NEED FOR WATER MANAGEMENT IN SOUTH ASIA WITH SPECIFIC REFERENCE TO INDIA

A dissertation submitted in partial fulfilment of the requirement for award of degree of Master of Philosophy in Social Sciences of the Panjab University, Chandigarh

By

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45th ADVANCED PROFESSIONAL
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CERTIFICATE

I have the pleasure to certify that **Commodore Iqbal Singh Grewal** has pursued his research work and prepared the present dissertation titled **"Need for water Management in South Asia with specific reference to India"** under my guidance and supervision. The dissertation is the result of his own research and to the best of my knowledge, no part of it has earlier comprised any other monograph, dissertation or book.

This is being submitted to the Panjab University, Chandigarh for the degree of **Master of Philosophy in Social Sciences** in partial fulfilment of the requirement for the Advanced Professional Program in Public Administration (APPPA) of Indian Institute of Public Administration (IIPA), New Delhi.

I recommend that the dissertation of **Commodore Iqbal Singh Grewal** is worthy of consideration for the award of M Phil degree of Panjab University, Chandigarh.

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DECLARATION

I, the undersigned, hereby declare that this dissertation entitled. **"Need for water Management in South Asia with specific reference to India",** is my own work, and that all the sources I have accessed or quoted have been indicated or acknowledged by means of completed references. This dissertation has not been submitted for any other degree of this university or elsewhere.

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LIST OF ABBREVIATIONS

NWDT	: Narmada Water Disputes Tribunal
WSS	: Water Supply and Sanitation Board
UWSS	: Urban Water Supply System
BCM	: Billion Cubic Metre
UNEP	: United Nations Environmental Program
EUWFD	: European Union Water Framework Directive
VWSSCs	: Village Water Supply and Sanitation Committees
RWSS	: Rural Water Supply System
SWRB	: State Water Resource Board
SWPO	: State Water Planning Organisation
RBOs	: River Basin Organization
SWRDC	: State Water Resources Data Center
GIS	: Geographic Information System
NWP	: National Water Policy
NGO	: Non-governmental Organisation
TMCFT	: Thousand Million Cubic Feet

Executive Summary

Water by virtue of its multifarious uses is one of the fundamental gifts of nature. Its availability greatly influences the sustenance of life, prosperity, development potential and health status of humans. When world population was limited, its bountiful supplies seemed endlessly renewable. This, however, is no longer possible since the exponential growth rates of human population, industries and farms have already reduced the availability of water to below its minimum per capita daily requirement of about 23 litres. Water resources have for too long been taken for granted, with little or no regard of understanding of the long-term consequences of its management. The situation is alarming and the present level of awareness is not commensurate with the gravity of the consequential situation.

The problem of water and its related management is global. However, Asia being the largest continent of the world with the highest percentage of world population, where most countries are developing, the problem seems more acute. South Asia being most populated region with in Asia hence needs focus due to conflicts on sharing of water, reduced per capita availability, increased dependence on irrigation, urbanisation as a result of globalization and related inability to match the growing requirement. More importantly, India being the largest nation in South Asia, with a vision of becoming the fastest-growing economy, population growth vis-a-vis water availability is automatically a source of concern.

The research is carried out to comprehend the need for water management in South Asia with specific reference to India with respect to following questions: 1) What are the source chain and modes of harnessing water by natural processes including

the availability of water resources in the world and Asia. 2) What are the river systems, its utilization trends and demand with an analysis of South Asian countries with a particular reference to India. 3) What are the problems and challenges in present status of water resources management in India. 4) What are the recommendations/suggestions based on problem areas.

The basics of the world of water, necessity and uniqueness, mode of harnessing and availability in the globe and Asia is being discussed in chapter 2. The chapter covers logically the aspects of water due to its unique intricacies is irreplaceable and is important for the sustenance of life. Meaning of water resources, the water source chain and its modes of harnessing by natural processes. And finally, the availability of water resources in the world and Asia.

Chapter 3 focuses on understanding magnitude of the problems in South Asia by studying systematically the availability, demand, utilisation and related internal problems. This chapter narrows the study to South Asia and India. The aspects covered are - River systems of South Asia and India, basic water information, its utilization trends and demand with an analysis of South Asian countries, problem areas being faced by each country less India, issues of cross-border water distribution, utilization, management and mega irrigation / hydro electric power projects and finally detailed water resources study of India.

Chapter 4 condenses the focus on problems in India. Gives a broad overview of centralized government institutions and policies on water, and their thrust areas. This chapter is covering the aspects of broad overview of policies and thrust areas on

use of water as formulated by the government and understanding of the problem areas.

Chapter 5 covers analysis of the recommendations/suggestions based on problem areas discussed in previous chapters. The aspects in focus (i) Efforts by governments / Non Governmental Organisations / individuals in various countries and states towards better water management. (ii) Individual sectoral recommendations directed towards policy framework attention from the micro to the macro level correlating it with other dependent areas. (iii) Broad based recommendations and our own responsibilities towards conserving and preserving the precious water resources.

CHAPTER 1

INTRODUCTION AND RESERCH METHODOLOGY

1.1 **Introduction**. "Everything originated in the water and everything is sustained by water" said Goethe and it holds very true. Water by virtue of its multifarious uses is one of the fundamental gifts of nature. Its availability greatly influences the sustenance of life, prosperity, development potential and health status of humans. When world population was limited, its bountiful supplies seemed endlessly renewable. This, however, is no longer possible since the exponential growth rates of human population, industries and farms have already reduced the availability of water to below its minimum per capita daily requirement of about 23 litres. Water resources have for too long been taken for granted, with little or no regard of understanding of the long-term consequences of its management. The situation is alarming and the present level of awareness is not commensurate with the gravity of the consequential situation.

1.2 The problem of water and its related management is global. However, Asia being the largest continent of the world with the highest percentage of world population, where most countries are developing, the problem seems more acute. South Asia being most populated region with in Asia hence needs focus due to conflicts on sharing of water, reduced per capita availability, increased dependence on irrigation, urbanisation as a result of globalization

and related inability to match the growing requirement. More importantly, India being the largest nation in South Asia, with a vision of becoming the fastest-growing economy, population growth vis-a-vis water availability is automatically a source of concern.

1.3 As per estimates over the next two decades world will need 17 per cent more water to grow food for increasing population in developing countries, and the total water use will increase by 40%. Consequently, any further expansion of our activity will depend upon how well are we able to prevent the loss and contamination of the available water resources. By the year 2050 it is also likely that two-thirds of the world population would be living in areas facing water stress conditions[1].

1.4 The dramatic rise in the demand for water across the world especially in South Asia and India, the related conflicts is a serious reminder that water crisis is becoming a highly emotive issue. These vary from clashes between nations and states alike on sovereignty of water from rivers to water tariff policies. The issue further gets complicated due to the alarming lack of long-term policies towards quality, quantity and management problems and understanding between and within the countries of South Asia.

[1] **Brochure** on "**Twelfth World Water Congress**" held at New Delhi from 22-25 Nov 05 by International Water Resources Association.

1.5 When the focus comes to India the problem is compounded by the apathy of the average Indian owing to its cheap availability and related squandering. In the rural areas old canal systems are falling apart because water rates to farmers (like electricity rates) are so low that there is no money to maintain the canals. Farmer's over-pump ground water to grow water guzzling crops because of these subsidies. Water is inevitably overused and this has turned vast stretches of land into water logged and saline wastes. There are 1592 water stressed blocks in 256 districts of India.

1.6 Challenges to evolving sustainable, equitable and efficient management of India's water resources are several. Firstly, it is the non-availability of adequate scientific data on water supplies, demand and problems; and economically viable and socially acceptable technological solutions. Secondly, existing institutions in the water sector are technically oriented, sectoral, and centralized, having the mandate of managing supplies. They adopt piece-meal approaches to solve problems, and seriously lack capabilities to alter social system to promote efficient water use and control pollution. They also lack institutional capabilities to ensure equitable allocation and efficient use of water across sectors to resolve conflicts. Thirdly policies to recognise water as an integral part of the ecosystem in the wake of climatic variations and consequent environmental, social economic problems are yet to be addressed. Fourthly in the larger perspective financially and economically viable technologies for efficient and more productive use, sharing of knowledge and experience among

developed and developing countries and capacity building is lacking due to financial and trained expertise.

1.7 The greatest scarcity in the 21st century will be of water – not of oil or fossil fuels. Along with scarcity, the water wars are likely to grow not only between sectors, but also within sectors. The situation hence stresses the need for effective water resource development strategies both traditional and modern and for coherent and effective policies and programs of development and management of water source. There is a need to rethink about the existing system of tapping water resources, its utilization in various fields. A vast country like India and particularly South Asia where being at the helm of affairs, a systematic approach is needed to the problem with orientation towards managing its water resources and increase its awareness.

1.8 **Statement of the Problem**. The statement of problem are as under:-

(a) There is a wide gap between requirement and availability of water at different level of consumption.

(b) The scarcity of water is leading to conflicts across countries/region.

(c) The South Asia lacks a regional framework for ecological water governance.

(d) Remedial measures for effective utilization, management and conservation of water resources are not adapted or replicated in a wider context across the water deficient region.

1.9 **Rationale of the Study**. Water scarcity is a major source of concern across the world. Examples are aplenty, from China to Bolivia to Thailand where diversion of rivers, privatization and pricing has resulted in conflicts. The issue of sovereignty over trans boundary waters, rivers and aquifers is thus likely source of serious water wars of the future. About 260 rivers of the world that cater to 40% of the world's population are shared by two or more countries. At least 50 countries in the world can be considered to be hence flashpoints due to problems related to water sharing. As the eight Secretary-General of UN (2007-2016), Ban Ki Moon has put it aptly, "The consequences for humanity are grave. Water scarcity threatens economic and social gains and is a potent fuel for wars and conflict,"[2]

1.10 The magnitude of the problem lies in the fact that only three per cent of world's water is fresh of which, approximately 77.7 % is locked in polar icecaps and glaciers, and is not available for human use. 22 % of the earth's freshwater

[2] RSN Singh. Article **Wars Over Water** from Indian Defence Review, Apr – Jun 2005, Page 76.

is ground water[3]. In the last 70 years, the global population has trebled, while the water consumption has increased six-fold due to industrial development and growing irrigation requirements. Supplies have also grown manifold, to keep pace with the demand through exploitation of surface and groundwater. The result is that ground water resources are over-exploited leading to ground water scarcity. Surface water resources are over-appropriated in many basins and are fast depleting due to siltation. Fresh water supplies are increasingly coming under threat of pollution from industrial effluents and municipal wastes. By 2030, the world population will increase from the current 7.6 to 8.6 billion which would need an additional 40 % water to sustain the same.

1.11 Global warming is resulting in a change in the pattern of rainfall, causing drought and floods. Theoretically the availability of renewable water is the same, however intangibly it is decreasing because of human interference with the natural course of rivers by the way of diversion, damming and industrial pollution which is contributing to global warming. It will have a disastrous impact in the long run, as each river basin has its own ecological profile which supports its own unique flora fauna and population. Water therefore, has both acute internal and external security dimensions across the world, in South Asia and particularly India.

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[3] *Ibid.*

1.12 In this entire gambit of water shortage Asia and South Asia become the focal points. Of the estimated 7.7 billion population of the world, nearly 60% are Asians[4] and South Asia contributes to 40 % of the Asian population. Estimates of the future indicate that majority of the Asia's population growth is forecast to come from South Asia, which expects to add 570 million people in India, 200 million in Pakistan, and 130 million in Bangladesh over the next 50 years, hence water stress and water scarcity will be confronted by countries of South Asia. Thanks to its location, size and contiguous borders with other South Asian countries, it is India, in its capacity as both upper and lower riparian state facing depletion of water resources. The situation has developed steadily and dramatically with the per capita freshwater availability declining from over 5000 cubic meter per year in 1947[5] to 1588[6] cubic meter per annum in 2005. Against this backdrop the study has been prompted as to why water is so important to us in South Asia especially in India, the present system of distribution, drawbacks in it and need for water management along with what could be the solutions. The study draws the focus from the problem in the world to South Asia and to more importantly India being the dominant power because of its size and population.

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[4] "**The World at 7.7 Billion**" online Dec 2019, https://www.un.org/en/development/desa/population/publications/pdf/popfacts/PopFacts_2019-6.pdf, Department of Economic and Social Affairs, UN, Year 2019.

[5] India Water Resource Management, World Bank Report in collaboration with Ministry of Water Resources, Government of India, volume on "**Intersectoral Water Allocation, Planning and Management**", Allied publishers New Delhi 1999 ; Page xvii.

[6] India-WRIS wiki 2015, Census, 2011, http://indiawris.gov.in/wiki/doku.php?id=india_s_water_wealth

1.13 Solutions to these problems particularly in South Asia and India need a systematic approach. Hence logically, solutions to manage water covering efforts undertaken, needed to be taken and lessons for the future are suggested. Sustained efforts towards water management are the key, is the summary of the entire study.

1.14 **Research Objectives**. The objectives of research are to:-

(a) Study the genesis of water security problems faced by South Asia and in particular by India

(b) Review the water management and development practices in South Asia and with specific reference to India, and

(c) Identify robust, implementable methods and recommendations towards conserving and preserving the precious water resources.

1.15 **Research Strategy and Design**.

(a) **Research Strategy**. The research strategy is both qualitative and quantitative in approach.

(b) **Research Design**. The research design is descriptive and exploratory in nature based on the following: -

(i) Existing policy of Govt of India towards water management including the focus of proposed Jal Shakti Abhiyan.

(ii) Water management & development reforms of South Asian countries.

(iii) Review of Books, Journals and Published Articles

(iv) Reports Released By GOI, Developed countries and Various Other Organisations

1.16 **Research Question**. The major research questions that the study intends to address are as follows: -

(a) What are the source chain and modes of harnessing water by natural processes including the availability of water resources in the world and Asia?

(b) What are the river systems, its utilization trends and demand with an analysis of South Asian countries with a particular reference to India?

(c) What are the problems and challenges in present status of water resources management in India?

(d) What are the recommendations/suggestions based on problem areas?

1.17 **Research Limitations/Delimitations**. The study confines itself to analysis of secondary data. It analyses the relevant policies, national framework bill and other pieces of data published by Ministry of Jal shakti and government sources in the developed countries. The focus is on a broad, vast array of related aspects about water, its management in the form of a logical buildup starting from its importance, available resources globally, regionally to South Asia and India, present mode of use and related policies, problem areas and finally the recommendations. The focus shifts from a broader plane to South Asia and particularly India.

1.18 **Literature Review**

(a) **Ballabh Vishwa, (2008) Governance of Water, Institutional Alternatives and Political Economy, SAGE**.

The author highlights that India particularly stands on the brink of an uncertain future, its ever-growing population is putting pressure on its increasingly meagre water resources. The challenges facing water governance in India cannot be addressed in the current policy framework. An oft-quoted, modern adage is that the next major global conflict is over water. In many areas of the world the present is already

marked by an uneasy competition among different water users leading to conflicts. The research on the transformation of water governance requires in-depth analysis to make the process more transparent, participatory and accountable to the larger society.

(b) **Mallet Victor, (2017) River of Life, River of Death, The Ganges and India's Future, Oxford University Press**. The author focuses on tracing of river from ancient times to the present day. The pollution that threatens human and animal health in India and around the world is covered and highlight that the same people who adore the river abuse it. The threats facing the Ganges – from pollution, overpopulation, climate change, and often bad politics – are also the severest problems threatening India's progress is discussed. A scientific management is required to minimise river pollution and improve water management and require further analysis.

(c) **Dinesh Kumar. M, (2010) Managing Water, In River Basins, Oxford University Press**. The author highlights that managing water resources effectively is one of India's prime concerns today. He provides an in-depth analysis of existing methods of water management and highlights the gaps in the use of water in various river basins. The kind of interventions that would be needed to avert the nature and magnitude of water scarcity would need further analysis.

(d) **RB Mandal, (2006) Water Resource Management, Concept Publishers.** The author addresses a variety of issues pertaining to water resource utilisation and management, the length of problems of water supply for agriculture and industrial use and the problems and solutions of inter-state river water disputes. The existing water harvesting techniques, sustainability of water resources and help rendered by watershed management and remote sensing is also discussed. The method to generate a realistic scenario for future water demands and assessing the type, nature, and magnitude of scarcity need further investigation.

(e) **Narendra Kumar Tripathi, (2011) 'Scarcity Dilemma as Security Dilemma: Geopolitics of Water Governance in South Asia', Economic and Political Weekly, Vol 46, No 7, 67-72.**

The author highlights that postcolonial character of south Asia imparts a Janus-faced perspective to our outlook. Many issues are much more than what they seem because they symbolise many other viewpoints. Water disputes in the region are a typical example of the scarcity dilemma acquiring the overtones of a security dilemma. However dire the mutual needs of the nations that face a water crisis, they are also caught in a vortex of geopolitical forces. The only way out of this "us" versus "them" circle is evolving a knowledge system on water resources that is interdisciplinary and one that dispenses with the colonial engineering models of development. The social sciences have

largely ignored the study of water; hence an engagement with water issues from the social science perspective is vital. Until and unless a fairly developed social science literature develops on transboundary resources, the discontent on access to them will prevail.

(f) **Bikramjit De (2014), 'Water management in the age of decolonization: An account of the development of the Ganges and Teesta water dispute in South Asia', Journal of the Indian Law Institute, Vol. 56, No. 3, 348-375.** The author seeks to address factors that were responsible for the making of the Ganges and Teesta water dispute, a transboundary water dispute between India and Bangladesh, after the start of decolonization of South Asia. Drawing on both primary and secondary sources, it seeks to explore historical, political and socio-cultural circumstances behind the making of a bitterly contested international water dispute spanning over sixty years. No study of contemporary South Asian law and politics is complete without a critical analysis of the democratic institutions, structures and processes that were involved in the creation and development of one of the most intractable international water crises of the second half of the twentieth century. The roles of the respective governments of these two South Asian neighbours in the manifestation and resolving of this dispute is evaluated in the context of the Indian government's legitimate demand for the use of the waters of these two rivers for the successful implementation of its interlinking of rivers project.

1.19 **Research Methods and Data Sources**

(a) **Research Methodology**. The methodology proposed to be adopted is exploratory in nature and comprises of the following:-

(i) Critical review of secondary literature.

(ii) Information collated from the secondary source will be interpreted and analysed to impart a logical flow of thought & arrive at specific facets of the problem.

(b) **Data Sources**

(i) Secondary data available in public domain i.e. relevant books, reports released by Govt of India, various other organisations/agencies viz, Reports on water resources management with a view to devise future strategy prepared by India's Ministry of Jal Shakti in collaboration with Ministry of Urban Affairs, Rural Affairs and the World Bank World bank etc.

(ii) Secondary data available in periodicals, national & international journals, published articles in newspapers & magazines, internet sites, website of the Ministry of Jal Shakti etc.

(iii) Inferences based on exploratory research for analysis of the information and formulation of views.

CHAPTER II

WATER – ITS NECESSITY, MODES OF HARNESSSING AND GLOBAL AND REGIONAL RESOURCES

1. The basics of the world of water, necessity and uniqueness, mode of harnessing and availability in the globe and Asia has been covered in this chapter. This chapter focuses on Gen aspects of water, water resources, hydrological cycle, modes of harnessing water, an overview of global and regional water resources and finally the major challenges for future.

Water – Gen Aspects[7]

2. **Origin and History**. The origin of water on the earth is not so clear. The volatile constituents bound in the earth's crust, oozing to the surface through volcanoes, rock movements and hot springs, condensed to form the ocean and the atmosphere. Thus, water came into being and became indispensable in earth's environment. The great epics tell about the determined King Bhagiratha who brought river Ganga to earth and the extraordinary act of Aruni in stopping the wastage of water by lying down at the spot where the canal was breached. The basis of civilization was the presence of water.

[7] Kulkarni U and Mrs Bhanu Kakrani, **"Water, Environment and Pollution"**, New Delhi; Agrobios India, Chapter 2 **"Water"** pp 05-07, Chapter 3 **"Water – Physical Characteristics"**, pp 27-29, Chapter 4 **" Water – Chemical Characteristics"**, pp 30-47, Chapter 5 **" Water – Biological Characteristics"**, pp 48-69 2000. (Chapter 3, 4 and 5 for reference only).

3. **Uniqueness**. Of the three states in which water occurs in the ecosphere (atmosphere, lithosphere and hydrosphere) gas, solid and liquid – only the last is indispensable resource. No other substance by virtue of its use and certain in-depth properties forms the basis of life and various facets of human development. The evidence for it lies in following facts:

(a) Its nearly three quarters of the weight of the living cell. It constitutes sixty percent of an adult human and 98 percent of the mass of certain jellyfish. Thus, high rainfall over a landmass invariably means a large biomass per unit area.

(b) Applications for humans vary from drinking, irrigation, fisheries, industrial processes, transportation and waste disposal.

(c) Water has a combination of the properties of being a universal solvent, natural insulator but conductor due to presence of salts, chemically inert, with ideal specific heat of 1.0 calorie, latent heat of vaporization and fusion and presence of oxygen, carbon di oxide and other salts which are unique. These have universal applications for sustenance of life and human activities.

Meaning of Water Resources

4. A mere 0.5 percent of all the water in the world is available to man. This statistic has no meaning as water has to be "borrowed" for a time before it finally makes its way back to the watercourse in the form of sewage or drainage water or another "link" in the water cycle. Its speed of replenishment, movement in the natural cycle is of concern. The replenished water to the sources alone can be extracted and has to be shared.

5. Hence the term "water consumption" strictly speaking is applicable in a technical sense only, because "consumed" water never disappears from the global circulation system. Therefore, the diversion of water is a shunting operation, a short-circuiting of the natural water cycle at one point or another[8].

Hydrological Cycle

6. The total flow of water circulating in the water cycle is the source of water supply. The sun, sea, and atmosphere can be said to form nature's own gigantic desalinization plant and distribution system. The sun supplies energy and drives the "water wheel", to keep fresh water in circulation through evaporation, precipitation and runoff all the time-from the sea to the atmosphere, to the land, and from the land back to the sea. This process is known as the hydrological cycle or the water cycle.

[8] Malin Falkenmark and Gunnar Lindh "**Water for a Starving World**" , Westview Press Page 12-14, 1976.

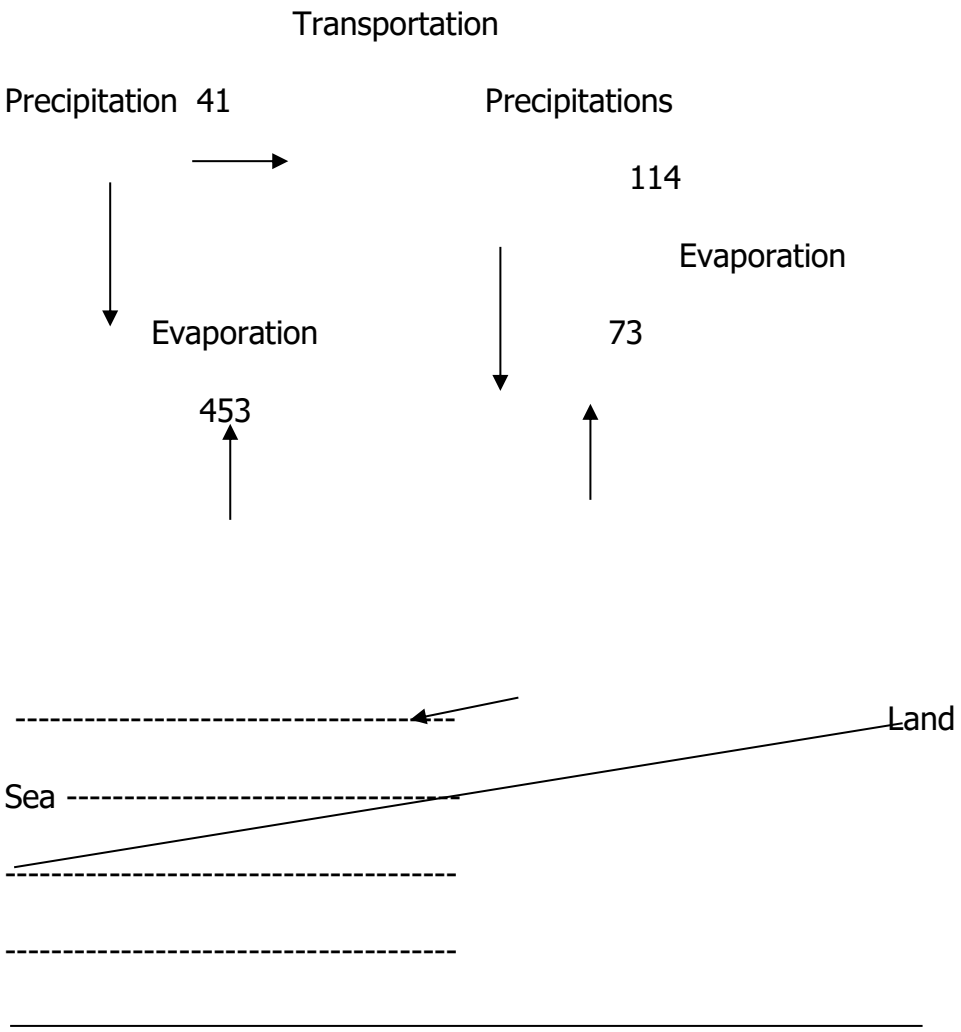

Fig 1 Global Water Balance (units of 1000 km³ per annum)[9]

7. The cycle is the continuous process of exchange of water from earth's surface to the atmosphere and vice versa under the influence of solar heat. Certain aspects of the hydrological cycle are:-

(a) Sun yearly, lifts about 453,000 km³ water out of the sea by evaporation. A unit of measurement is the flow unit (flow unit equals

[9] Malin Falkenmark and Gunnar Lindh "**Water for a Starving World**" , Westview Press Page 12-14, 1976.

1,000 km³ per annum). Seawater evaporation hence equals 453 units. Of it, 412 units return to the sea as rain. The remaining 41 units are carried by the winds over land areas, to join the 73 units evaporated from the land areas. Altogether, 114 units are precipitated as rains or snow over the land areas and penetrate the soil to different degrees. Most precipitation returns to the atmosphere from water surfaces, damp soil surfaces and from plant transpiration. The remaining 41 units return to the sea again via rivers and groundwater flow, thus completing the water cycle[10].

(b) Excluding the ice and water which runs off in Greenland and the Antarctic, only about 38 units is in the inhabited continents. These 38 units are an average for the whole of the year. Both precipitation and evaporation vary from time to time resulting in floods, low water flow or drought.

(c) The transport of water by these means is maintenance of water balance in the environment. The assumption is that the water in the oceans and ice caps is fairly constant. Averages over a period of years and the water balance of the Earth's surface can be expressed by the simple relationships[11].

[10] *Ibid*, pp 15

[11] Kulkarni U and Mrs Bhanu Kakrani, **op.cit..** , Chapter 2 **"Water"** pp 14-15.

Water lost = Water gained

For the Oceans

Evaporation = Precipitation + Runoff

(Loss) (P) (R)

For the Continents

Evaporation + Runoff = Precipitation

E + R P

(Loss) (Gain)

(d) Wind, temperature and humidity continuously control evaporation and evapo –transpiration.

(e) Atmosphere adjusts change in equilibrium of the hydrological cycle by transportation of water vapour from the excess areas to the deficient areas. But the clouds deposit their precious contents in varying quantities at different places mostly over oceans leaving vast areas of land water starved.

(f) **Runoff.** Variations in runoff are extreme in some parts of the world, owing to differences in climatic and storage conditions. The total low-water runoff can be said to equal about 14,000 km ^{3} per annum, or 14 flow units. The difference between the total runoff of 38 units and

the retained portions of 14 units, which is about 25 units flow in the rivers for a short time and are in the form of spring floods or heavy rain floods flows directly into the sea, cause damage and cannot be harnessed.

(g) The total available water is essentially the same. 97.3 % are contained in oceans and balance 2.7 % is mostly in solid form. Atmospheric water is a mere 1x10 -5 of the total resources and less than a percent of total mass of atmosphere[12]. A detailed water source chain or corporate feed is given at Appendix 'A' and its annexure. The water available is only 2.61% of the total hydrosphere i.e. 36020 cu km of water can be utilized and management of which is required.

Modes of Harnessing[13]

8. A detailed study of fresh water enables division under five well marked classes which also are their modes of harnessing as under:-

(a) **Atmospheric Water**. Rain water and water from snow are grouped under atmospheric waters. They wash the dusty atmosphere and bring down dust, soot, other suspended particles and air –borne

[12] Dr KL Rao, "**India's Water Wealth Its Assessment, Uses and Projections** " Longman, 1975, Chapter 1 **" Origin of Rain and Water"** , Page 1-2.

[13] Kulkarni U and Mrs Bhanu Kakrani, **op.cit..** , Chapter 2 **"Water"** pp 11-13.

bacteria to the earth. It forms 0.001% of the fresh water (2.61%) present in hydrosphere.

(b) **Surface Water**. The raindrops and snowflakes on reaching the surface of the earth become contaminated with soil micro flora of the area. Initially these waters have few microorganisms but as it flows from higher regions to lower regions, they increase considerably. Highest count of micro- organisms in river water is during rainy seasons. They form part of lakes and rivers.

(c) **Stored Water**. Water present in ponds, reservoirs, lakes or ocean for a considerable period is called stored water. These waters are microbe rich.

(d) **Ground Water**. Rain fall on earth is acted upon by, forces of gravity and electrical attraction between the water and the other materials. After all land surfaces get wet, gravity pulls the excess of water down through the spaces in the rock, sand or gravel below. Finally the water blocks up to form water table when it meets rock that has no porosity. Below the water table the rock is saturated and above it is moist. This forms 0.58% of fresh water (2.61%) on earth.

(e) **Soil Water**. A thin film of water in chemically combined / uncombined form normally surrounds soil water from which plant roots

take up all the water. In the former, it exists as water of crystallization of mineral grains and hydration of clay mineral particles. Both these kinds are not at all available to the living organisms. Uncombined water is held as soil adhesion (attraction between soil particles and water molecules) and cohesion (attraction between molecules of water). Soil water sources are of four types :-

(i) Gravitational Water.

(ii) Capillary Water

(iii) Hygroscopic water.

(iv) Water Vapour.

Global and Regional Water Resources – An Overview

9. The yearly availability of actual water after evaporation or absorption into ground water is between 39,500 km³ and 42,700 km³ a year[14], which after runoff in floods and need for aquatic ecosystems to function and inaccessibility leaves only 9000 km³ readily accessible to humans. An additional 3500 km³ is stored in reservoirs. However world water situation differs due to uneven distribution. The maps at Appendices P and Q explain the same.

(a) The map at Appendix P gives following inferences:-

[14] "**Will There be Enough Water**" online 27 Sep 2005, www.earthtrends.com, Source – Pilot Analysis of Global Ecosystems : Freshwater Systems by Carmen Ravenga pp 1-2.

(i) Arid and semiarid regions receive only two per cent of the world's runoff, even though they occupy roughly 40% of the terrestrial land.

(ii) 41 per cent of world's population, or 2.3 billion people, live in river basins with high water demand relative to the available runoff, hence under "water stress". The per capita water supply is between 1000 - 1700 m^3 /year.

(iii) Approximately 1.7 billion people (out of the 2.3 billion) live in high water scarcity basins with water supply less than 1000 m^3 per capita[15]. South Asia has most countries in the water stress /scarce zones.

(b) The inferences from map at Appendix Q are:-

(i) Water supply from precipitation is compared with water requirements of plant life i.e., potential evaporation which is water requirements of vegetation governed by climatic conditions alone. Natural type of vegetation is governed by the existence of a surplus or deficiency of water. Higher deficiency results in deserts and semi deserts.

[15] *Ibid.*

(ii) In areas of moderate shortage vegetation takes the form of Steppe, Prairie, or Savannah.

(iii) Developing countries are situated in water deficient zones. Agricultural conditions in these are dependent on the compensation of this water deficiency.

(iv) Water surplus is in tropical areas of the equatorial zone, where morel water is left over when the needs of vegetation have been supplied. Vegetation is deciduous or coniferous forest in temperate climates, and tropical rainforest in the tropics.

(v) South Asia especially India is predominantly situated in the water deficiency zone, the vegetation is monsoon rain forest, the reason being that vegetation of this kind can survive on less water[16].

(c) Estimate of water consumption / availability patterns based on above maps show that at least 3.5 billion people or 48 per cent of the words projected population will live in water stressed river basins in 2025

[16] Falkenmark **op.cit.,** pp 2-4.

(Appendix 'B')[17]. Even in regions with high per capita water availability shortages in the dry season are likely.

(d) Populous river basins will also gradually slip into water stress (with water per capita falling below 1000 m^3 per year) by 2025 as water consumption rises.

(e) **Summary of Global Resources.** These facets must be kept in mind while studying water resource potential of regions and countries:

(i) The absolute quantity of water on earth is enough to sustain all life forms known to exist today. The fresh water supply is renewed each year by the hydrological cycle. But global abundance is unfortunately uneven across different parts of the world.

(ii) Besides physical distribution, variant rates of population growth, demand for irrigation, drinking and domestic use, industrial purpose, hydropower generation, navigation etc determine the relative availability in different countries.

(iii) Human activities have continuously polluted the fresh water. The quality of fresh water also determines its usefulness.

[17] Carmen Ravenga **op.cit.,** , pp 2-3.

(iv) The urban surface runoff and agricultural run off are almost impossible to control. Moreover, the unpredictable and volatile nature of fresh water makes its dependability suspect. A summarized format of water resources potential in terms of the runoff is given at Appendix 'C'[18].

10. **Regional Resources.** The fresh water availability and withdrawals in Asia is at Appendix 'D'. The irrigation effectiveness in present and changed scenarios in withdrawal patterns against global averages is given at Appendix 'R'[19]. The major indicators are:-

(a) Asia with about 60% of world population uses maximum water for irrigation and extracts ground water to a great extent. India and China with its maximum population are major contributors to the same. Other sectors use comparatively small percentage of water resources.

(b) Growing population and industrialization will place greater demand on other sectors. Thus, competing requirements between irrigation and other sectors will increase in the future. Better irrigation

[18] Falkenmark **op.cit.,** pp 17.

[19] "**World Water Demand and Supply**", online, 27 Sep 2005, www.adb.com, 1990-2025 Scenarios and Issues. IWMI (Appendix D and R)

techniques are hence required to improve the situation to compete with the global averages (Appendix 'R').

(c) South Asian countries will be the key to overall improvements envisaged in Asia towards availability and use of fresh water.

11. **Challenges.** The major challenges for the future are:

(a) **Irrigation.** Population vis –a- vis water availability and requirement for irrigation needs to be addressed. By 2025 to meet food requirements for a population of approximately eight billion (up 1.7 billion from 2005), water requirement for irrigation has to match up to present proportional rise of 2.5-fold. Presently the irrigation techniques are obsolete and wastage is up to 60 %[20].

(b) **Ground Water.** More than one billion people in Asian cities and 150 million in Latin American cities rely on groundwater from wells or springs. The rural records are incomplete in most countries. Humans withdraw approximately 600-700 km³ of groundwater per year—about 20 percent of global water withdrawals. Over drafting and pollution are robbing the streams and ponds of the water required for its flow[21].

[20] Carmen Ravenga **op.cit.** ,pp 3-4.

[21] *Ibid.*

(c) **Pricing.** Water needs to be priced adequately as irrigation and domestic users are paying only a pittance.

(d) **Developing Countries**. They need to reform the systems of water use, address the issues of irrigation techniques, pollution, and population growth and overcome disputes on sharing of rivers.

12. Thus, the understanding of global and regional water resources as elucidated above with the problem areas highlighting the future challenges required to be addressed, lead us logically to South Asia which constitutes 40 % of the Asian population.

CHAPTER III

AVAILABILITY, DEMAND, UTILISATION AND RELATED INTERNAL PROBLEMS IN SOUTH ASIA

1. This chapter focuses on understanding magnitude of the problems in South Asia by studying systematically the availability, demand, utilisation and related internal problems of water resources.

2. Freshwater is the most crucial resource issue facing South Asia. The countries in South Asia, primarily India, Pakistan, Bangladesh, Nepal and Bhutan are experiencing massive population growth, and also suffering from rampant poverty from economic and human development terms. Availability and demand of this resource is increasingly becoming a mismatch. High population density coupled with low per capita income and a predominantly agricultural economy necessitates the sustainable water management of shared river[22]. The challenges are on several fronts. The main ones are:

(a) **Rise in Population.** It is expected to reach 1.5 million by 2020. 50 per cent of current population lives below poverty line. The region has the lowest per capita incomes in the world despite substantial

[22] Ashok Swain, " **Managing Water Conflict**", **Asia, Africa and the Middle East**, London and New York, Routledge Taylor and Francis group, 2004, Chapter 2, pp 43-45, 2004.

economic growth in the 90s. Growing subsistence needs, impose larger demands on water, arable land, forests and coastal habitats.

(b) **Rivers, India and Security.** South Asia is primarily fed by Indus and the Ganges – Brahmaputra which are the source of riparian disputes and cooperation. The linkage between land and water use of one kind in one part of a basin can negatively or positively influence activities in other different parts of the basin. There is a failure to perceive this interconnectedness causing conflict. India at the core of the region being both a upper and lower riparian state, occupying 73% of the total area, with gross national product three fourths of the region, and three times more population than the combined population of the other countries is viewed with fear and suspicion. Water thus mars bilateral relations among the countries of the subcontinent[23]. Analysts are of the view that Pakistan's overriding strategic interest in Kashmir, is to secure its river waters. Water therefore has both acute internal and external security dimensions[24].

(c) **Failure of Large Scale Water Projects.** High capital costs, recurring expenditures, location specific disruptions of the environment and problems of rehabilitation mar the large scale water projects in South Asia particularly India.

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[23] *Ibid.*

[24] RSN Singh **loc.cit.,**

(d) **Utilisation.** Major portion of the water resources are utilised and subsidized for domestic use and surface irrigation systems causing large scale wastage, apathy due to accompanying low tariffs. Other sectors are neglected.

(e) **Failure of Governments.** Water management in the present state is lacking direction, concerted efforts on part of governments of all countries of South Asia.

Overview River Systems – South Asia and India

3. **South Asia.** The region is primarily fed by the Indus River and its tributaries and Ganga – Brahmaputra – Meghna /Barak basin.

(a) The Indus River (2900 km) originates in the Tibetan Himalayas. After flowing through Jammu and Kashmir the river enters Pakistan. The basin comprises of the Jhelum, Chenab, Ravi, Beas and Sutlej rivers and one major right bank tributary, the Kabul river. It covers the largest irrigated area, nearly 26 million hectares, of anyone river system in the world. According to the Indus Water Treaty of 1960, signed between India and Pakistan, flows of four main rivers are available to Pakistan ie, Indus, Kabul, Jhelum and Chenab, while India has exclusive rights to waters of Ravi, Beas and Sutlej rivers. India is barred from interfering

with flow of Indus, Chenab and Jhelum feeding Pakistan, but allows it to generate electricity from them.

(b) The Ganga – Brahmaputra – Meghna / Barak basin sustains about 10 per cent of the world's population. The Ganga basin constitutes 25 per cent of India's land area and is home to 25 per cent of the Indian population. Of the countries that form part of the Ganga – Brahmaputra – Meghna / Barak basin, China contributes solely to the flow of the Brahmaputra and Nepal to the flow of the Ganges. The 2900 kilometre long Brahmaputra has the greatest volume of water of all rivers in India, because of heavy rainfall in the basins catchments. The Ganga – Brahmaputra – Meghna / Barak river system flow into the Bay of Bengal is one of the largest in the world for a single outlet. The Barak river feeds both the Surma and Kushiara rivers in Sylhet which are crucial to the vitality of the Meghna and its tributaries for Bangladesh. Her water related interface with India is rather crucial since 80% of annual fresh water supplies come to her as trans boundary inflow through 54 common rivers with India[25].

(c) The overall picture which emerges in the mainland of South Asia is as follows: -

(i) India and Pakistan have more or less equal riparian status.

[25] Viktor Danilov Danilyan. Article "**Global Thirst**" from Indian Defence Review, Apr – Jun 2005, Page 81.

(ii) Bangladesh is a lower riparian as compared to India.

(iii) Nepal acts as an upper riparian to India.

4. **India.** The river systems of India are given at Appendix 'S'. Rivers form the natural source of water. Three well-defined watersheds control the drainage of India. In the north, there is the great Himalayan watershed, along with Karakoram branch. In central India, the watershed of the Vindhya and Satpura – Maikala mountainous ranges. In South, the Sahayadri watershed directs course of the rivers of Deccan plateau. Thus, basins and catchments areas are created which vary in size and in volume of flow of water. Indian River system is classified on a three-fold basis: the area of origin, the nature of the river and the feed system (snow or rain) of the streams. Interlinking the three systems Indian rivers are divided into four groups, Himalayan, Deccan, Coastal and Inland drainage basin rivers. Based on the above classification river basins drained by the major, medium, minor and desert rivers of India are as under.

(a) **Ganga**. The river basin drained with its catchment area is of 861452 sq km which is one-fourth of India's total surface area[26]. The boundaries are Himalayan ranges in the north and the ranges of the Vindhyas in the south. Perennial rivers feed area between these two ranges. There are two main headwaters in the Himalayas, the Bhagirathi and the Alakananda. As the Ganges flows through the northern plains,

[26] Website Ministry of Water Resources online 30 Oct 2005, www.mowr@nic.in, Natural Water Resources at a Glance.

it is joined by tributaries of the Ganga system ie, the Yamuna, Ghagra, Gandak and Kosi. Yamuna rises in the Yamontri glaciers and joins the Ganga at Allahabad. In Central India Chambal, Betwa, and Son join the Ganges. The total flow of water through the rivers of the Ganga basin is approximately around 489,397 m^3 of which the available flow is around 165,000 million.

(b) **Brahamputra & Indus**. The Brahmaputra drains 194413 sq km and the Indus 321289 sq km[27], of which approximately 10 percent is of India's total area. The Brahamputra needs investment and coordination to utilize its maximum discharge at the beginning of the rainy season between India, China and Bangladesh.

(c) **Godavari- Krishna**. The second largest river basin is the Godavari which drains another 10 percent of India's total surface area. The Godavari basin extends to some 312812 sq km[28]. The Godavari is a deltaic river, vulnerable to floods cyclones but is agriculturally rich and is responsible for the prosperity of Andhra Pradesh. The basin of the Krishna in the south extends to over 258948 sq km. Krishna too is a deltic river of considerable economic importance.

[27] *Ibid.*
[28] *Ibid.*

(d) **Mahanadi, Narmada and Cauvery.** The third largest peninsular basin is of river Mahanadi, draining 141589 sq km. The Narmada drains 98796 sq km and the Cauvery 81155 sq km[29].

(e) **Tapi & Pennar**. Tapti in the north – east and Pennar in the south draining 65145 and 55213 sq km[30] respectively are small but economically important. Through its streams and rivulets, they cover a fairly large area, measuring 556,800 sq km.

(f) **Medium and Minor Rivers.** Medium rivers are west flowing to include Periyar, Ambika etc which drain 2000-20000 sq km, whereas minor rivers drain less than 2000 sq km[31].

(g) **Desert Rivers.** These flow in the Rajasthan deserts to include Luni, Saraswathi, Machai etc[32].

(h) The river flow totals some 16,77,000 million cubic meters or 1350 million acre-feet. Of this, 5,50,000 million cubic meters is usable for irrigation.

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[29] *Ibid.*

[30] *Ibid.*

[31] KL Rao, **op.cit.,** Chapter II, **" Rainfall and Drought Areas in India** " pp 99, 102.

[32] *Ibid.*

Availability, Demand, Utilization and Internal Problems

5. A study of individual South Asian countries in terms of its water resources is covered to understand the magnitude of problems within and regionally.

6. **Pakistan.** The basic water information is given at Appendix 'E'[33]. Leaving aside inland drainage area of Balochistan, and the southern coastal region, major part of Pakistan lies in their Indus basin.

(a) The data on water information indicate the following :-

(i) 75% of water is received as share from international rivers.

(ii) Per capita availability is one of the lowest in South Asia.

(iii) Major usage is for agriculture.

(iv) A healthy percentage of population has got access to water supply but access to sanitation especially in rural areas is poor.

(b) The major problem areas are:-

(i) Fresh water availability has decreased from 5.103 m^3 /cap/ year to 1.703 m^3 /cap/ year which is one of the least. A crisis is in the offing[34].

[33] "**Basic Water Information** ",online, 27 Sep 2005, www.earthtrends.com, updated 2002.

[34] Zaigham Habib, Article "**Pakistan: Indus Basin and Water Issues"** from journal South Asian Jan – Mar 2005, pp - 142.

(ii) Out of a total of 18 million hectares (mha) of irrigated land, about 6.22 mha is affected by water logging and salinity[35].

(iii) Inter-provincial conflicts on water distribution including flood management. Sindh and NWFP provinces oppose Kalabagh dam on the Indus River as they feel that more Indus water will be diverted to Punjab.

(iv) Over all shortage particularly in saline and arid areas.

7. **Bangladesh.** The basic water information is given at Appendix 'F'. Crisscrossed by rivers and streams, Bangladesh is a water abundant country.

(a) The data on water information indicate following:-

(i) In South Asia she has higher annual water resources and accessibility in terms of the area covered.

(ii) Drawls per capita are amongst the lowest in South Asia.

(b) The major problem areas[36] are:-

[35] Ramaswamy R Iyer, Article "**South Asian Water Concerns"** from journal South Asian, Jan – Mar 2005, Page 7.
[36] Emaduddin Ahmad, Article "**Bangladesh Water Issues"** from journal South Asian Jan – Mar 2005, pp 13, 55-56, 62.

(i) **Flood Management.** The country acts as a narrow funnel for Ganga, Brahmaputra and Meghna to drain into the sea, thus the periodical occurrence of disastrous flooding. Projects for flood control (Flood Control Plan or FAP) and drainage are not well maintained due to the lack of funds.

(ii) Adverse impact of water -logging, disallowing available necessary flooding, closing navigational routes and overall shortage of freshwater fish are seen.

(iii) Agricultural and fisheries sector are in conflict. The plans are for expanding fisheries resources and reduce agricultural land. Hence self-sufficiency in food production is in danger.

(iv) Deteriorating quantity and quality with presence of arsenic in groundwater.

8. **Nepal[37].** The basic water information is given at Appendix 'G'. A large number of rivers and streams flow through Nepal and into India. 6000 of world's most forceful rivers and streams are here. Out of 194471 sq km of drainage area, 76% falls within Nepal and 33 of them are greater than 1000 sq km. Nearly 225 billion cubic metre of water from Nepal flows into the Bay of Bengal

[37] BH Nepal, Article "**Managing Nepalese Waters"** from journal South Asian Jan – Mar 2005, pp 44-46.

via India. The Karnali, Sapta Gandaki and Sapta Koshi, all trans – Himalayan rivers flowing through Nepal, contribute 71 per cent of the dry season flows and 41 per cent of the annual flows of the Ganges.

(a) The data on water information indicate the following:-

(i) It has the lowest percentages of water share from international rivers in South Asia.

(ii) Despite resources availability, access to water supply is one of the lowest.

(iii) Water withdrawals mostly in Kathmandu valley per capita are the highest.

(iv) Incidence of water related diseases is high.

(b) The major problem areas are:-

(i) Potential of hydroelectric power has not been exploited fully. Controversies exist within Nepal over these projects. There is also inadequate hydro meteorological network to back up the same.

(ii) Annual abstraction is much greater than the maximum recharge estimates into the rivers.

(iii) Potential of water transportation - navigation not fully utilized.

9. **Bhutan.** The basic water information is given at Appendix 'H'. She is well endowed with water; the people are inclined to economics and management as also preservation of ecological balance.

(a) The data on water information indicate the following :-

(i) Has richest water resources.

(ii) Per capita water withdrawal is the lowest in South Asia.

(iii) There is a fine balance in both accessibility to water supply and sanitation.

(b) The major problem areas are:-

(i) Full exploitation of the resources is yet to be done.

(ii) The country is not geared up for population growth and the related economic development.

Cross border Water Issues.

10. The issues of cross-border water distribution, utilization, management and mirror irrigation / hydro electric power projects are affecting countries in South Asia with India in centre stage. Settlement amicably within framework of riparian statutes respecting upstream and downstream rights is still farfetched[38]. The major issues affecting South Asia are in succeeding paragraphs.

11. **India – Pakistan Water Issues.**

(a) The Indus Water Treaty has survived the ups and downs of Indo Pak relations. The differences persist over projects being undertaken by India over Jhelum (two projects) and Chenab (nine projects) rivers. In all cases Pakistan accuses India of violating the Indus Water Treaty[39]. Most of these controversial projects are in Jammu and Kashmir and Pakistan's overriding strategic interest is to secure its river waters.

(b) The major projects among these include Baglihar hydroelectric project on River Chenab, Wullar barrage project on River Jhelum, Kishanganga hydroelectric project on River Kishanganga (Neelam), Dulhasti hydroelectric project and Sawalkot dam on River Chenab.

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[38] Editorial, "**Water Issues in South Asia"** from journal South Asian Jan – Mar 2005.

[39] *Ibid.*

(c) **Tulbul Navigation Project.** The dispute is over the proposed construction of a barrage on the Jhelum river just below Wullar lake. Pakistan calls it Wullar Barrage. India wants to construct the barrage to control the flow of water in the Jhelum in the lean season to make the river navigable which is permissible under the Indus Water Treaty. Pakistan feels that the barrage is a storage work. Both countries reached the basic agreement between 1989 and 1992, but the stalemate continues.

(d) **Baglihar Hydroelectric Project[40].** Pakistan is concerned that the gated spillways provided in the project would give India the capability to manipulate, flow of water which would allow an increased storage capacity, while reducing the flow of Chenab waters from 8000 to 7000 cusecs per day to her disadvantage. Despite discussions and talks mutual mistrust continues.

12. **Indo – Bangladesh Water Issues[41].** The Ganges water sharing treaty was signed in 1996 and dispute over Farakka barrage was resolved. The deal was reasonable as the treaty offered even share of water to Bangladesh and also provided three guaranteed 10 day periods of 35,000 cusecs of water.

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[40] Khaled Ahmed, Article "**South Asia's Unresolved Disputes"** from journal South Asian Jan – Mar 2005, pp 13-14.

[41] Khaled Ahmed **op,cit.,** pp 15-16.

The treaty will remain in force for 30 years. The major differences are on sharing of water during the lean period and Indian plan for interlinking of rivers which includes diversion of water from the Ganges and the Brahmaputra. Bangladesh feels that the project is a violation of UN Convention on the Law of Non-navigational Uses of International Watercourses and article nine of the 1996 Ganges Water Sharing Treaty.

13. **Indo – Nepal Water Issues[42].** Nepal is the upper riparian state. The Mahakali and other treaties signed between the countries on harnessing water and hydel power is basically beleaguered by mistrust and suspicion on the part of Nepal. These are over multipurpose projects on environmental concerns, displacement of people and misgivings on projects in the seismically active Himalayan region.

Overall Analysis

14. Certain issues common to all countries are summarized, which have to be addressed:

(a) Poor irrigation techniques.

(b) Excessive ground water extraction.

[42] Editorial **loc.cit.,**

(c) Pollution, poor sewage and sanitation facilities.

(d) Dams and environmental issues.

(e) Movement of population from rural to urban areas and corresponding lack of access to water.

(f) Problems of flood forecasting, seismic studies, subsidies on water and apathy of public.

(g) Lack of focus in all countries on integrated approach and vision for future to water management.

Detailed Resource Availability - India

15. India comes under the category of 'water poor' along with China. An estimate of the same is given at Appendix 'J'. Basic water information on India is at Appendix 'K'[43]. Salient aspects of water resource availability are as under:

(a) **Rainfall[44].** India is one of the wettest countries in the world, with average annual rainfall of 1170 mm. But variation in rain both temporally

[43] Basic Water Information " **loc.cit.,**.

[44] World Bank Report, "**Intersectoral Water Allocation, Planning and Management** ", Chapter 2 The Resource Situation and Emerging Issues, pp7-9, 2000.

and spatially is considerable. These vary from low value of 100 mm in Western Rajasthan to over 11000 mm in Meghalaya in Northeastern India. Higher rainfall of 1000 mm and above are found in Eastern and Northeastern India and deltaic localities like Assam, eastern parts of Uttar Pradesh, Bihar, West Bengal, Northern Orissa, and the Cauvery delta. Rainfall ranges from 300 -800 mm in Western India – Punjab, Haryana, Western Uttar Pradesh and Rajasthan and rainshadow areas of the Deccan plateau. These variations can cause situations of drought and of floods in the same locality.

(b) **Surface Water.** Based on India's river systems average annual surface run-off generated by rainfall and snowmelt is about 1869.35 cu km per year, details of which are at Appendix 'L'[45]. However, only about 690 cu km or 37 percent of it can be used as over 90 % and 80 % of the annual flow of the peninsular and Himalayan rivers respectively occur over a four-month period. Potential to capture such resources is complicated by limited reservoir sites. Water availability is also variable; with the Himalayan Rivers being semi perennial due to snowmelt supplies as well as rainfall while most peninsular are dry for about eight months of the year. By contrast the Brahmaputra Barak, due to its flood flow nature, may only be able to utilize 24 cu km out of its average annual flow of 586 cu km[46].

[45] Basin Surface Water Potential India, online, 31 Oct 2005, http://www.wrmin.nic.in /resources.htm.

[46] World Bank Report, "**Intersectoral Water Allocation, Planning and Management** ", **loc,cit.,**

(c) **Ground Water.** Ground water potential of the rivers is at Appendix 'M'[47]. About 30 percent of it has been tapped for irrigation and domestic use, which includes the surplus areas of Eastern and Northeastern India. Actually large parts of India have already exploited about 94 percent of their ground water resources. Areas with depleting groundwater tables are found in Rajasthan, Gujarat, Uttar Pradesh and in Deccan states. Rising groundwater tables and salinization are also found due to poor drainage or cumulative impact of irrigation in certain localities UP, Haryana, Punjab and Rajasthan. Hence combination of depletion and rise are found.

(d) **Artificial Resources.**

(i) **Canals.** River systems and underground water make canals practical in Punjab, Uttar Pradesh and parts of Rajasthan, Bihar, eastern coastal plains of Madhya Pradesh, Andhra Pradesh and in Maharashtra. These are of two types, inundation canals and perennial canals. Perennial are ideal for irrigation. Dams and hydroelectric projects are part of this system.

[47] Basin Ground Water Potential India, online, 31 Oct 2005, http://www.wrmin.nic.in /resources.htm.

(ii) **Wells.** The traditional well is spread out almost all over India. In addition modern tube wells are found in Uttar Pradesh and Punjab.

(iii) **Tanks.** Tanks are the principal source of irrigation in the Deccan Plateau and in South.

16. In the overall analysis India is water stressed. At independence with a population of less than 400 million, per capita water availability was over 5000 cu m per annum. The situation has developed steadily and dramatically with the per capita freshwater availability declining from over 5000 cubic meter per year in 1947 to 1731 cubic meter per annum in 2005. In 2025, population is predicted to grow to 1.4 billion and per capita availability of water is projected at only 1500 cu m per annum[48]. A more detailed analysis of the problem areas are discussed in the next chapter.

[48] World Bank Report, "**Intersectoral Water Allocation, Planning and Management** ", **op,cit.,**, pp 1.

CHAPTER IV

POLICIES, PROBLEM AREAS AND CHALLENGES IN PRESENT STATUS OF WATER RESOURCES MANAGEMENT IN INDIA

1. This chapter gives a broad overview of centralized government institutions and policies on water, and their thrust areas. The problem areas and challenges are enumerated in detail.

Current and Past Government Policies

2. **Institutions.** There are a number of institutions dealing with water resources and its management. Water being a state subject complicates the scope and functioning of these institutions. The ministry of water resources is at the helm of affairs. The important institutions under this ministry are as under:-

(a) **National Water Resources Council.** Set up in March 1983 as a national apex body, the Prime Minister is the Chairman, Union Minister of Water Resources as Vice-Chairman and concerned Union Ministers, Chief Ministers of State governments and Administrators / Lt governors of the Union Territories as Members. The Secretary, Ministry of Water Resources is the secretary of the council. The National Water Policy was

adopted in 1987 duly amended in 2002 and later in 2012, which is the basis of formulating future policies.

(b) Other national bodies are National Water Board (set up in 1990) for monitoring implementation of National Water Policy, Command Area Development Programme and Accelerated Irrigation Benefits Programme to monitor irrigation. Central Water Commission coordinates with state governments on issues of water, Hydrology Project and National Institute of Hydrology does scientific, hydrometric and water quality tests.

(c) **River Water Disputes.** Number of tribunals to resolve disputes on sharing of river waters, by negotiations between states concerned with the assistance of the centre have been created as given below: -

(i) Godavari Water Disputes Tribunal.

(ii) Krishna Water Disputes Tribunal.

(iii) Cauvery Water Disputes Tribunal.

(iv) Narmada Wa ter Disputes Tribunal.

(v) Ravi-Beas Water Disputes Tribunal.

(d) Task forces created to look into specific issues include the following

(i) **Farakka Barrage Project**. For preservation and maintenance of Calcutta Port by improving the Bhagirathi-Hooghly river system.

(ii) **Sardar Sarovar Construction Advisory Committee**. It was constituted in 1980 as per the directive of the Narmada Water Disputes Tribunal (NWDT) for scrutiny of Sardar Sarovar Project . The states affected are Gujarat, Maharashtra, MP and Rajasthan. The committee's recommendations were challenged by the Narmada Bachao Andolan which was overruled by the Supreme Court.

(iii) **Ganga Flood Control Commission**. To monitor and manage the Ganges river.

(iv) **Tungabhadra Board**. As per Krishna Water Disputes Tribunal Tungabhadra water is to be shared by the states of Karnataka and Andhra Pradesh which is to be monitored by this board.

(v) **Cauvery River Authority.** To oversee the implementation of the Cauvery Water Disputes Tribunal interim order under which Karnataka is to release water equal to 205

TMCFT (thousand million cubic feet) in four equal instalments to Tamil Nadu's Mettur Reservoir.

(vi) **Brahmaputra Board**. For planning and implementation for the control of floods and bank erosion in the Brahmaputra valley.

(e) **Namami Gange Programme.** This programme is an Integrated Conservation Mission, approved as 'Flagship Programme' by the Union Government in June 2014 with budget outlay of Rs.20,000 Crore to accomplish the twin objectives of effective abatement of pollution, conservation and rejuvenation of National River Ganga. Its implementation has been divided into Entry-Level Activities (for immediate visible impact), Medium-Term Activities (to be implemented within 5 years of time frame) and Long-Term Activities (to be implemented within 10 years).

3. **National Water Policy and Action Plan 2020[49].** This basic document of 2002 and the alternative policy 2020 are the framework of governments thought process. The salient features of both these documents are as under:-

[49] **"National Water Policy 2002**" policy document, https://pib.gov.in/newsite/PrintRelease.aspx?relid=70832.

(a) Highlights the unevenness of the water distribution, problem of floods and drought, food security, water demand for drinking and other purposes, quality management and public awareness system.

(b) Need for central and state level well-developed information system based on Geographical Information System in terms of all data required for water management.

(c) Optimising the resources by setting up of multidisciplinary units, conservation, recycling and reuse and transfer from one river basin to another to meet the shortfall.

(d) Environment and ecological balance across the spectrum.

(e) The water allocation priorities laid down are as follows:-

(i) Drinking water.

(ii) Irrigation.

(iii) Hydro power.

(iv) Navigation.

(v) Industrial and other purposes.

(f) Pricing of water to convey its scarcity and value.

(g) Participation of farmers and voluntary agencies in management of water and irrigation systems.

(h) Regular monitoring of surface and ground water for quality.

(j) Means of flood control and management.

(k) Prevention of land erosion by sea or river and drought management techniques.

(l) Intensifying research efforts in fields of Hydrometeorology, assessment of water resources, ground water hydrology and recharge, prevention of salinity ingress, water- harvesting, evaporation and seepage losses, crops and cropping systems, sedimentation of reservoirs, safety and longevity of water related structures, river morphology and hydraulics, better water management practices and recycling and re-use of sea water resources.

Problem Areas and Challenges

4. Despite the efforts of government policies there are number of problem areas which are responsible for unequal distribution of existing water resources, harnessing of new potential and related disputes between states. These are enumerated in succeeding paragraphs. Some problems are common to South Asia as a whole as given out.

5. **Pollution**[50]**.** Contamination is entering water bodies as direct point sources (from municipals and household), diffuse agricultural sources (from pesticides, fertilizers) and diffuse sources (from commercial activities). Water quality issues are as under

(a) **Rivers**. India today has completely turned its back on its rivers. The problems are:-

(i) Changes in physical characteristics due to human activities and erosion affect temperature, turbidity and total suspended solids.

(ii) Contamination by untreated faecal, organic matter, heavy toxic pollutants and salinisation reduces oxygen and increases ammonia and nitrogen concentrations. These have health and environmental hazards. Yamuna in Delhi and Agra is affected by the same.

(iii) **Eutrophication.** Nutrient enrichment leading to increased plant arid algae growth affects oxygen content and hydrogen ion concentration. This affects marine life.

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[50] **"Water Quality Issues"**, online, 31 Oct 2015, http://cgwb.gov.in/WQ/GROUND%20WATER%20QUALITY%20SCENARIO%20IN%20INDIA.pdf.

(iv) Activities such as changes to depth and width for navigation, creation of flood control ponds, reservoirs for drinking water supply, damming for hydroelectric power generation and diversion for irrigation purposes cause modifications to rivers and affect water quality.

(b) **Ground Water.**

(i) Unsewered domestic (septic tanks or pit latrines), industrial and solid wastes are not carefully disposed or regulated.

(ii) Fertilizers, salinity due to dissolved salts in irrigation water, contaminate the shallow, private bore wells used in rural areas.

(c) **Extent of Problem[51].** Refer Appendix 'N'.

(i) Wastewater generated during 1981 was estimated to be 74,529 million litres per day i.e. about 27km^3 annually, which poses a perennial danger to the potable ground water resource. Inspite of sewage treatment plant, Delhi discharged 100 million gallon of untreated sewage into the Yamuna. The problem was compounded further in 2000 when about 40km^3 (110,000 million litre/day) was discharged.

(ii) The industries daily produce about 55000 million m^3 of wastewater per day, out of which 68.5 million m^3 is discharged into river streams. Hence about 70% of rivers and streams in India contain polluted water.

[51] *Ibid.*

(iii) Thirteen states in India have been identified as endemic to fluorosis. These are A.P, Gujarat, Haryana, Orissa, Punjab, Rajasthan, Tamilnadu, U.P., Karnataka, Madhya Pradesh, Maharastra, Bihar and Delhi. Half a million people are suffering from ailment due to excess of fluoride in drinking water.

(iv) Salinity has affected ground water in 10,6019 sq. km area (about 31 %) of Rajasthan, vast areas in Punjab and about 3766 sq. km. area in Haryana.

(v) Arsenic in ground water have been reported in shallow aquifers from 61 block in eight districts of West Bengal.

6. **Floods.**

(a) Floods are a common phenomenon in the high land lowland interactive system of the Ganga river system which takes a heavy toll of property and life.

(b) The average area annually affected by floods has similarly increased from 2.29 million hectares in 1953 to about 10 million hectares in 2005.

(c) In 2005 Mumbai had the rainwater's flooding the streets, mixing with the sewage and finally with freshwater.

(d) Excessive water from these floods in flood prone areas have not been harnessed or channelised.

(e) Other factors heightening and aggravating flood impact are notably population pressures in vulnerable zones, deforestation, drainage congestion caused by roads and railways, urbanization and reclamation of flood cushions.

Rural Water Supply System (RWSS)[52] (Refer Appendix `O')

7. Official records state that 85 % rural population is provided safe drinking water by tapping ground and surface water through three million hand pumps, and other water supply schemes and traditional sources. Since the Sixth Five Year Plan (1980-85) and the launch of the International Drinking Water Supply and Sanitation Decade, approximately 3 % of the budget has been allocated for rural drinking water. Over the past ten years, the allocation to the Department of Drinking Water and Sanitation has seen an annual average increase of 6.6%. The department saw the highest increase of 49% in 2016-17, over the previous year. This year the estimated expenditure has seen a

[52] World Bank Report, "**Rural Water Supply and Sanitation**", Executive Summary pp xiii – xix and Institutional Frameworks and Sustainability pp 13-28. 2000.

marginal decrease of 0.1%, over the revised expenditure estimates of 2018-19.

8. **Burning Issues.**

(a) Almost 40 % of the budget is funded by the central government which it is not in a position to continue during the 10th plan period.

(b) Potential scope for participation by non-governmental organizations, the private sector and village consumers are less due to government domination.

(c) Lack of planning and assessment in investment in terms of ignoring existing privately – financed sources, community and user preferences.

(d) Rigid design norms, lack of integration of environmental sanitation with water supply programs and quality of hydrological investigations, are impeding the development.

(e) Decentralization process is fraught with lack of coordination and lack of accountability.

(f) Local level panchayats are reluctant to assume responsibilities for the schemes.

(g) **Financial Issues**. Corporate / private sector participation is limited, due to high inherent risk, long payback periods and low profitability. Investment on costly piped water schemes and inefficient procurement are causes for rising per capita costs.

(h) **Government Agencies.**

(i) **National Level**. At national level, drawbacks of the Rajiv Gandhi Mission have been limited influence, lack of coverage and coordination and apathy of states.

(ii) **State Level**. State-level institutions i.e. public health engineering department and an autonomous Water Supply and Sanitation Board (WSS) are failing on cost recovery and personnel management issues.

(iii) **Local Level.** Gram Panchayat's role is very limited with non implementation of the Panchayat Raj Act, polarization and factionalism.

(j) **Operations and Maintenance**

(i) **Hand Pumps**. It accounts for 95 percent of the rural water schemes, serving 395 million people (75 percent of the rural population). Some of these projects are irrelevant and government dominance over procurement of materials has impeded repairs.

(ii) **Small Piped Schemes**. Technical know how to repairs is poor, electricity costs for the pump sets are high and recurring costs are unmanageable.

(iii) **Large Piped Schemes**. They rely on surface water sources and subsequently involve treatment processes which are difficult to operate and maintain due to recurring costs.

Urban Water Supply System (UWSS)[53]

9. The stepped up economic boom is clearly felt by the requirement of water which is not keeping pace with the increase in population. Indicators of this are as under:-

[53] World Bank Report, " **Urban Water Supply and Sanitation**", Executive Summary pp xv and Sector Issues and Assessment pp 1-15. 2000.

(a) As per the census of 2001, 28 % of the population lives in cities, an increase of 5% in five years.

(b) There are 35 cities with over one million population. The smaller cities and towns, from technical, administrative and financial standpoint, are much weaker than the larger ones.

(c) 88 per cent of urban population officially has access to potable water supply with 25 - 50 % losses, just about 2-8 hours of daily peak supply that too is highly erratic and unreliable. As per World Bank study Chennai and Delhi are ranked as the worst performing metropolitan cities in terms of hours of water availability per day, while Mumbai is ranked as second worst performer and Calcutta fourth worst[54].

10. **Burning Issues.**

(a) The government has an ambivalent attitude towards urban areas and the mega-cities in particular.

(b) Many providers are not financially viable to maintain services due to excessive subsidies and low tariffs.

[54] "**Urban Water Supply System**", online, 05 Nov 2005 www.rainharvesting.org.

(c) Non coverage of the full population, and low quality of Operation and Maintenance (O&M).

(d) **Service Coverage and Quality.**

(i) Supplies are intermittent with regular shortages. Chennai survives on water tanks in many places due to the lobby of private water service providers. Low pressure and intermittent supplies allow back-siphoning resulting in contamination of water especially at crossover points between water distribution mains and street drains.

(ii) Meters are a farce as they do not work due to high particulate matter in the mains, which block the clock mechanisms, or due to surges when pressure returns to the intermittent water supply, or vandalism.

(iii) The poor estimated between 40 – 60 % lack access to basic urban water services. Subsidies or programs if any will have a large amount of leakage to the non-poor also.

(iv) The latest problem is of excessive rains and consequent impact on availability of water, blocking of sewage systems, illegal construction of buildings on erstwhile canals/tanks/lakes and its

resultant flooding as evident during the floods in Chennai and Mumbai in 2005.

(e) There are no legal or administrative frameworks, which allow for the reallocation of water from low value agricultural use to high value urban and industrial use.

(f) Poor procurement of materials, construction practices, inadequate maintenance and lack of information systems including detailed maps of the areas has reduced the operating efficiencies of water systems.

(g) **Financing Urban Water**.

(i) Municipal authorities are largely dependent on grants and loans through the budgetary allocations of governments, and to a limited extent on surplus from their own budgets.

(ii) The three main sets of recovery mechanisms are user charges where commercial and industrial establishments pay higher tariffs as against domestic consumers, service taxes which are combined with property tax and other charges to include connection, development and betterment levies which have no clear link with actual costs.

Inter-Sectoral Water Allocation, Planning, and Management[55]

11. Conflict between sectoral uses – domestic needs in rural and urban areas, agriculture, industry, energy, ecological, navigation, fisheries, recreation, ceremonial and religious purposes is already a serious problem. The past management of the country's water resources has been unable to cope effectively with these issues.

12. **Growth Trends.**

(a) **Domestic Demand**. Domestic water use which at present is 25 Billion Cubic Metre (BCM) is expected to rise to about 52 BCM by 2025.

(b) **Industrial Requirements**. Water demand of 67 BCM for industry, energy generation is projected to grow at a rate of 4.2 percent per annum, to about 227 BCM by 2025.

(c) **Irrigation**. At 92 % of total water consumption, usage would be approximately 700 BCM by 2025.

[55] World Bank Report, "**Inter Sectoral Water Allocation, Planning and Management**", Executive Summary, pp xvii, The Need for Better Managing India's Water Resources pp 1-5, Resource Situation and Emerging Issues7-16. 2000.

(d) The above planning figures would result in total demand for water increasing from the current 552 BCM to 1050 BCM by 2025. This would represent virtually the entire utilizable resources of the country.

13. **Burning Issues**

(a) River basin management for surface and groundwater, incorporating quality and quantity aspects is lacking.

(b) Government monopoly, a top-down and supply side approach has resulted in high economic, social and environmental costs.

(c) Imbalance in resources across the country is causing management problems to allocate such resources between competing users.

(d) Riparian states like Punjab are investing in basins on new constructions simply to lay claim on rivers.

(e) Irrigation efficiency is only 30 to 40 percent and water losses in domestic supply schemes range from 30 to 50 percent.

(f) **Inter-State Cooperation**. The catchment areas of all major river basins are located in more than one state, and many rivers have a

number of riparian states. The Ganges basin is shared between eight states (UP, HP, Haryana, Rajasthan, Delhi, MP, Bihar and West Bengal). The Krishna Basin is shared between Maharashtra, AP and Karnataka. The Cauvery is shared between Karnataka, TN, Kerala and Pondicherry. Regulation and development of inter state rivers and river valleys are a 'central subject', but water is a 'state subject' and the states have substantial autonomy over water usage within their jurisdiction. Development of administrative structures for managing water on a river basin basis and especially across state boundaries is poor and hence cooperation is lacking for cross-state riparian issues. Old disputes between states have still not been resolved and implementation of tribunal awards is proving difficult. Inter–basin transfer of water from surplus to deficit basins has been considered a solution. But necessity to construct large reservoirs to store monsoon flows and to divert water involves enormous economic, social and environmental costs and concurrence of the basin states is also required. This is a politically sensitive issue as states are reluctant to relinquish water perceived as rightfully theirs.

Ground Water Management[56]

14. Ground Water supplies 80 percent of water for domestic use in rural areas and 50 percent of water for urban and industrial uses.

15. **Burning Issues**. The rapid development and exploitation in groundwater has resulted in blocks classified as dark or critical has increased at a continuous rate of 5.5 percent over the period 1984-85 to 1992-93 (refer Appendix 'AA')[57]. If not checked, over 35 percent of all blocks will become over exploited within 20 years. The problems are as under:-

(a) Private investment by farmers being means to exploit ground water, initiatives are unlikely to address the management needs.

(b) Large areas, in the command of surface irrigation systems, suffer from water logging, salinity and alkalinity (refer Appendix `AB').

(c) Seasonal fluctuations in water table are affecting shallow wells, low seasonal flows in surface streams.

(d) Groundwater recharge has been suggested as a solution, but they are very limited in scope. There is lack of data collection and analysis.

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[56] World Bank Report, " **Ground Water Regulation and Management**", Executive Summary, pp xv-xvii, From Development to Management pp 9-10, 2000.

[57] *Ibid,* pp 12.

(e) Duplication in groundwater activities between states and centre. Eg, the Central Ground Water Board focuses on macro level data analysis, while state groundwater organizations focus on micro levels which are incorrect for effective analysis of hydrological system.

(f) Restrictions on credit and electricity connections, the only effort implemented to date – has had only limited success.

(g) Measures like ground water legislation are lacking.

(h) It has not been studied in detail whether the use for irrigation is optimal.

16. The problem areas give a gloomy picture but solutions are there which are discussed in the next chapter.

CHAPTER V

CONCLUSION AND RECOMMENDATIONS FOR WATER MANAGEMENT

1. It appears from previous analysis, identifies the problem areas and challenges on water management in South Asia with specific reference to India, though at cost of repetitive it is important to recall the main findings.

(a) Broad overview of policies and thrust areas on use of water as formulated by the government.

(b) Understanding the problem areas to include :

(i) Water Pollution.

(ii) Floods.

(iii) Burning Issues – Rural Water Supply system.

(iv) Burning Issues - Urban Water Supply system.

(v) Inter-Sectoral Water Allocation.

(vi) Policy framework drawbacks in all related fields.

(vii) Ground Water Management.

2. In view of the above, the major recommendations to manage and conserve water in South Asia as a whole with specific reference to India are being suggested, broadly under following heads:

(a) Specific efforts by governmental/Non-Governmental Organisations/individuals.

(b) Sector wise recommendations.

(c) Recommendations and responsibility of citizens towards conservation and preservation.

Specific Efforts

3. Disasters teach communities to help themselves without waiting for the government which are signs that initiative and perseverance, can bring about attitudinal changes and work miracles. These examples form basis of the recommendations suggested.

(a) **Gujarat.** A drought-prone state, is today an oasis.

(i) Groups of citizens and NGOs like Aga Khan Rural Support Programme[58] under Sajjata Sangh (a network of NGOs) have initiated a quiet revolution. They have constructed about 50000 check dams to revive and inject rainwater collected underground through wells, promoted roof rain water harvesting, lobbied with

[58] "**Water Harvesting A Social Movement in Gujarat** " article by Jyotsana Bhatnagar and "**Tapping Water** " by Niraj Joshi online 02 Nov 2005, www.financialexpress.com, pp 1-2 and www.bjp.co.in.

the government to supply water under the supervision of village *Pani Samitis* (water committees) and carried out renovation of tanks thus generating employment[59]. State government has now stepped in with the Sujalam Sufalam Yojana to promoted these effort.

(ii) A similar successful initiative is taking place to fight salinity in coastal areas of Saurashtra and Kutch by building dams on 30 out of 168 rivers just before they merge into the sea seawater.

(b) **United Nations Environmental Program (UNEP).** UNEP has successfully provided quality water and started successful initiatives using locals to conserve water in Burkino Faso, Cape Verde, Namibia, Sudan and Senegal[60].

(c) **Jhabua (MP).** Deforestation leading to soil erosion, uncontrolled grazing, illegal felling and fires had created an ecological disaster that saw widespread migration of people from the region. Today with programs started by the state government in 1995, rainwater harvesting and soil water conservation have led to water tables climbing in many places. More than 1000 check dams, 1050 tanks and 1100 community lift irrigation schemes – many of them managed by NGOs –

[59] *Ibid*.

[60] "**UN – Success Stories**", online UNEP website.

dot the profile of the district. The benefits of watershed development in the district are summarized as under:

	Pre Project	**Current Position**
Crop Area	76,382	1,16,939
Irrigated Area	3,033	3,353
Forest Cover	2,884	9,404
Waste Land	18,952	7,146
Income From Fodder	38 Lakhs	153 Lakhs

(d) **Maharashtra.**

(i) Sustainable agriculture by not using agrochemicals, simple water management techniques such as with percolation tanks, bunding and terracing are on due to the efforts of NGOs like *Prakriti* and *Sarvodaya* workers[61].

(ii) At Devrukh village in Ratnagiri District with no easy access to electricity Chandrakant Pathak through his eco friendly innovative techniques of harnessing bulls to system of transformers and pulleys creates energy to run sprinkler irrigation systems which is now being popularized by the government[62].

[61] "**A Green Alternative** ", article in Frontline by Lyla Bavadam, Jul 2005.

[62] *Ibid.*

(e) **Water Treaties.** The European Union Water Framework Directive (EUWFD) of 2000 has been a visionary document on water sharing in Europe. It highlights the relative importance of terrestrial followed by aquatic and finally to human environment in terms of water management. It emphasises the management of river water according to ***natural geography and hydrological unit instead of administrative and political boundaries***, protection of water, community measures and water pricing. This is a model South Asia and within India states need to emulate to overcome the problems of water management[63].

Sector - Wise Recommendations

4. Sector wise analysis of suggested recommendations is discussed based on problem areas explained in Chapter V. The solutions / recommendations are covered under following parts :-

(a) Eradicating Water Pollution.

(b) Overcoming Floods.

(c) Improving Rural Water Supply System.

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[63] Ashok Swain **op cit** pp 169-170

(d) Improving Urban Water Supply System.

(e) Inter Sectoral Water Allocation.

(f) Ground Water Management.

(g) Irrigation Sector.

Eradicating Water Pollution.

5. The two major challenges under water pollution eradication are firstly protection of the quality from further deterioration and secondly is the gradual restoration. Increasing population, urbanization and industrialization make it difficult to achieve. The aim of pollution control should be to reduce the harm of a potential pollutant. This should be a multi-step process.

6. Three options are available in controlling industrial wastewater. Control can take place at the point of generation in the plant; wastewater can be pretreated for discharge to municipal treatment sources; or wastewater can be treated completely at the plant and either reused or discharged directly into receiving waters. Raw sewage includes waste from sinks, toilets, and industrial processes. Treatment of the sewage (refer Appendix 'T') is required before it can be safely buried, used, or released back into local water systems. In a treatment plant, the waste is passed through a series of screens, chambers,

and chemical processes to reduce its bulk and toxicity. A systematic process of waste water treatment would include in general:-

(a) **Primary Treatment.** A large percentage of the suspended solids and inorganic material is removed from the sewage.

(b) **Secondary Treatment.** The focus is on reducing organic material by accelerating natural biological processes.

(c) **Tertiary Treatment.** Water reclamation i.e reuse of water in which 99 percent of solids are removed and various chemical processes are used to ensure the water is as free from impurity as possible[64].

7. The various physico-chemical techniques devised for removal of chemical, biological or radiobiological pollutants involve adsorption, electro dialysis, ion exchange and reverse osmosis. Some measures to eradicate the pollutants are control of brackishness involving treatment with the help of processes like reverse osmosis, electro dialysis, etc, removal of excess iron (limit one parts per million (ppm) by treating with iron removal plants, control of fluoride (within permissible limit 1.5 ppm) with the help of treatment processes such as Nalgonda technique or activated alumina process and control of arsenic by methods of co-precipitation and absorption technique, arsenic

[64] " **Water Pollution and Society**", article by David Krantz and Brad Kifferstein online 05 Nov 2005, www.bkiffers@emich.edu.com, pp 4.

plants and domestic filters[65]. Some techniques devised by Centre for Scientific and Industrial Research for the control of water pollution have been successfully implemented. Some of them are as follows :-

(a) **Ammonia Removal.** Ion-exchange technique enables ammonia to be removed in the form of ammonium sulphate a useful salt.

(b) **Removal of Mercury.** Mercury thrown out from chloral-alkali plants is removed and recovered by mercury-selective ion exchange resin.

(c) **Removal of Phenolics**. Phenolics in waste water produced from industries like pulp and paper mills, petroleum refineries, tanning industries are removed by the use of polymeric adsorbents.

(d) **Removal of Sodium Salts**. Reverse osmotic technique enables to recover sodium sulphate. The technique is also employed to recover water for reuse[66].

Overcoming Floods

[65] "**Water Quality – An Overview** " , article by Department of Drinking Water, online 05 Nov 2005, http://ddws.nic.in/water_qualitypop.htm, pp 2.

[66] Kulkarni U and Mrs Bhanu Kakrani **op cit** pp 248.

8. Overcoming floods / flood management i.e. methods available to reduce the hazard to lives and property by the most cost effective measures, and harness water are preferred over flood control. These along with recommendations are as under:-

(a) **Natural Means of Reduction.** Systems in the form of open space of flood plains adjacent to rivers and streams helps store and slowly release flood waters thus reducing flood flow peaks and their impacts. Similarly wetlands at as giant sponges soaking up flood waters and filtering to ground water supplies. Forests can all slow runoff from mountains and hillsides. Restoring natural meanders by creating large flood ways also help[67].

(b) **Restoration of River Systems[68].**

(i) Restore the historic capacity of rivers and their floodplains to accommodate flood waters by setting back levees to widen the floodway (the river channel during high floods flows).

(ii) Increase wetland and riverside forest habitat within the widened river zone.

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[67] "**Beyond Flood Control**", online article, www.friendsoftheriver.org Beyond Flood Control Part I-III.

[68] "**Principles of Flood Management and Floodplain Restoration**", online article, www.friendsoftheriver.org Beyond Flood Control pp 1-2.

(iii) Strengthen existing, properly sited but vulnerable levees.

(iv) Reassess reservoirs and waterworks to ensure efficient use of flood control space.

(v) Dams and waterworks need to be structurally modified to improve their ability to release water to avoid downstream flooding.

(vi) Improve weather forecasting and monitoring of upstream conditions to have better early warning system.

(c) **Management of Flood Plains.** Eliminate development in dangerous parts and reform mapping programs.

(d) Manage entire watershed by discouraging development in wetlands and flood plains.

(e) **Inundations**. In the Bengal Delta, the muddy crest waters of the annual inundations that carried silt and fish eggs were leached through a sophisticated system of channels. The silt helped nourish and fertilize the soil, the eggs soon spawned and the fish mosquitoes were devoured. Inundation helped fertilize the soil, check malaria and enabled the

general build up of the cultivable land above the riverbeds. In the flood plains of West Punjab (Pakistan) the alluvial lands inundated by '*sailabs*' (silt) and referred to as `hithar' are examples to control flood.

(f) **Bangladesh.** A host of techniques, adaptations and practices have been in operation to mitigate the effects of floods and alternatively utilize them. These include :-

(i) Cultivation, based on their traditional knowledge about the timing and periodicity of the floods, have developed elaborate adaptation of crop varieties to varied flood depths.

(ii) Besides developing rice strains that grow in virtually submerged conditions (often harvested in boats), the cropping regime has been timed to dodge the highest phases of the flood.

(g) The conventional responses need to be reviewed. These are post event relief and the structural solutions in the form of multipurpose projects and embankments resulting in aggradations of channel beds, and consequently the spill over of flood water and water logging.

(h) **Disaster Management Plans.** Flood mitigation, is presently undertaken by host of agencies and absence of flood disaster management plans are conspicuous. Integrated data collection stations (gauging stations, rainfall collecting stations, weather satellite

information and geographical information system techniques), flood forecasting / warning systems and appropriate response mechanisms are required. Dissemination of information in time is the second most important aspect.

Improving Rural Water Supply System[69]

9. Micro level corrective measures include:-

(a) Public awareness programs to cover conservation, hygiene, preservation of wet ecosystems, participatory interventions, pushing for policy change and development of self regulating water institutions are required[70].

(b) Financial conditionality terms need to be defined explicitly and reformed before the allocation of central and state funds. Full cost recovery should be the buzz word which will ensure financial viability and sustainability.

(c) Implementation of a participatory demand-driven approach in the form of Village Water Supply and Sanitation Committees (VWSSCs)

[69] World Bank Report, "**Rural Water Supply and Sanitation**", **op. cit** pp xx, xxi, 54-57.
[70] Wouter Schaap and Frank van Steenbergen, "**Ideas for Water Awareness Campaign** ", online book www.watermagazine.com, pp 6, 14 Oct 2005.

associated with under the gram panchayat will ensure that users can directly influence the level of service they desire and can afford.

(d) Externally funded projects should be consistent with the National Drinking Water Mission, state governments and finally the VWSSCs in its implementation.

(e) Management and financial autonomy to VWSSCs to ensure full participation in projects by preparing long term Gram Plan and thus ensuring that responsibilities are taken on.

(f) A recommended distribution of funding of projects are 25 percent each from local administration (user contributions and VWSSCs own sources), state agencies and central agencies.

(g) Enable, promote and facilitate participation of NGOs and the private sector. Define appropriate roles for these to avoid duplication and ensuring integration.

(h) Strengthen Institutional capabilities in consumer orientation, policy development, planning, implementation, O&M, monitoring and evaluation and promotion of health and sanitation.

(j) Strengthen operational guidelines and procedures for RWSS agencies by developing standard operations and maintenance procedures, improving design and specifications to reflect user needs. Strengthening pre-qualification criteria, transparent procurement procedures, quality control and a monitoring and evaluation system are required.

(k) **Water Harvesting Techniques.** Rural South Asia especially India has tremendous expertise in traditional techniques. Investment in these as per the peculiarity of the region will bear dividends. These techniques are listed as under:-

(i) **Paar System.** A practice called *Patali paani* in the western Rajasthan region in which the rainwater flows from the agar (catchment) and in the process percolates into the sandy soil. In order to access the *rajani pani* (percolated water) *kuis or beris* (5-12 m deep) numbering six to ten are dug in the *agor* (storage area).

(ii) **Talab / Bandhis**. They are reservoirs in the form of man made ponds *(pokhariyan* used for drinking and irrigation*)* in the Bundelkhand region or lakes in Udaipur. Reservoir of less than five *bighas* is called a *talai*; a medium sized lake is called a *bandhi* or *talab*; bigger lakes are called *sagar* or *samand*. When the water

in these reservoirs dries up after the monsoon, the pond beds are cultivated with rice.

(iii) **Saza Kuva**. An open well, for irrigation in Aravalli hills in Mewar, eastern Rajasthan. The soil dug out is used to construct a huge circular foundation / elevated platform sloping away from the well. The first is built to accomodate the *rehat*, a traditional water lifting device; the sloping platform is for the *chada*, in which buffaloes are used to lift water. *Harva,* a man with special skills in ground water detection helps fix their sites.

(iv) Other methods include the *Johad* (check dams)*, Pat* (divert water from swift-flowing hill streams into irrigation channels), *Rapat* (percolation tank), *Kuis* (tanks to collect seepage) *, Tobas* (depression with a natural catchment area) etc[71].

Improving Urban Water Supply System[72]

10. A fundamental policy change is coming up to address the problems of India's urban water and sewerage sector, but nevertheless they persist. A few of these positive approaches and recommendations to improve UWSS are:-

[71] "**Rain Water Harvesting – Traditional Harvesting Systems**" online 07 Nov 2005, www.rainwaterharvesting.org, pp 1-4.

[72] World Bank Report, " **Urban Water Supply and Sanitation**" **op. cit** pp xvi – xx, Annex 1, International Experience in Decentralisation pp 74-75, 80-81.

(a) An incentive based enabling strategy the key elements of which are: -

(i) **Democratic Decentralization**. Devolve UWSS responsibilities to municipal authorities and give them incentives to make choices in the best interests of citizens.

(ii) **Commercialization of UWSS Providers, and Private Sector Participation** Commercialized managers having incentives to operate systems efficiently.

(iii) **Market Oriented Financial System** – These will promote financial viability and efficiency in utilization of resources mobilized on market terms.

(b) A possible UWSS water sector structure to address the problem areas is given at Appendix 'AC'.

(c) **Reform the State UWSS Providers**. Separate policy and regulatory functions from operations, disaggregate operations into functional areas, and commercialize/privatize entities.

(d) Rationalize tariff structures and tariff setting procedures through legislative changes and system of incentives and sanctions.

(e) **Customer Responsiveness and Role of Civil Society**. Institute customer consultation, develop and publish citizen's charters for water and sewerage services and support development and strengthening of civic-community groups.

(f) State level reform and regulation agenda is a must.

(g) **Financial Reforms**. Promote financial viability, tariff reforms, efficiency gains, market-oriented financing systems to enhance the incentives for efficiency and financial viability as well as increase the capital available to financially viable entities in the sector.

(h) Promote rainwater harvesting techniques which have been found effective to make up for lack of ground water, prevent runoff going to sewer and drains, reduce urban flooding and recharge aquifers[73].

11. A few successful reform agendas in certain countries and other parts of India are described below as insight to how problems are being solved:-

[73] "**Rain Water Harvesting – Urban Harvesting Systems**" online 08 Nov 2018, www.rainwaterharvesting.org, pp 1-2.

(a) **Successful Private Participation - Ostrava, Czech Republic**. The municipality has introduced a French firm for a period of 30 years through lease into the water sector, to provide the necessary expertise while retaining ownership and ensuring public participation. The municipality retains a 20% stake, 31% by the French firm and balance 49% by private individuals. A shareholder agreement, valid for 10 years, between the municipality and the French firm provides for them to seek each others agreement on all major decisions affecting the sector.

(b) **Serving the Disadvantaged in Brazil and Ahmedabad**. Under a project in Recife Brazil, the local government offers families three choices; continue with their current system, connect to conventional water borne system or connect to a conditional system, which reduces the construction costs by 75 percent and monthly tariffs by 65 percent. In Ahmedabad, under the slum networking project, a partnership involving local government, community, NGOs, the private corporate sector and a community credit system is underway. All contribute equally to the costs of local infrastructure networks particularly water, sewerage and landscaping.

(c) **Private Participation – Developing Countries**. Private management and finance can reduce the problems considerably. In many cities across the world private participation has been successful.

Some glaring examples of successful private participation in developing countries worth emulating are:-

(i) In Buenos Aires, tariffs were reduced by 17% and coverage was up by 9 % while in Manila the price reduction was around 50% for half the city and 75% for the other half. Since private participation, Buenos Aires no longer suffers from water shortages in the summer months.

(ii) In Puerto Rico, pre existing implicit government subsidies were made explicit and continued once the UWSS provider was in private hands. The private operator is required to comply with tough US environmental and drinking water quality standards and is liable for large fines, in case of default.

(iii) In Chile, a direct government subsidy is paid to poor household.

(iv) In Trinidad and Tobago, the operator is paid a bonus for increasing the number of households with at least a 12-hour daily supply.

Inter Sectoral, Water Allocation, Planning and Management[74]

12. **State Level.** The reforms suggested are:

(a) Establish Interim Water Resources Task team.

(b) Prepare a draft state water policy to overview the water resources situation, key issues, future vision and objectives along with broad intentions for current and future development of state's water resources.

(c) Formulate state water policies and action agenda to include following:-

(i) Comprehensive approach on a river basin basis.

(ii) Treatment of surface and groundwater as unitary resources.

(iii) Multi-sectoral perspective.

(iv) Integration of quantity, quality and environmental issues.

(vi) Integration of pricing and economic incentives.

(vii) Introduction of administrative allocation mechanisms.

(viii) Technological improvement aspects, including productivity enhancement, water conservation and water reuse.

[74] World Bank Report, " **Inter Sectoral Water Allocation, Planning and Management**" **op.cit.** Chapter 5 Strategy and Action Plan, pp 71-85

(d) Prepare an action agenda for specific short-term actions for improving water resource management.

(e) Strengthen legislative and regulatory framework for regulation of water resources, pollution control, establishment of water users association, participation of private sector and civil society, new forms of water charges and collection procedures, surface and groundwater rights and management. Assess options for defining and making transferable surface and groundwater rights as under: -

(i) **Surface Water.** Maintenance of riparian rights coupled with introduction of government administered licensing of transferable water rights.

(ii) **Ground Water.** Institution of government administered permit system for selective groundwater extraction and use, including provision for transferability.

(f) **Establishing Government and Non Government Institutions.** Establish a multi sectoral state-level institution with: -

(i) **Apex Body.** Responsible for comprehensive water planning, allocation and analysis.

(aa) Create a State Water Resource Board (SWRB) for multi-sectoral planning and allocation decisions.

(ab) Formal committee, comprising of heads of relevant government departments and agencies connected with water, supplemented by representatives from water user groups, industry, academicians and other stakeholders.

(ii) Create SWRBs State Water Planning Organisation (SWPO) for technical advice.

(iii) An Environmental Working Group in SWRB.

(iv) Reorganize and broaden mandate of State Bulk Water supply agency (eg. Irrigation Department).

(v) Create River Basin Organization (RBOs) at state level responsible for implementing integrated basin management at the basin level.

(vi) Create Inter State River Basin Organisations (RBOs) for interaction with other states and centre.

(g) Introduce economic incentives.

(h) **Technological Improvements**. Increase water use efficiency and improve productivity of end use in all sectors. Improve modelling, data performance, environment monitoring and public information by:

(i) Preparing river basin plans and environmental assessments.

(ii) Improve hydrological data as under:-

(aa) Establish a State Water Resources Data Center (SWRDC)

(ab) Assemble and monitor all quantity and quality related data from collecting sources in the state based on river basins or a part thereof lying within the state.

(ac) Develop Geographic Information System (GIS).

(ad) Disseminate data to all bona fide users on a periodic and regular basis.

(ae) Expand and improve data measurement access in each state and river basin existing network of measuring stations.

(af) Expand existing network of measuring stations for surface and groundwater, including water quality.

13. **Central Level Actions.** These are at par with state level actions. The additional reforms suggested are:-

(a) Government needs to come out with an ***updated version of the National Water Policy*** (NWP) with ***key changes in water governance structure and regulatory framework***. Plans are required to set up a ***National Bureau of Water Use Efficiency***. The new policy framework should be based on the recommendations of NITI Aayog's ***Composite Water Management Index 2.0, 2018*** which are very realistic and alarming at the same time. A unified Ministry of Jal Shakti was launched in May, 2019 as an immediate response to the escalating water crisis in India is in right direction.

(b) **Cooperative Federalism.** In the earlier water policies, state water policies were also incorporated so involvement and contribution from the states is important. Although water is a state subject but centre has always played an active role in the decision taking process and in interstate disputes. The process has to be dialogue driven taking care of the sensitivities of the states and should not be imposed on them. Emphasis needs to be shifted towards ***participatory groundwater management to ensure sustainability and quality of water***.

(c) Strengthening legislative and regulatory framework to include:

(i) Facilitate establishment of river basin organizations.

(ii) Improve performance of tribunal awards systems.

(iii) Introduce bill for bringing water under control of the centre.

(d) Establishing government and non-government institutions, strengthening the national water resources council in order to more effectively coordinate activities amongst various central government agencies involved in water.

(e) River linking projects to be given impetus.

14. South Asia must resolve its disputes and focus on overall development of the entire region by going in for inter-linking of all rivers and harnessing hydro electric potential. This calls for strengthening the SAARC framework and dispelling mutual distrust.

Ground Water Management[75]

15. The suggested recommendations for this sector are as under :-

[75] World Bank Report, " **Ground Water Regulation and Management**", **op.cit.** pp xx.-xxi.

(a) Shift in policy and operations from development to management of ground water resources, including integration of environmental issues. This should include:-

(i) Involve local population in management.

(ii) Reduce subsidies on groundwater.

(iii) Integrate groundwater, surface water, pollution, irrigation and municipal water supply data collection, planning and management.

(iv) Improve technical skills in hydrological data monitoring, analysis.

(b) **Create Legal and Regulatory Mechanisms**. Objective should be to develop legal and regulatory framework that has broad based community support and is implement able.

(c) **Reform Institutional Structures and Operations**. Objective should be to create institutional structure and procedure that support the new emphasis on management.

(d) Improve utilization for agriculture by pricing mechanisms.

Irrigation Sector[76]

16. The focus should be on how to avoid over exploitation of ground water. The government level actions are on the lines of recommendations given in other sectors. By improving the efficiency of water use, and by reducing its loss due to evaporation, we can reduce water demand. The numerous methods to reduce such losses and to improve soil moisture are:-

(a) Mulching, i.e., the application of organic or inorganic material such as plant debris, compost, etc., slows down the surface run-off, improves the soil moisture, reduces evaporation losses and improves soil fertility.

(b) Soil covered by crops, slows down run-off and minimizes evaporation losses. Hence, fields should not be left bare for long periods of time.

(c) Ploughing helps to move the soil around and retains more water thereby reducing evaporation.

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[76] "**Water Conservation – Reducing Water Demand**", online 05 Nov 2005, http:/edugreen.teri.res.in/explore/water/conser.htm, pp 3.

(d) Shelter belts of trees and bushes along the edge of agricultural fields slow down the wind speed and reduce evaporation and erosion.

(e) Planting of trees, grass, and bushes breaks the force of rain and helps rainwater penetrate the soil.

(f) Fog and dew contain substantial amounts of water that can be used directly by artificial surfaces such as netting-surfaced traps or polyethylene sheets. The resulting water can be used for crops.

(g) Contour farming is adopted in hilly areas and in lowland areas for paddy fields. Farmers recognize the efficiency of contour-based systems for conserving soil and water.

(h) Salt-resistant varieties of crops in saline areas. Overall agricultural productivity can be increased without making additional demands on freshwater sources.

(j) Transfer of water from surplus areas to deficit areas by inter-linking water systems through canals, etc.

(k) Desalination technologies such as distillation, electro-dialysis and reverse osmosis are available.

(l) Use of efficient watering systems such as drip irrigation and sprinklers will reduce the water consumption by plants.

Own Responsibilities

17. Having seen the various sector wise needs to improve the situation for a better future it would be pertinent to know simple responsibilities of citizens.

(a) Try to do one thing each day that will result in saving water.

(b) Remember to use only the amount one actually need.

(c) Form a group of water-conscious people and encourage friends and neighbours to be part of this group. Promote water conservation in community newsletters and on bulletin boards.

(d) Make sure that homes are leak-free. Many homes have leaking pipes that go unnoticed.

(e) Housewives or maids should be judicious while consuming water as well as storing it.

(f) Water can be stored in a variety of ways. A simple method is to place a drum on a raised platform directly under the rainwater collection source. You can also collect water in a bucket during the rainy season.

18. Water management is the responsibility of the citizen and government alike. South Asia needs a coherent responsible structure to be in place to ensure that water crisis which looms large with the population explosion is minimized.

The recommendations are only the tip of the iceberg. A number of initiatives can be undertaken to manage this precious commodity. Plenty of traditional and modern innovative techniques are available. It just needs a coordinated effort at all levels.

Conclusion

19. The aspects brought out in the chapters are still miniscule portion of the highly complicated, subject of water management especially in India. A concerned effort right from our homes is the need of the hour where we tell our children and ourselves the importance of this precious commodity. As President John F Kennedy told his countrymen "Do not ask as to what the country can do for you, ask what you can do for the country". Similarly it's at the smallest level water conservation needs to be driven home to ensure a ray of hope in a not so pleasant future. A comprehensive approach is recommended that simultaneously combines mechanisms in policy, institutions legal and regulatory framework, economic and financial incentive framework and the strengthening data, technological and information systems for a better tomorrow.

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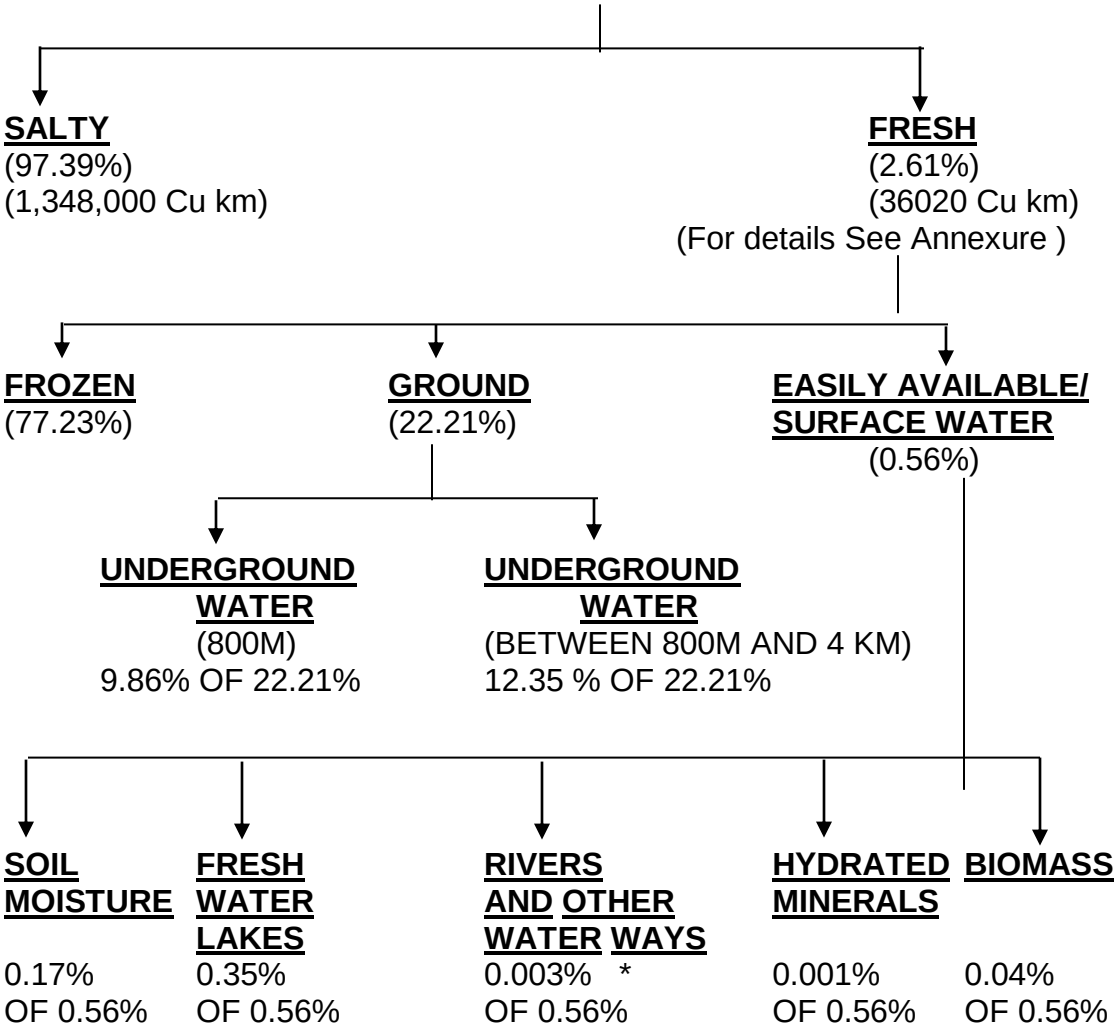
Appendix 'A'

(Refers to Chapter II Para 7 (g) of Script)

WATER SOURCE CHAIN

WATER

(**70% of EARTH & 60% OF HUMAN BODY**)



* 40% OF HUMANITY DEPENDS ON WATER FROM 214 RIVER SYSTEMS.

Annexure
(Refer to appendix `A')

FRESH WATER AS PART OF HYDROSPHERE

SER.NO	FORM	MASS (Cu km)	RELATIVE PROPORTION % OF HYDROSPHERE
1.	Polar Ice Caps, Glaciers	27820	2.01
2.	Underground Water, Soil Moisture.	8062	0.58
3.	Lakes and Rivers	225	0.02
4.	Atmospheric Water Vapour	13	0.001
TOTAL		**36020**	**2.611**

SOURCE : Chapter 2 **The Water** summary of Table 2.1 and 2.2 Water, Environment and Pollution by Dr. U Kumar & Dr (Mrs) Bhanu Kakrani – Agrobios (India) Publications.

Appendix 'B'

(Refers to
Chapter II Para 9
(c) of Script)

ESTIMATE OF GLOBAL WATER RESOURCES IN 2025

Water Supply (m3/person /year)	1995 Population (millions)	1995 Percent of Total	2025 Population (millions)	2025 Percent of Total
<500	1,077	19.0	1,783	24.5
500-1,000	587	10.4	624	8.6
1,000-1,700	669	11.8	1,077	14.8
Subtotal	2,333	41.2	3,484	47.9
>1,700	3,091	54.6	3,494	48.0
Unallocated	241	4.2	296	4.0
Total	5,665	100.0	7,274	100.0

Source: WRI. The 2025 estimates are considered conservative because they are based on the United Nations' low-range projections for population growth, which has population peaking at 7.3 billion in 2025 (UNDP 1999:3). In addition, a slight mismatch between the water runoff and population data sets leaves 4 percent of the global population unaccounted in this analysis.

SOURCE Website World Resources Institute.

Appendix 'C'

(Refers to
Chapter II, Para 9
(e) (iv) of Script)

POTENTIAL WATER RESOURCES IN DIFFERENT PARTS OF THE WORLD

Continent	Runoff, km3 per annum			Stable Runoff as Percentage of Total Runoff
	Total	Stable Portion✧	Unstable Portion	
Africa	4225	1905	23201	45
Asia, except USSR	9544	2900	6644	30
Australia	1965	495	1470	25
Europe, except USSR	2362	1020	1342	43
North America	5960	2380	3580	40
South America	10380	3900	6480	38
USSR	4384	1410	2974	32
All continents, except polar areas	38820	14010	24810	36

✧ Derived from groundwater regulated by lakes or reservoirs.

SOURCE : Malin Falkenmark and Gunnar Lindh "**Water for a Starving World**" Page 17, 1976.

Appendix 'D'
(Refers to Chapter II Para 10 of Script)

ASIA - FRESHWATER AVAILABILITY AND WITHDRAWAL

Country	Pop 2000 ('000)	Annual Renewable Freshwater Resources					Annual Freshwater Withdrawals							Groundwater	
		Internal (billion m3)	River flow From other countries (billion m3)	Total annual Water Resources (AWR) (billion m 3)	External flow as share of total AWR	Per capita (m3)	Year of data	Total (billion m3)	Per capita (m3)	As % of total Freshwater resources	%for domestic	%for industry	% for agricultu re	Year of data	Groundwater withdrawal per capita (cu m)
Sources year of data Definition	UN 2003 (1)	WRI (2)	WRI (3)	WRI (4)=(2)+(3)	(5)=(3)/(4)* 100	(6)=(4)/(1)	(7)	WRI (8)	WRI (9)	(10)=(8)/(4) * 100	WRI (11)	WRI (12)	WRI (13)		WRI
Afghanistan	21 767	55.0	10.0	65	15	2,986		26.11							
Azerbaijan	8 041	8.1	27.0	29	72	5,019	1996	16.63	2,188	56.8	5	25	70		
Bangladesh	137 439	105.0	1,105.6	1,211	91	8,808	1990	14.64	134	1.2	12	2	86	1990	97.6
Bhutan	2 085	95.0	-	95	-	45,564	1987	0.02	13	0.0	36	10	64		
Cambodia	13104	120.6	355.6	476	75	36,340	1987	0.52	66	0.1	5	1	94		
China, PR	1282437	2,8124	17.2	2,830	1	2,206	1993	523.46	439	10.6	5	16	77	1993	47.1
Cook Islands															
Fiji	814			0											
India	1008937	1,260.6	647.2	1,908	34	1,891	1990	500.00	588	26.2	5	3	92	1990	223.3
Indonesia	212082	2,838.0	-	2,838		13,381	1990	74.35	407	2.8	6	1	93		
Kazakhstan	16172	75.4	34.2	110	31	6,777	1993	33.67	2,019	30.7	2	17	81	1993	143.9
Kiribati															
Korea (rep.of)	46740	64.9	4.9	70	7	1,493	1994	23.67	531	33.9	26	11	63	1995	55.1
Kyrgyzstan	4821	48.5	-	47	-	9,440	1994	10.09	2,219	21.7	3	3	94	1994	132
Laos	5279	190.4	143.1	334	43	63,175	1987	0.99	260	0.3	8	10	82	1995	19
Malaysia	22218	580.0	-	580		28,105	1985	12.73	633	22	11	13	76	1993	149.1
Maldives	291														
Marshall Islands				0		n.a									
Micronesia				0		n.a									
Mongolia	2533	34.8	-	35		13,730	1993	0.43	162	1.2	20	27	63		
Myanmar	47749	880.6	165.0	1,046	16	21,898	1987	3.96	102	0.4	7	3	90		
Nauru															
Nepal	23043	198.2	12.0	210	6	9,122	1994	29.00	1,397	13.8	1	0	99		

Appendix D Contd…….

ASIA - FRESHWATER AVAILABILITY AND WITHDRAWAL

Country	Pop 2000 ('000)	Annual Renewable Freshwater Resources					Annual Freshwater Withdrawals							Groundwater	
		Internal (billion m3)	River flow From other countries (billion m3)	Total annual Water Resources (AWR) (billion m 3)	External flow as share of total AWR	Per capita (m3)	Year of data	Total (billion m3)	Per capita (m3)	As % of total Freshwater resources	%for domestic	%for industry	% for agricultu re	Year of data	Groundwater withdrawal per capita (cu m)
Sources year of data Definition	UN 2003 (1)	WRI (2)	WRI (3)	WRI (4)=(2)+(3)	(5)=(3)/(4)* 100	(6)=(4)/(1)	(7)	WRI (8)	WRI (9)	(10)=(8)/(4) * 100	WRI (11)	WRI (12)	WRI (13)		WRI
Pakistan	141258	84.7	170.3	255	57	1,806	1991	165.60	1,287	81.0	2	2	97	1991	489.6
Papua New Guinea	4809	801.0	-	801	-	166,563	1987	2.00	28	0.2	29	22	49		
Philippines	75653	479.0	-	479	-	8,332	1985	55.42	811	11.6	8	4		1993	82.8
Samoa	159			0		n.a									
Singapore	4019														
Solomon Islands															
Sri Lanka	18924	50.0		50	-	2,842	1990	9.77	573	19.5	2	2	9		
Taipei, China			-												
Tajikistan	6087	06.3	13.3	80	17	13,077	1994	11.87	2,095	14.8	4	4	92	1994	398.7
Thailand	62806	210.0	199.9	410	49	6,526	1990	33.13	596	8.1	5	4	91	1980	50
Tonga															
Turkmenistan	4737	1.4	59.5	61	98	12,856	1994	23.78	597	39.0	1	1	98	1994	100.3
Tuvalu															
Uzbekistan	24881	16.3	98.1	114	86	4,598	1994	58.05	2,626	50.7	4	2	94	1994	334.3
Vanuatu	197	5		0		n.a									
Viet Nam	78137	366.	524.7	891	59	11,406	1990	54.30	814	6.1	4	10	86	1990	11.9

SOURCE ASIAN DEVELOPMENT BANK WEBSITE, www.adb.com.

Appendix 'E'

(Refers to Chapter III Para 6 of Script)

BASIC WATER INFORMATION PAKISTAN

Indicators	Use	Data	Source
Water Resources			
Total annual water resources (AWR)		255 cu. km.	
Surface water produced internally		47 cu km	
Ground water recharge		55 cu km	
Overlap (shared by ground and Surface water)		50 cu km	9
Total internal renewable water resources (surface + ground - overlap)		52 cu km	
Total withdrawals		155.6 cu km	
Withdrawals per capita		1382 cu km	
Withdrawals as percentage of renewable Water resources		99.9 %	
Water from international rivers as share of annual water resources		67 %	
Total resources per capita		1,805.0 cu. m.	4,9
Water Use			
Total annual water withdrawals as share of AWR	Total	61.0 %	9
	Domestic	2 %	9
	Industry	2 %	9
	Agriculture	97 %	9
Water withdrawals per capita		1,267 cu.m	9
Irrigated land as percentage of irrigation potential		*na* %	
Groundwater withdrawals per capita		489.5 cu.m	9

Appendix 'E' Contd….

Indicators	Use	Data	Source
Watershed Management			
Annual rate of change in forest cover		1.5 %	2
Water and Poverty			
Population with access to water supply	Urban	96 %	7
	Rural	84 %	7
Population with access to sanitation	Urban	94 %	7
	Rural	42 %	7
Incidence of diarrhoea in children under 5 years of age		26.0 %	5
Number of deaths due to floods and droughts 1990-2004		138 persons	8
Economic losses due to floods and droughts 1990-2004		1,823.2 $ million	8

Sources:

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5. UNICEF (http://www.childinfo.org/index2.htm)
6. World Bank (http://www.worldbank.org/data/databytopic/databytopic.html)
7. World Health Organization (http://www.who.int/water_sanitation_health/Globassessment/GlasspdfTOC.htm)
8. WHO Collaborating Centre for Research on the Epidemiology of Disasters (http://www.cred.be/emdat/into.html)
9. World Resources Institute (http://earthtrends.wri.org/)

Appendix 'F'

(Refers to Chapter III Para 7 of Script)

BASIC WATER INFORMATION BANGLADESH

Indicators	Use	Data	Source
Water Resources			
Total annual water resources (AWR)		1211 cu. km.	
Surface water produced internally		84 cu km	
Ground water recharge		21 cu km	
Overlap (shared by ground and Surface water)		0 cu km	9
Total internal renewable water resources (surface + ground - overlap)		105 cu km	
Total withdrawals		14.6 cu km	
Withdrawals per capita		133 cu km	
Withdrawals as percentage of renewable Water resources		1.6 %	
Water from international rivers as share of annual water resources		91 %	
Total resources per capita		8808 cu. m.	4,9
Water Use			
Total annual water withdrawals as share of AWR	Total	1.2 %	9
	Domestic	12 %	9
	Industry	2 %	9
	Agriculture	86 %	9
Water withdrawals per capita		134 cu.m	9
Irrigated land as percentage of irrigation potential		49 %	
Groundwater withdrawals per capita		97.6 cu.m	9

Appendix 'F' Contd….

Indicators	Use	Data	Source
Watershed Management			
Annual rate of change in forest cover		1.3 %	2
Water and Poverty			
Population with access to water supply	Urban	99 %	7
	Rural	97 %	7
Population with access to sanitation	Urban	82 %	7
	Rural	44 %	7
Incidence of diarrhoea in children under 5 years of age		6.1 %	5
Number of deaths due to floods and droughts 1990-2004		2110 persons	8
Economic losses due to floods and droughts 1990-2004		3250 $ million	8

Sources:

1. FAO Aquastat (http://www.fao.org/ag/agl/aglw/aquastatweb/main/html/aquastat.htm)
2. FAO State of the World's Forests (http://www.fao.org/forestry/FO/SOFO/sofo-e.stm)
3. Raskin, P et al. 1997. Water Futures: assessment of long range patterns and problems. Stockholm Environment Institute.
4. United Nations (http://www.un.org/popin/data.htm)
5. UNICEF (http://www.childinfo.org/index2.htm)
6. World Bank (http://www.worldbank.org/data/databytopic/databytopic.html)
7. World Health Organization (http://www.who.int/water_sanitation_health/Globassessment/GlasspdfTOC.htm)
8. WHO Collaborating Centre for Research on the Epidemiology of Disasters (http://www.cred.be/emdat/into.html)
9. World Resources Institute (http://earthtrends.wri.org/)

Appendix 'G'

(Refers to Chapter III Para 8 of Script)

BASIC WATER INFORMATION NEPAL

Indicators	Use	Data	Source
Water Resources			
Total annual water resources (AWR)		210 cu. km.	
Surface water produced internally		198 cu km	
Ground water recharge		20 cu km	
Overlap (shared by ground and Surface water)		20 cu km	9
Total internal renewable water resources (surface + ground - overlap)		198 cu km	
Total withdrawals		29 cu km	
Withdrawals per capita		1451 cu km	
Withdrawals as percentage of renewable Water resources		16.7 %	
Water from international rivers as share of annual water resources		6 %	
Total resources per capita		9122 cu. m.	4,9
Water Use			
Total annual water withdrawals as share of AWR	Total	13.8 %	9
	Domestic	1 %	9
	Industry	2 %	9
	Agriculture	99 %	9
Water withdrawals per capita		1397 cu.m	9
Irrigated land as percentage of irrigation potential		52 %	
Groundwater withdrawals per capita		NA	9

Appendix 'G' Contd….

Indicators	Use	Data	Source
Watershed Management			
Annual rate of change in forest cover		- 1.8 %	2
Water and Poverty			
Population with access to water supply	Urban	85 %	7
	Rural	80 %	7
Population with access to sanitation	Urban	75 %	7
	Rural	20 %	7
Incidence of diarrhoea in children under 5 years of age		27.5 %	5
Number of deaths due to floods and droughts 1990-2004		2287 persons	8
Economic losses due to floods and droughts 1990-2004		265.3 $ million	8

Sources:

1. FAO Aquastat (http://www.fao.org/ag/agl/aglw/aquastatweb/main/html/aquastat.htm)
2. FAO State of the World's Forests (http://www.fao.org/forestry/FO/SOFO/sofo-e.stm)
3. Raskin, P et al. 1997. Water Futures: assessment of long range patterns and problems. Stockholm Environment Institute.
4. United Nations (http://www.un.org/popin/data.htm)
5. UNICEF (http://www.childinfo.org/index2.htm)
6. World Bank (http://www.worldbank.org/data/databytopic/databytopic.html)
7. World Health Organization (http://www.who.int/water_sanitation_health/Globassessment/GlasspdfTOC.htm)
8. WHO Collaborating Centre for Research on the Epidemiology of Disasters (http://www.cred.be/emdat/into.html)
9. World Resources Institute (http://earthtrends.wri.org/)

Appendix 'H'

(Refers to
Chapter III
Para 9 of Script)

BASIC WATER INFORMATION BHUTAN

Indicators	Use	Data	Source
Water Resources			
Total annual water resources (AWR)		95 cu. km.	
Surface water produced internally		95 cu km	
Ground water recharge		-	
Overlap (shared by ground and Surface water)		-	
Total internal renewable water resources (surface + ground - overlap)		95 cu km	9
Total withdrawals		0	
Withdrawals per capita		13 cu km	
Withdrawals as percentage of renewable Water resources		0.001 %	
Water from international rivers as share of annual water resources		0	
Total resources per capita		45564 cu. m.	4,9
Water Use			
Total annual water withdrawals as share of AWR	Total	0.02 %	9
	Domestic	36 %	9
	Industry	10 %	9
	Agriculture	54 %	9
Water withdrawals per capita		13 cu.m	9
Irrigated land as percentage of irrigation potential		NA	
Groundwater withdrawals per capita		NA	9

Appendix 'H' Contd….

Indicators	Use	Data	Source
Watershed Management			
Annual rate of change in forest cover		NA	2
Water and Poverty			
Population with access to water supply	Urban	86 %	7
	Rural	60 %	7
Population with access to sanitation	Urban	65 %	7
	Rural	70 %	7
Incidence of diarrhoea in children under 5 years of age		-	5
Number of deaths due to floods and droughts 1990-2004		-	8
Economic losses due to floods and droughts 1990-2004		-	8

Sources:

1. FAO Aquastat (http://www.fao.org/ag/agl/aglw/aquastatweb/main/html/aquastat.htm)
2. FAO State of the World's Forests (http://www.fao.org/forestry/FO/SOFO/sofo-e.stm)
3. Raskin, P et al. 1997. Water Futures: assessment of long range patterns and problems. Stockholm Environment Institute.
4. United Nations (http://www.un.org/popin/data.htm)
5. UNICEF (http://www.childinfo.org/index2.htm)
6. World Bank (http://www.worldbank.org/data/databytopic/databytopic.html)
7. World Health Organization (http://www.who.int/water_sanitation_health/Globassessment/GlasspdfTOC.htm)
8. WHO Collaborating Centre for Research on the Epidemiology of Disasters (http://www.cred.be/emdat/into.html)
9. World Resources Institute (http://earthtrends.wri.org/)

Appendix 'J'

(Refers to Chapter III Para 15 of Script)

ANNUAL RUN OFF FROM ENDOGENOUS PRECIPITATION IN SELECTED COUNTRIES

		Total Cubic Kilometers	Thousand Cubic Meters per Person
Water Rich Countries			
1.	Iceland	170	685.48
2.	Canada	2901	111.74
3.	Brazil	5190	36.69
4.	Australia	343	21.30
5.	U S S R	4384	15.44
6.	U S A	2478	10.23
Water Poor Countries			
7.	China	2800	2058
8.	**India**	**1850**	**2.35**
9.	South Africa	50	1.47
10.	Kenya	14.80	1.47
11.	Saudi Arabia	2.20	0.66
12.	Egypt	1.00	0.02

SOURCE WORLD RESOURCES INSTITUTE.

Appendix 'K'

(Refers to Chapter III Para 15 of Script)

BASIC WATER INFORMATION INDIA

Indicators	Use	Data	Source
Water Resources			
Annual Precipitation		4000 cu km	10
Average annual potential rivers		1869 cu km	
Total annual water resources (AWR)		1908 cu km	9
Surface water produced internally		1222 cu km	
Ground water recharge		419 cu km	
Overlap (shared by ground and Surface water)		380 cu km	
Total internal renewable water resources (surface + ground - overlap)		1261 cu km	
Total withdrawals		500.0 cu km	
Withdrawals per capita		592 cu km	
Withdrawals as percentage of renewable Water resources		32.5 %	
Water from international rivers as share of annual water resources		34%	
Total resources per capita		1891 cu. m.	4,9
Water Use			
Total annual water withdrawals as share of AWR	Total	26.2 %	9
	Domestic	5 %	9
	Industry	3 %	9
	Agriculture	92 %	9
Water withdrawals per capita		588 cu.m	9
Irrigated land as percentage of irrigation potential		44 %	
Groundwater withdrawals per capita		223.3 cu m	9

Appendix 'K' Contd…..

Indicators	Use	Data	Source
Watershed Management			
Annual rate of change in forest cover		NA	2
Water and Poverty			
Population with access to water supply	Urban Rural	92 % 86 %	7 7
Population with access to sanitation	Urban Rural	73 % 14 %	7 7
Incidence of diarrhoea in children under 5 years of age		19.2 %	5
Number of deaths due to floods and droughts 1990-2004		15,846	8
Economic losses due to floods and droughts 1990-2004		4604 $ million	8

Sources:

1. FAO Aquastat (http://www.fao.org/ag/agl/aglw/aquastatweb/main/html/aquastat.htm)
2. FAO State of the World's Forests (http://www.fao.org/forestry/FO/SOFO/sofo-e.stm)
3. Raskin, P et al. 1997. Water Futures: assessment of long range patterns and problems. Stockholm Environment Institute.
4. United Nations (http://www.un.org/popin/data.htm)
5. UNICEF (http://www.childinfo.org/index2.htm)
6. World Bank (http://www.worldbank.org/data/databytopic/databytopic.html)
7. World Health Organization (http://www.who.int/water_sanitation_health/Globassessment/GlasspdfTOC.htm)
8. WHO Collaborating Centre for Research on the Epidemiology of Disasters (http://www.cred.be/emdat/into.html)
9. World Resources Institute (http://earthtrends.wri.org/)
10.Ministry of Water Resources, www.wrmin.nic.in.

Appendix 'L'

(Refers to
Chapter III Para
15 (b) of Script)

INDIA - BASIN WISE SURFACE WATER POTENTIAL

Ser No.	Name of the River Basin	Average Annual Potential River (Cubic Km/Year)
1.	Indus (up to Border)	73.31
2.	a) Ganga	525.02
	b) Brahmaputra, Barak & Others	585.60
3.	Godavari	110.54
4.	Krishna	78.12
5.	Cauvery	21.36
6.	Pennar	6.32
7.	East Flowing Rivers Between Mahanadi & Pennar	22.52
8.	East Flowing Rivers Between Pennar and Kanyakumari	16.46
9.	Mahanadi	66.88
10.	Brahmani & Baitarni	28.48
11.	Subernarekha	12.37
12.	Sabarmati	3.81
13.	Mahi	11.02
14.	West Flowing Rivers of Kutch, Sabarmati including Luni	15.10
15.	Narmada	45.64
16.	Tapi	14.88
17.	West Flowing Rivers from Tapi to Tadri	87.41
18.	West Flowing Rivers from Tadri to Kanyakumari	113.53
19.	Area of Inland drainage in Rajasthan desert	NEG.
20.	Minor River Basins Drainage into Bangladesh & Burma	31.00
	Total	1869.35

SOURCE : Ministry of Water Resources.

Appendix 'M'

(Refers to Chapter III Para 15 (c) of Script)

INDIA - BASINWISE GROUND WATER POTENTIAL

Ser No.	Name of Basin	Replenishable Ground Water Resources (Cubic Km/Year)
1.	Brahmai with Baitarni	4.05
2.	Brahmaputra	26.55
3.	Cambai Composite	7.19
4.	Cauvery	12.30
5.	Ganga	170.99
6.	Godavari	40.65
7.	Indus	26.49
8.	Krishna	26.41
9.	Kutch & Saurashtra Composite	11.23
10.	Madras and South Tamil Nadu	18.22
11.	Mahanadi	16.46
12.	Meghna	8.52
13.	Narmada	10.83
14.	Northeast Composite	18.84
15.	Pennar	4.93
16.	Subarnrekha	1.82
17.	Tapi	8.27
18.	Western Ghat	17.69
	Total	431.42

SOURCE : Ministry of Water Resources.

Appendix 'N'

(Refers to Chapter IV Para 5 (c) of Script)

INDIA - GROUND WATER POLLUTION INDIA

Pollutant	State	Place of Occurrences
Salinity (Inland)	Maharashtra	Amravati, Akola
	Bihar	Begusarai
	Haryana	Karnal
	Rajasthan	Barmer, Jaisalmer, Bharatpur, Jaipur, Nagaur, Jalore & Sirohi
	U.P.	Mathura
Salinity (Coastal)	Andhra Pradesh	Vishakapatnam
	Orissa	Puri, Cuttak, Balasore
	West Bengal	Haldai & 24 Pargana
	Gujarat	Junagarh, Kachch, Varahi, Banskanta & Surat
Flouride	Kerala	Palaghat Krishna, Ananipur, Nellor, Chittoor.
	Andhra Pradesh	Cuddapah, Guntur and Nalgonda
	Gujarat	Banskanta, Kachch & Amreli
	Haryana	Hissar, Kaithal & Gurgaon
	Orissa	Bolangir, Bijapur, Bhubaneshwar and Kalahandi
	Punjab	Amritsar, Bhatinda, Faridkot, Ludhiana & Sangrur
	Rajasthan	Nagaur, Pali, Sirohi, Ajmer & Bikaner
	Tamil Nadu	Chengalput, Madurai
	U.P.	Unnao, Agra, Aligarh, Mathura, Ghaziabad, Meerut & Rai Baraili
Sulphide	Orissa	Balasore, Cuttak & Puri
Iron	U.P.	Mirjapur
	Assam	Darrang, Jorhat, Kamrup
	Orissa	Bhubaneshwar
	Bihar	E. Champaran, Muzaffarpur, Gaya, Manger, Deoghar & Madubani
	Rajasthan	Bikaner, Alwar, Bharatpur
	Tripura	Dharmnagar, Kailasanar, Ambasa, Amarpur & Agartala

Appendix 'N' Contd…….

INDIA - GROUND WATER POLLUTION

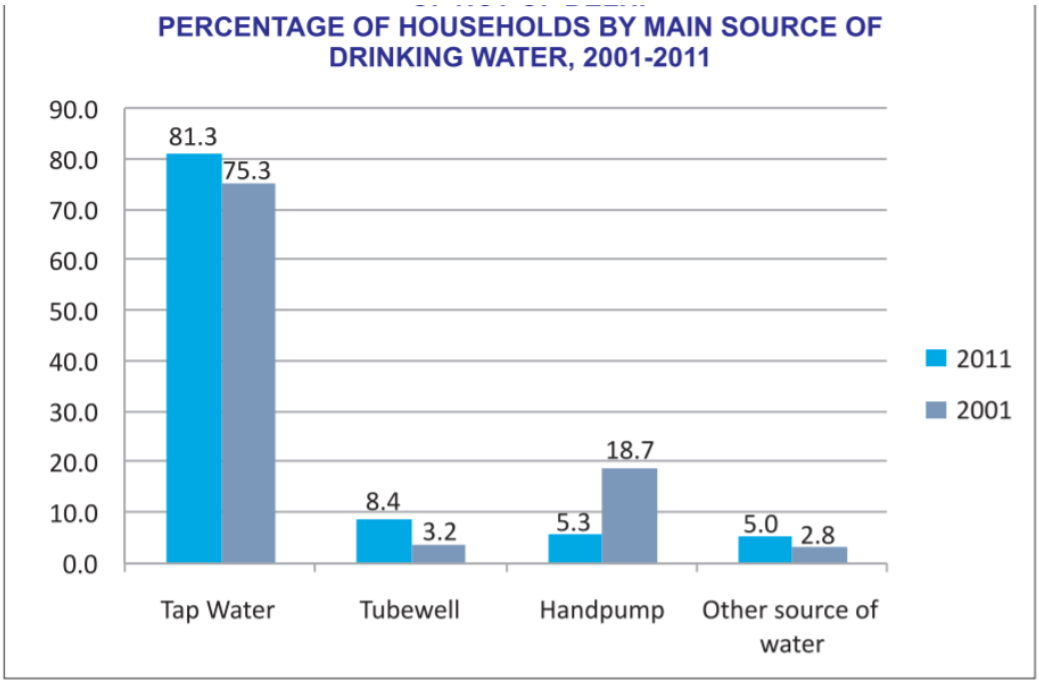
Pollutant	State	Place of Occurrences
	West Bengal	Madnipur, Howrah, Hoogly and Bankura
Maganese	Orissa	Bhubaneshwar, Athgaon
	U.P	Muradabad, Basti, Rampur & Unnao
Arsenic	West Bengal	Malda, Murshidabad, Nadia, 24 Pargana
Nitrate	Bihar	Patna, East Champaran, Palamu, Gaya, Nalanda, Nawada and Banka
	Andhra Pradesh	Vishakapatnam, East Godvari, Krishna, Prakasam, Nellor, Chittoor, Anantpur, Cuddapah, Kurnool, Khamam and Nalgonda
	Delhi	Naraina, Shehadr (Blocks)
	Haryana	Ambala, Sonepat, Jind, Gurgaon, Faridabad & Hissar
	Himachal Pradesh	Kulu, Solan, Una
	Karnataka	Bidar, Gulbarge and Bijapur
	Madhya Pradesh	Sehore, Bhopal & (West & Central Part of state)
	Maharashtra	Jalna, Beed Nanded, Latur, Osmanabad, Solapur Satara, Sangli and Kolhapur
	Punjab	Patiala, Faridkot, Firozpur, Sangrur & Bhatinda
	Rajasthan	Jaipur, Churu, Ganganagar, Bikaner, Jalore, Barmer, Bundi and Sawaimadhopur
	Tamil Nadu	Coimbatore, Penyar and Salem
	West Bengal	Uttar Dinajpur, Malda, Birbhum, Murshidabad, Nadia, Bankura and Purulia.
Chloride	Karnataka	Dharwad, Belgaum
	Madhya Pradesh	Bhind, Shagapur and Sehore
	Maharashtra	Solapur, Satara, Amravati, Akola & Buldana
	Rajasthan	Barmer, Jaisalmer, Jodhpur & Jalore
	West Bengal	Contai, Digha, Haldia
Zinc	Andhra Pradesh	Hyderabad, Osmania University campus
	Delhi	R.K. Puram
	Rajasthan	Udaipur
Chromium	Punjab	Ludhiana

Appendix 'O'

(Refers to Chapter IV Para 7 of script)

CONDITION OF EXISTING RURAL WATER SUPPLY SCHEMES

Type of Technology	Total number installed	Require Repair or Rehabilitation		Defunct	
		Number	Percent	Number	Percent
Hand Pumps Schemes	2071569	459887	22.2	254000	12.3
Piped Water Schemes	116324	44565	25.8	-	-
Stand Posts	1528000	278000	18.2	-	-



SOURCE Censes 2011

Appendix 'AA'

(Refers to Chapter IV Para 15 of script)

OVEREXPLOITED AND DARK BLOCKS : 1984-93

State	1984-85	1992-93
AP	0	30
Bihar	14	1
Gujarat	6	26
Haryana	31	51
Karnataka	3	18
MP	0	3
Punjab	64	70
Rajasthan	21	56
Tamilnadu	61	97
UP	53	31
Total	253	383

SOURCE : WORLD BANK REPORTS

Appendix 'AB'

(Refers to Chapter IV Para 15 (b) of script)

EXTENT OF WATERLOGGING, SALINITY AND ALKALINITY IN IRRIGATION PROJECTS

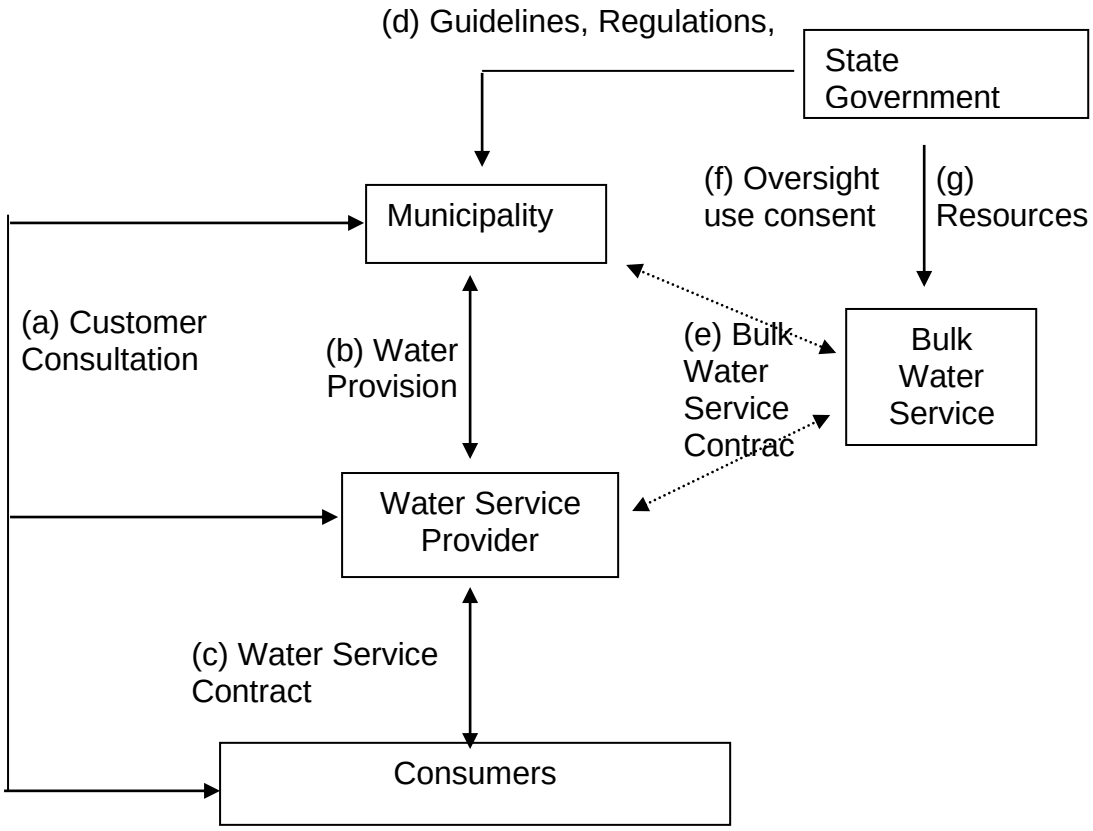
State	Number of Projects affected	Waterlogging (Hectares)	Salinity (hectares)	Alkalinity (hectares)
AP	4	266400	5000	
Bihar	3	362670	224300	
Gujarat	7	89408	1214165	
Haryana	3	229840		
J&K	0	1500		
Karnataka	9	24543	34244	
Kerala	8	11600	10610	
MP	1	4260		
Maharashtra	1	6000		
Orissa	1	196260		
Punjab	1	200000	1008000	1211300
Rajasthan		179500	7000	
TN		18000	20120	27480
UP		35200	483000	
Total		1625181	3069439	1277990

SOURCE : WORLD BANK REPORTS 2010

Appendix 'AC'

(Refers to Chapter V Para 9 (b) of script)

POSSIBLE UWSS SECTOR STRUCTURE



Notes :

(a) **Customer Consultation.** The municipality consults with consumers priorities guide planning and the water service provision contract.

(b) **Water Provision Contract.** Where the municipality uses an independent provider it will enter into a water provision contract governing coverage, tariff setting and service standards.

(c) **Water Service Contract.** Specifies consumers rights and obligations.

(d) **Guidelines, Regulations.** State government will support municipalities. For example, the state may issue high-level guidelines for contents of development plans, contracts and/or public consultation.

(e) **Bulk Water Contract.** Bulk water services providers will provide bulk service under contract to the municipality (or the distribution service provider). The contract will specify price, quantity, reliability etc.

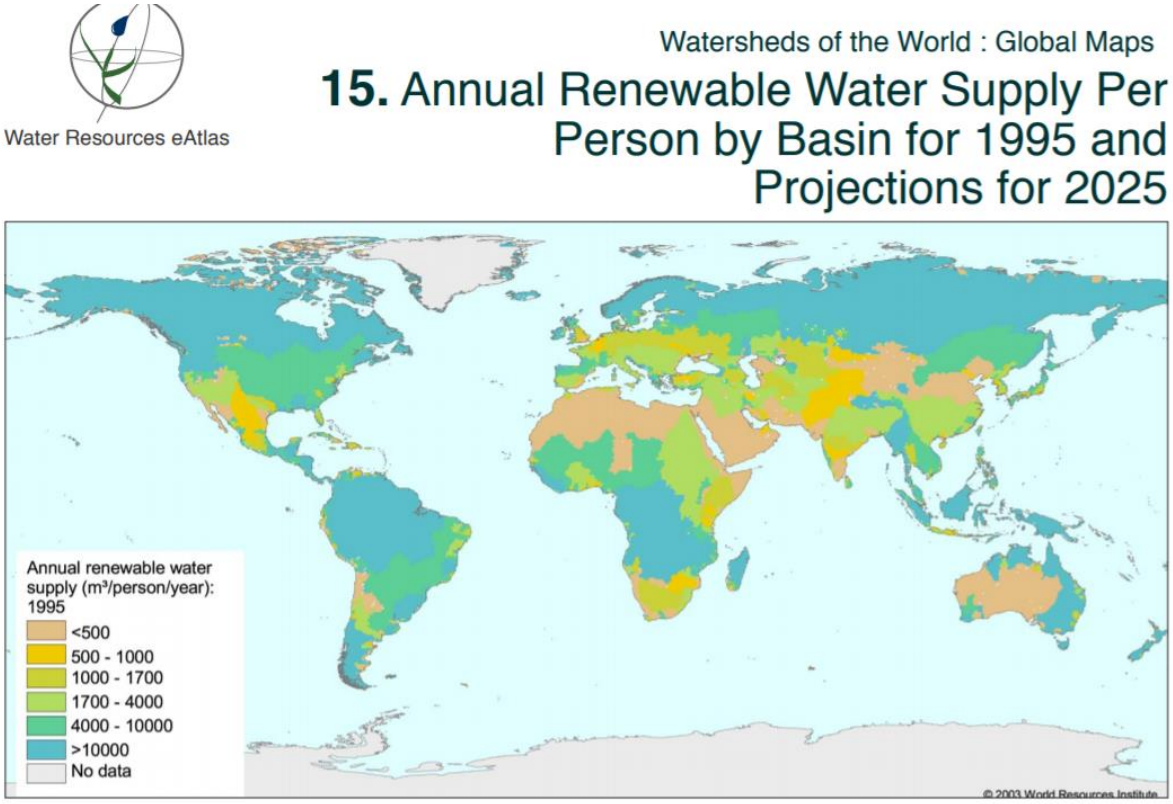
(f) **Oversight Powers.** Governments supervise bulk water service suppliers to prevent exploitation of monopolies.

(g) **Resource Use Consent.** There will be a resource use consent which will govern the bulk provider's access to the resource.

Appendix 'P'

(Refers to
Chapter II Para 9
(a) of Script)

MAP – WORLD - ANNUAL RENEWABLE WATER SUPPLY PER PERSON



SOURCE. CIESIN et al.2000, World Resources Institute website.

Appendix 'Q'

(Refers to
Chapter II Para 9
(b) of Script)

MAP – WORLD - WATER DEFICIENT AND SURPLUS ZONES

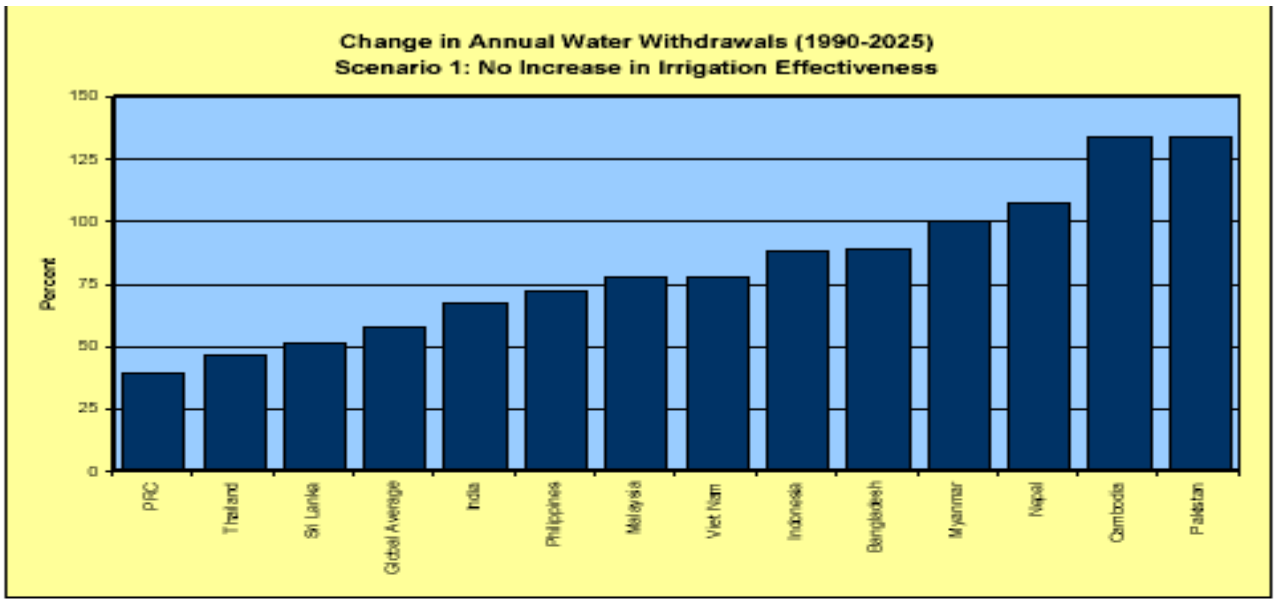
A WATER DEFICIENCY EXISTS IF PRECIPITATION SUPPLIES LESS WATER THAN WOULD BE NEEDED FOR WELL WATERED VEGETATION. IN THE REVERSE CIRCUMSTANCES THERE IS A WATER SURPLUS.

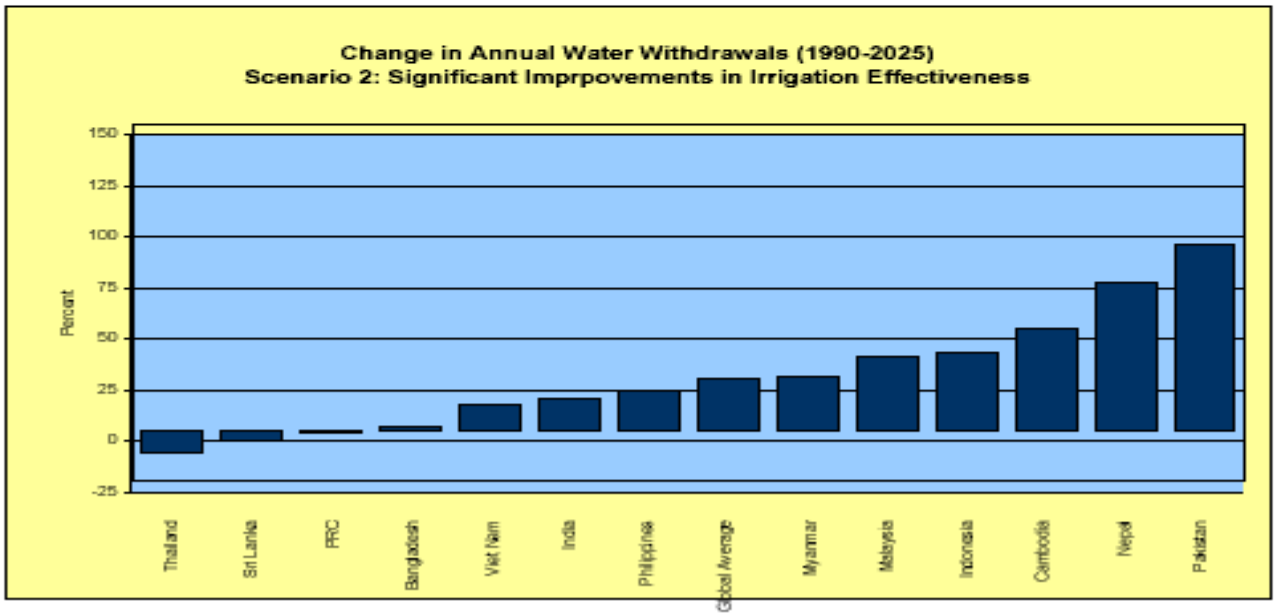
SOURCE Malin Falkenmark and Gunnar Lindh "**Water for a Starving World**" Page 03, 1976.

Appendix 'R'

(Refers to Chapter II Para 10 of Script)

ASIA - CHANGE IN ANNUAL WATER WITHDRAWALS (1990-2025)



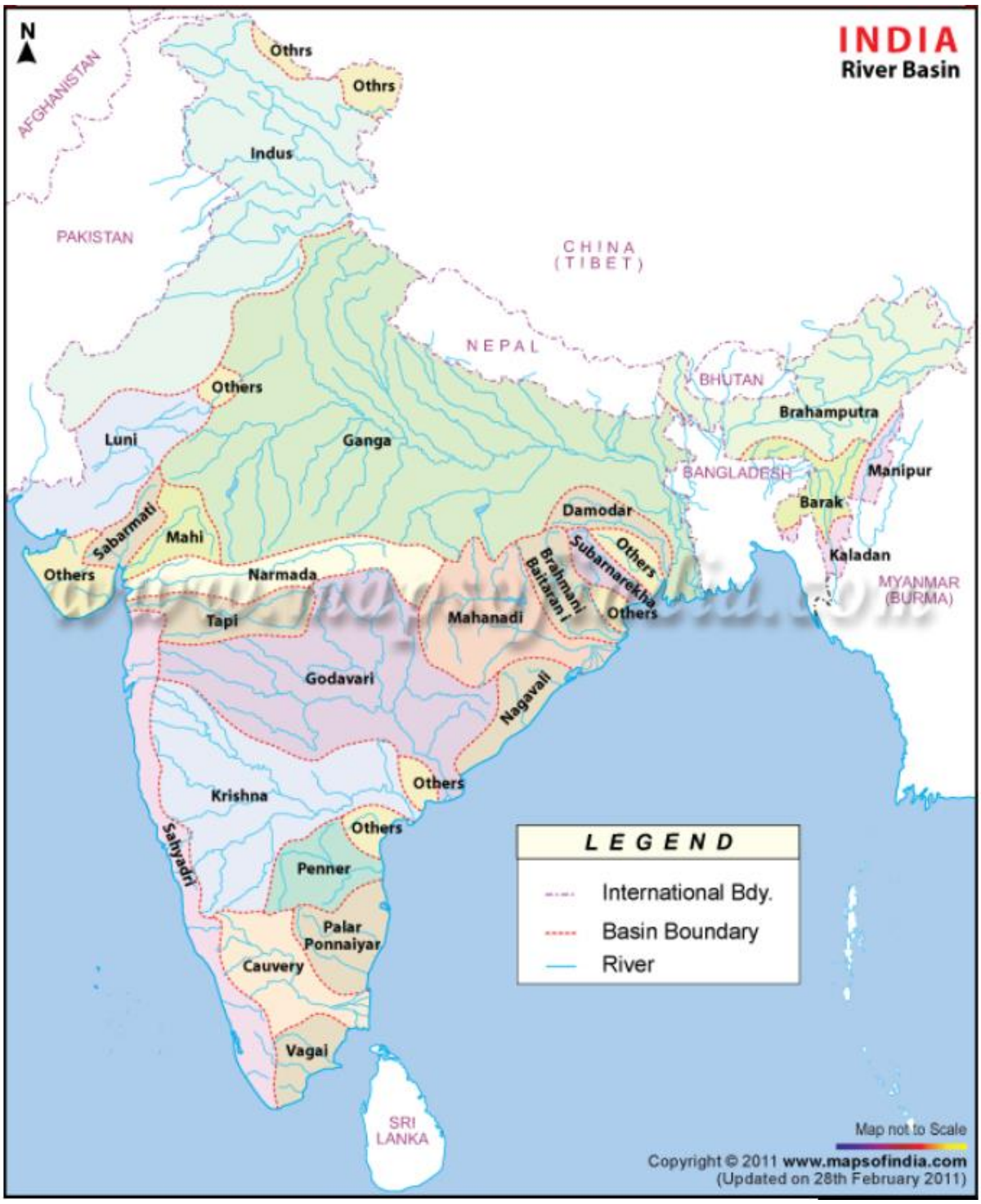


Source: Seckler, D., et al. World Water Demand and Supply, 1990-2025: Scenarios and Issues. IWMI. 1998

Appendix 'S'

(Refers to Chapter III Para 4 of Script)

MAP – MAJOR RIVER BASINS OF INDIA



SOURCE : www.mapsofindia.com

Appendix 'T'

(Refers to Chapter V Para 5 of Script)

METHODOLOGY - SEWAGE TREATMENT