-is-here/.

[368] Abigail Klein Leichman, "How Israel Swims against Tide of Worldwide Water Crisis," *Israel21c*, January 6, 2019, http://www.israel21c.org/how-israel-swims-against-tide-of-worldwide-water-crisis/.

[369] Brian Browdie, "Cape Town Delayed Day Zero but South Africa's Water Woes Aren't over," *Quartz Africa*, January 16, 2019, https://qz.com/africa/1525526/cape-towns-day-zero-water-shortage-fear-spreads-in-south-africa/.

[370] Ibid.

[371] Suzanne Goldenberg, "How El Paso Is Beating the Worst Drought in a Generation," *The Guardian*, June 27, 2011, sec. Environment, https://www.theguardian.com/environment/2011/jun/27/water-conservation-el-paso-texas.

[372] Patricia Els, "Embracing Closed-Loop Technology for Recycling and Reuse," *WaterWorld*, October 28, 2013, https://www.waterworld.com/municipal/technologies/article/16212349/embracing-closedloop-technology-for-recycling-and-reuse.

[373] Nadia Kounang, "El Paso to Drink Treated Sewage Water due to Climate Change Drought," *CNN*, December 5, 2018, https://www.cnn.com/2018/11/30/health/water-climate-change-el-paso/index.html.

[374] Vries J and Maarten Wolsink, "Making Space for Water: Spatial Planning and Water Management in the Netherlands," in *Planning for Climate Change* (Earthscan, 2009), 191–204.

[375] "New Water Management in the Netherlands," *Stichting Deltawerken Online*, 2004, http://www.deltawerken.com/New-water-management-in-the-Netherlands/353.html.

[376] Bokhari, S. M. H. "Case study on waterlogging and salinity problems in Pakistan." *Water Supply and Management* 4, no. 3 (1980): 171-192.

[377] Ibid.

[378] A. S. Qureshi et al., "Managing Salinity and Waterlogging in the Indus Basin of Pakistan," *Agricultural Water Management* 95, no. 1 (January 1, 2008): 1–10, https://doi.org/10.1016/j.agwat.2007.09.014.especially the smallholders, in the affected areas of the Indus Basin. These problems are the result of a multitude of factors, including 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. About 6.3 million ha are affected by different levels and types of salinity, out of which nearly half are under irrigated agriculture. Since the early 1960s, several efforts have been made to improve the management of salt-affected and waterlogged soils. These include lowering groundwater levels through deep tubewells, leaching of salts by excess irrigation, application of chemical amendments (e.g. gypsum, acids, organic matter

[379] "Water Well Installation in Umerkot, Sindh," *NUST*, 2015, http://www.nust.edu.pk/News/Pages/Water-Well-Installation-in-Umerkot,-Sindh.aspx.

[380] Waleed Majidyar, "Afghanistan and Pakistan's Looming Water Conflict," *The Diplomat*, December 15, 2018, https://thediplomat.com/2018/12/afghanistan-and-pakistans-looming-water-conflict/.

[381] "Small Dams, Big Gains," *DAWN*, May 12, 2008, http://www.dawn.com/news/302316.

[382] "Diamer Basha Dam," *WAPDA*, 2019, http://www.wapda.gov.pk/index.php/projects/hydro-power/ready-for-construction/diamer-basha-dam.