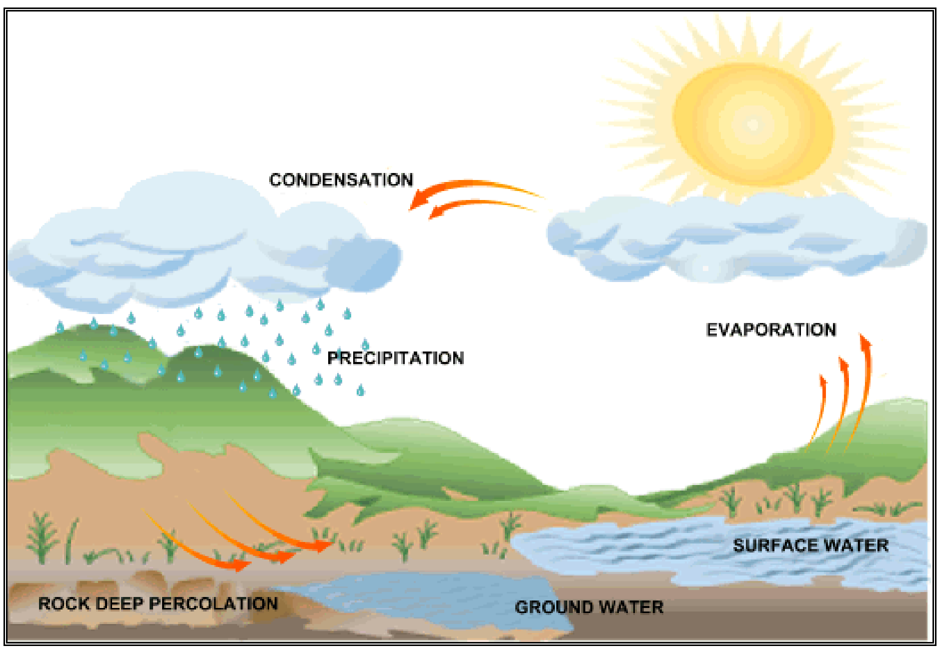
Draft

GOVERNMENT OF INDIA
MINISTRY OF WATER RESOURCES

NATIONAL WATER MISSION
under
National Action Plan on Climate Change



COMPREHENSIVE MISSION DOCUMENT

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Contents

Report of Sub-Committee

on

Policy and institutional Framework

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Contents

Abbreviations and Common terms

Abbreviation	*Full form*
B/C	Benefit/Cost
CBIP	Central Board of Irrigation and Power
CCRS	Center for Climate Research Studies
CFC	Chlorofluorocarbon
CGWB	Central Ground Water Board, Faridabad
CH_4	Methane
CO_2	Carbon dioxide
CPT	Kolkata Port Trust
CWC	Central Water Commission, New Delhi
CW&PC	Central Water and Power Commission, New Delhi
CWPRS	Central Water and Power Research Station, Pune
DDP	Drought Development Programme
DoOD	Department of Ocean Development
DPAP	Drought Prone Area Programme
DST	Department of Science and Technology
EAP	Employment Assurance Programme
EFR	Environmental Flow Requirement
EIA	Environment Impact Assessment
FAO	Food and Agriculture Organisation
GBM	Ganga-Brahmaputra-Meghna Basin
GCM	General Circulation Model/ Global Climatic Model
GFCC	Ganga Flood Control Commission, Patna
GFDL	Geo-physical Fluid Dynamic Laboratory
GHG	Green House Gases
GISS	Goddard Institute for Space Studies
GLOF	Glacial Lake Outburst Flood
GoI	Government of India
GPS	Geographical Positioning System
GSI	Geological Survey of India
hm^3 (MCM)	Hectometer (Million Cubic Metre) (10^6 Cubic Metre)
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research
ICID	International Commission on Irrigation and Drainage
ICIMOD	International Centre for Integrated Mountain Development
IIT	Indian Institute of Technology
IITM	Indian Institute of Tropical Meteorology, Pune
IMD	India Meteorological Department, New Delhi
INCID	International National Committee on Irrigation and Drainage
IPCC	Intergovernmental Panel on Climate Change
IWMI	International Water Management Institute
IWRS	Indian Water Resources Society
JGSY	Jawahar Gram Samridhi Yojana
km	Kilometre
km^3 (BCM)	Cubic Kilometre (Billion Cubic Metre) (10^9 Cubic Metre)
m	Metre
mm	Millimetre
MoAC	Ministry of Agriculture and Cooperation
MoEF	Ministry of Environment and Forests
MoWR	Ministry of Water Resources
NCAER	National Council of Applied Economic Research
NCIWRD	National Commission on Integrated Water Resources Development

Abbreviation	*Full form*
NGO	Non-Governmental Organisation
NIES	National Institute of Environmental Studies, Japan
NIH	National Institute of Hydrology, Roorkee
NO_2	Nitrogen Oxide
NWA	National Water Academy, Pune
NWDA	National Water Development Agency, New Delhi
NWP	National Water Policy
O_3	Ozone
PIM	Participatory Irrigation Management
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
RBA	Rashtriya Barh Ayog
RCM	Regional Climatic Model
R&R	Resettlement and Rehabilitation
SPF	Standard Project Flood
SPS	Standard Project Storm
SWAT	Soil and Water Assessment Tool
UKMO	United Kingdom Meteorological Office
UNFCCC	United Nations Framework Convention on Climate Change
WALMI	Water and Land Management Institute
WMO	World Meteorological Organization

CHAPTER 1
BACKGROUND

1.1 Introduction to India's Water Resources

The main water resources of India consists of the precipitation on the Indian territory which is estimate to be around 4000 km^3/year, and trans-boundary flows which it receives in its rivers and aquifers from the upper riparian countries.

Out of the total precipitation, including snowfall, the availability from surface water and replenishable groundwater is estimated as 1869 km^3. Due to various constraints of topography, uneven distribution of resource over space and time, it has been estimated that only about 1123 km^3 including 690 km^3 from surface water and 433 km^3 from groundwater resources can be put to beneficial use. Table 1.1 shows the water resources of the country at a glance. Precipitation over a large part of India is concentrated in the monsoon season during June to September/October. Precipitation varies from 100 mm in the western parts of Rajasthan to over 11000 mm at Cherrapunji in Meghalaya.

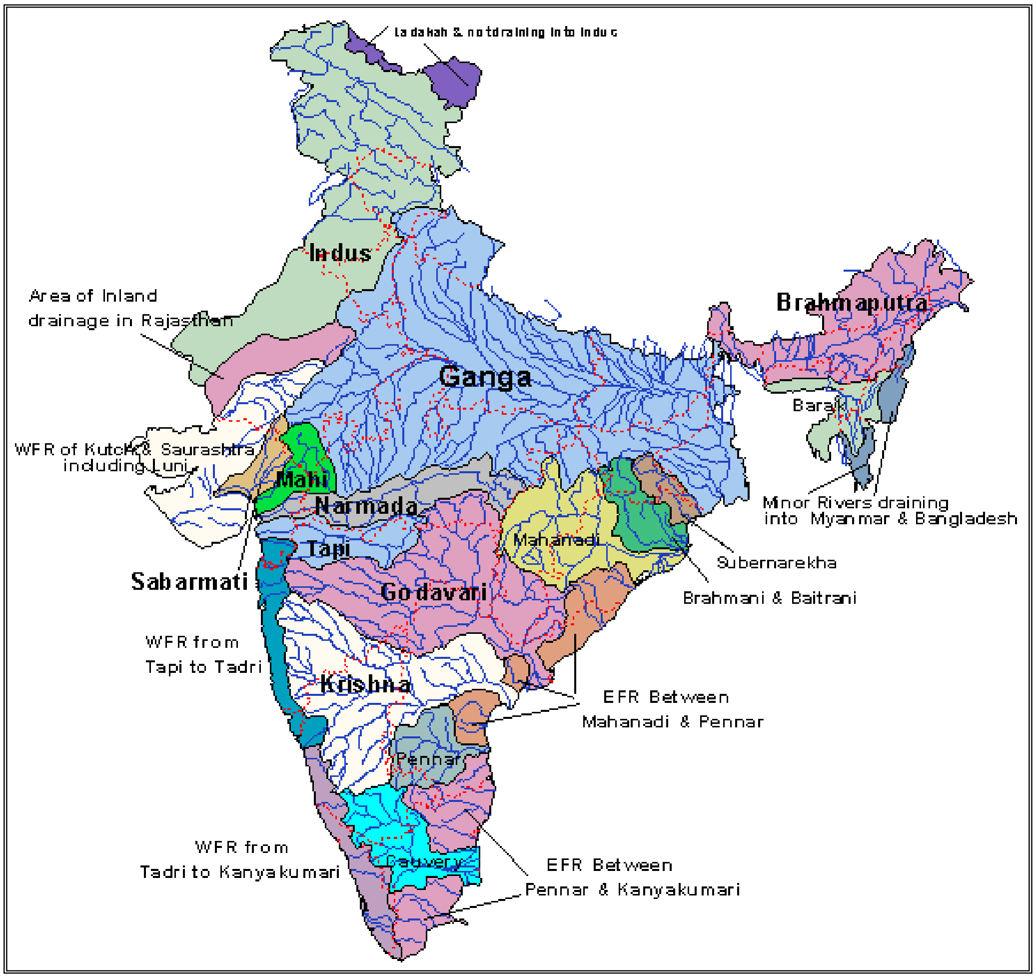
Table 1.1: Water resources of India

Estimated annual precipitation (including snowfall)	4000 km^3
Run-off received from upper riparian countries (Say)	500 km^3
Average annual natural flow in rivers and aquifers.	1869 km^3
Estimated utilisable water	1123 km^3
(i) Surface	690 km^3
(ii) Ground	433 km^3
Water demand ≈ utilization (for year 2000)	634 km^3
(i) Domestic	42 km^3
(ii) Irrigation	541 km^3
(iii) Industry, energy & others	51 km^3

Extreme conditions exist in the country – there are floods followed by droughts. Due to excess rainwater, floods occur in certain parts. It has been estimated by Rashtriya Barh Ayog(RBA) that 40 mha of area is flood-prone and this constitute 12% of total geographical area of the country. Droughts are also experienced due to deficient rainfall. It has been found that 51 mha area is drought prone and this constitute 16% of total geographical area.

The population of the country has increased from 361 million in 1951 to 1130 million in July 2007. Accordingly, the per capita availability of water for the country as a whole has decreased from 5177 m^3/year in 1951 to 1654 m^3/year in 2007. Due to spatial variation of rainfall, the per capita water availability also varies from basin to basin. The distribution of water resources potential in the country shows that the average per capita water availability in Brahmaputra & Barak basin was about 14057 m^3/year whereas it was 308 m^3/year in Sabarmati basin in year 2000.

A map of the river basins of India is shown below:



The details of water resources potential of these river basins are given in Table 1.2 below:

Table 1.2: Water resources of major river basins of the country

River Basin	Catchment area *(km^2)	Average annual potential (km^3)	Utilisable surface water resources (km^3)
Indus	321289 (1165500)	73.31	46.00
a) Ganga	861452 (1186000)	525.02	250.00
b) Brahmaputra c) Barak and others	194413 (580000) + 41723	585.60	24.00
Godavari	312812	110.54	76.30
Krishna	258948	78.12	58.00
Cauvery	81155	21.36	19.00
Subernarekha	29196	12.37	6.81
Brahmani & Baitarni	51822	28.48	18.30
Mahanadi	141589	66.88	49.99
Pennar	55213	6.32	6.86
Mahi	34842	11.02	3.10
Sabarmati	21674	3.81	1.93
Narmada	98796	45.64	34.50
Tapi	65145	14.88	14.50
WFR from Tapi to Tadri	55940	87.41	11.94
WFR from Tadri to Kanyakumari	56177	113.53	24.27
EFR between Mahanadi & Pennar	86643	22.52	13.11
EFR between Pennar & Kanyakumari	100139	16.46	16.73
WFR of Kutch & Saurashtra including Luni	321851	15.10	14.98
Area of Inland drainage in Rajasthan	-	Negligible	Not applicable
Minor Rivers draining into Myanmar & Bangladesh	36202	31.00	Not applicable
Total		**1869.35**	**690.31**

*Figures in parenthesis represent the total catchment areas including areas outside India.

India has a long history of water development. However, large scale water development started in the 19th century. Initially, a large number of “run of the river” type of diversion projects for irrigation got built at the foot hills of the Himalayas as also at the deltas of the peninsular rivers. However, later, the emphasis is shifted to storage development, from 1940 onward. After the electric energy became available in the rural areas, i.e. after about 1975, a very large ground water based development took place.

By now, as per the public statistics of the Central Water Commission, a live storage of around 220 km^3 has been built in the various places. However, this information does not include the small (minor and small medium) storages. Currently, around 17 million ha. are being irrigated from surface minor projects, and for achieving this, a live storage of about 60 km^3 would have been constructed through the lakhs of such dams. Thus, the current live storage available in surface reservoirs in India would be around 280 km^3. In addition, around 60 km^3 of storage is under construction through the larger projects. However, this storage appears insufficient for meeting all the future demands.

Although the large scale ground water use in India is a unique feature, not noticed in most other countries, the ground water development in some areas, is already leading to over-exploitation of the available ground water and consequently to falling trend in the ground water levels.

The main water resources of India consists of the precipitation on the Indian territory which is estimate to be around 4000 km^3/year, and trans-boundary flows which it receives in its rivers and aquifers from the upper riparian countries. For the latter, no ready quantitative estimate is available. However, estimates as projected by FAO are available. FAO estimate for China‘s total contribution is 347 km^3.This appears too large. After correcting this, the following estimate appears reasonable:

Table 1.3: A preliminary estimate of average annual trans-boundary receipts

Country of origin	Assumed receipt in India (km^3)			
	Indus	GBM		Total
		Ganga	Brahmaputra & Meghana	
China	70	12	113	195
Nepal	0	210	0	210
Bhutan	0	0	95	95
Total	**70**	**222**	**208**	**500**

This preliminary estimate is merely for bringing out the role of trans-boundary flows in the water balance of India. It does not represent an officially accepted estimate.

It needs to be stressed that any climate change may alter both the precipitation received on the Indian territory as also the hydrology of the catchments in the upper riparian countries. Thus, the climate change in these countries, and the larger utilizations in these countries (including the additional demand driven by climate change) would alter the Indian water situation.

1.2 Introduction to Climate – Climate Change and Anthropogenic Climate Change

Climate in a narrow sense is defined as "average weather", or more rigorously, as the statistical description in terms of mean and variability of relevant quantities of weather parameters over a period of time ranging from months to thousands or millions of years. The classical period is 30 years, as defined by WMO. These parameters are most often surface variables such as temperature, precipitation and wind. Climate change in IPCC usage refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that of UNFCCC which defines climate change as, "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods".

The earth's atmosphere - the layer of air that surrounds the earth - contains many gases. Short-wave radiation from the sun passes through the earth's atmosphere. Partly this radiation is reflected back into space, absorbed by the atmosphere and remainder reaches the earth's surface, where it is either reflected or absorbed. In turn the earth's surface, emits long-wave radiation toward space. The Green Houses Gases (GHG) available in the atmosphere, which principally include CO_2, NO_2, CH_4, CFCs and O_3, absorb some of this long-wave radiation emitted by the Earth's surface and re-radiate it back to the surface. Thus GHG modify the heat balance of the Earth by retaining long-wave radiation that would otherwise be dispersed through the Earth's atmosphere to space. This effect is known as the greenhouse effect. Evidently, GHG have an important role in controlling the temperature of the earth and an increase in their concentration in the atmosphere would increase the temperature of the Earth. In addition, presence of excess quantities of CFCs affects the protective ozone layer which deflects the harmful short wave rays. The IPCC observed that global average air temperature near earth's surface rose to $0.74\pm0.18\ ^{o}C$ in the last century.

1.3 A Short Status of Knowledge about Climate Change

Studies have been carried out by NIH to analyze the trends of variation in temperature over India/Indian sub-continent and the results have been compared with global trend. An analysis of temperature data of 125 stations distributed all over India shows an increase of 0.42^0 C, 0.92^0 C and 0.09^0 C in annual mean temperature, mean maximum temperature and mean minimum temperature respectively over the last 100 years. However, the trends are varying on regional basis. It has been observed that the changes in temperature in India/Indian-Subcontinent over last century are broadly consistent with global trend of increase in temperature.

Scenarios of future climate change are usually developed using the Global Circulation Models with different scenarios of GHG emissions. GCMs are complex 3-dimensional models of the land, atmosphere and oceans. GCMs are invaluable tools for identifying climatic sensitivities and changes in global climate characteristics; the major problem of the current generation of GCMs is the limitation of their spatial resolution. A single grid of GCM may encompass hundreds of square kilometers and include mountainous and desert terrain, oceans and land areas. Usually, the output of GCMs is given for a scale much larger than that of even a large watershed. There are more than 200 GCMs available which have been developed by different agencies. Input data requirement for the these GCMs are generally same but the output results vary and sometimes with slight variation in input parameters (which may be due to different data collection agencies) the results are contradictory giving confusing future climate scenarios. Despite recent improvements in modeling of the climate dynamics with complex and large-scale models, use of GCMs is still limited in evaluating regional details of climatic changes. For generating future climate scenarios on regional basis there are downscaling models called RCMs which use output of GCMs. However, RCMs do not give basin level scenarios.

1.4 Predictive Findings of Scientists about Likely Climate Change in India

Studies related to the impacts of climate change on various components of the hydrological cycle may be classified broadly into two categories: (i) studies using GCM/RCMs directly to predict impact of climate change scenarios (ii) studies using hydrological models with assumed plausible hypothetical climatic inputs.

IITM is active in studying long-term climate change from observed and proxy data as well as model diagnostics and assessment of climatic impacts, with a particular focus on the Indian summer monsoon. IITM used the Hadley Centre Regional Climate Models (RCMs) for the Indian subcontinent to model the potential impacts of climate change.

The RCMs have shown significant improvements over the global models in depicting the surface climate over the Indian region, enabling the development of climate change scenarios with substantially more regional detail. High-resolution climate change scenarios have been generated for different states of India. Some of the major findings concerning water resources are:

- The rainfall scenarios are dependent on climate scenarios.
- There are substantial spatial differences in the projected rain fall changes. The maximum expected increase in rainfall (10 to 30%) is for central India.
- There is no clear evidence of any substantial change in the year-to-year variability of rainfall over the next century.
- Surface air temperature shows comparable increasing trends by as much as 3 to 4° C towards the end of the 21st century.

- The warming is widespread over the country, and relatively more pronounced over northern parts of India.

1.5 Findings of Scientists "if – then type"

The scientists of NIH, Roorkee have a made a literature survey to examine the findings of the various important studies in regards to climate Change and its likely effect on Water Resources of India. The results of these surveys are extracted in Table 1.4.

Table 1.4: Predictions about Hydrological Changes over India

Author	GCM Used	Scenario in Brief	Effect on Rainfall				Effect on PET				Remarks
			North India	South India	North West	East and North east	North India	South India	North West	East & North east	*Remarks*
Gosain A K and Sandhya Rao, 2003	Hadley Centre Regional Model – 2	Severity of extreme events such as floods and droughts in different parts of India increased									Study area is India
K Rupa Kumar, A K Sahai et al. 2006.	PRECIS.	A general increase in precipitation and temperature, for the country as a whole	Slight decrease in Punjab, Rajasthan	Slight decrease in Tamilnadu		Maximum increase					
Hassel and Jones 1999.	RCM.	A maximum anomaly of 5^0C seen in central northern India seen in the GCM simulation was reduced and shifted to							Excessive drying of the soil		

Author	GCM Used	Scenario in Brief	Effect on Rainfall				Effect on PET				*Remarks*
			North India	South India	North West	East and North east	Nort h India	Sout h India	North West	East & North east	
		the North-West in the nested RCM, with a secondary maximum appearing to the south east									
IPCC 1990.	High resolution GCM.	The model simulated an increase in total seasonal precipitation									By 2030 warming varies 1-2^{0}C throughout the year, precipitation generally increases throughout the region by 5-15% in summer and little in winter, summer soil moisture increases by 5-10%.
Lal et al. 1992.	Hamburg global coupled atmosphere-ocean	Examined the possible climate change over northwest									

Author	GCM Used	Scenario in Brief	Effect on Rainfall				Effect on PET				
			North India	South India	North West	East and North east	North India	South India	North West	East & North east	*Remarks*
	circulation model.	area (Thar desert).									
Lal and chander. 1993b.	ECHAM3 T-42.	Annual mean area averaged surface warming should range between 3.5 to 5.5°C over the region by 2080.				More rainfall in north east in enhanced global temperature conditions.					
Lal and bhaskaran 1993a.	ECHAM3 T-42.				No significant change in rainfall over the next 100 years				Enhancement in evaporation rate		Decrease in rainfall between 5-25% in winter whereas 10-15% increase in area averaged monsoon rainfall over the Indian subcontinent. The date of onset of summer monsoon over central India could become more variable in near future. More

Author	GCM Used	Scenario in Brief	Effect on Rainfall				Effect on PET				
			North India	South India	North West	East and North east	North India	South India	North West	East & North east	*Remarks*
											extreme rainfall events are projected.
Murari Lal et al. (Dinar *et al.*, 1998).	CCSR/NIES coupled A-O GCM. United Kingdom Meteorological Office (UKMO). Goddard Institute for Space Studies (GISS) GCM.	United Kingdom Meteorological Office (UKMO) GCM predicts a temperature increase for India of 16.2%, the Goddard Institute for Space Studies (GISS) GCM predicts an increase of 10%, and the Geophysical Fluid Dynamics Laboratory (GFDL) GCM									Each of these three models predicts an increase in precipitation with a doubling of CO_2 levels from pre-industrial levels, but they predict differing magnitudes of increase at different times of the year (Dinar *et al.*, 1998).

Author	GCM Used	Scenario in Brief	Effect on Rainfall				Effect on PET				*Remarks*
			North India	South India	North West	East and North east	Nort h India	Sout h India	North West	East & North east	
		predicts an increase of 23.5%. Some recent studies, however, have indicated that the GCMs temperature predictions are too high (Dinar *et al.*, 1998).									

Although the findings of each study are different the general consensus in these studies seems to be as follows:

- Temperatures may increase throughout India and particularly in Northwest and Southeast;
- As a consequence there may be an increase in potential evapo-transpiration;
- As a further consequence, there may be more glacial melt for some years, recession of glaciers and less melt later on;
- Summer monsoon precipitation may increase throughout, but this would be more marked in the Northeast;
- There may not be any increase or there may be a decrease in winter precipitation;
- Rainfall variability may increase;
- The date of onset of summer monsoon may become more variable;
- More extreme rainfall events are projects.
- Some further relevant information is in section 2.1 of this report

1.6 The Purpose and Scope of the Report

The Prime Minister has unveiled the National Action Plan for Climate Change on 30-06-2008 wherein eight missions including National Water Mission were launched. This Report is formed for the Sub-committee on Policy and Institutional Framework as established by the High Level Steering Committee of the National Water Mission headed by Secretary (Water Resources).

The Report does not take any position about the causes and certainty of the climate change. However, the possible range of effects on Water Sector is culled out from other expert opinions. On this basis, the possible mitigative measures and the new strategies required for such mitigative measures are outlined and the programmes.

The High Level Steering Committee of the National Water Mission has set-up six Sub-Committees as follows:

- Policy and Institutional Framework
- Surface Water Management
- Ground Water Management
- Domestic and Industrial Water Management

- Efficient Use of Water for various Purposes
- Basin Level Planning and Management

Obviously, the Policy and Institutional Framework Sub-Committee has to deal with the issues brought out by the other five Sub-Committees and then discuss the policy related issues. This would also include institutional and legal issues, regulatory structures, entailment and pricing, etc. The Surface Water Management Sub-Committee also deals with a large number of issues with considerable overlaps with the coverage of the other four Sub-Committees. The Sub-Committees on Ground Water Management, Domestic and Industrial Water Management, Efficient use of Water for various purposes and Basin level management, deal with more pinpointed issues.

Considering that the Sub-Committee has not have to do any basic work on areas allotted to other Sub-Committees, the Report is arranged as follows:

Chapter-1 Background (this chapter is almost same as the Chapter "Background" in the Report of the Sub-Committee on Surface Water)

Chapter	Theme	Remarks
1	Background	This chapter is almost same as the Chapter "Background" in the Report of the Sub-Committee on Surface Water
2.	Action Plan	The material is based on the similar material from the Report of the Sub-Committee on Surface Water, but with additions in regard to other Sub-Committees
3.	Policy modifications in view of climate change concerns	The material is based on the similar material from the Report of the Sub-Committee on Surface Water, but with additions in regard to other Sub-Committees
4.	Legal Issues	Mainly discussed in this report
5.	Institutional Aspects	Mainly discussed in this report
6.	Pricing, Financing and Incentives structures.	Mainly discussed in this report

Although the Policy and Institutional Framework Sub-Committee is to work on the feedback received from the other Sub-Committees, time constraints required it to work in parallel. (The present draft has been worked without any information feedback from Sub-Committees other than one on Surface Water Management).

CHAPTER 2

PRELIMINARY PLAN OF ACTION AND COSTS

2.1 Plan of Action

An Action Plan based on this report is given in the following pages:

Note that this Action Plan mentions a list of actors which may not be exhaustive. Also the actors, as mentioned, are mainly Governmental. This merely indicates that these actors have to get the necessary work done and not that they have to do the work themselves. Outsourcing to consultants and other Institutes and even privatization in implementation using Private capital can be allowed or even encouraged. Involvement of Academic and Research bodies, private or public, in items involving research is very desirable, and there involvement in studies also is possible.

Table 2.1: Preliminary Action Plan for Policy and Institutional Framework in view of likely Impacts of Climate Change on Water Resources

Objective	*Strategy/*	*Sub-Strategy*	*Action Points*	*XI Plan*			*XII Plan*					*Actor*
				Y1	*Y2*	*Y3*	*Y4*	*Y5*	*Y6*	*Y7*	*Y8*	
(A) Better understanding of Water Resources, particularly aspects likely to be affected by Climate Change	**(i) Data Collection**	**1. Estuarine Region**										
		a. Coastal and estuarine water and salinity and tidal water levels and the changing discharges in both directions.	Network planning									CWC, DoOD, Maritime Boards, States
			Data collection									
		2. Areas Sensitive to Climate Change										
		a. Low rainfall areas	Network planning									CWC, IMD, States
			Data collection									
		b. Himalayan region, above permanent Snow line, and glaciated areas	Network planning									GSI, CWC, NIH, States
			Data collection									
		c. Himalayan region, seasonal snow areas	Network planning									GSI, CWC, NIH, States
			Data collection									

Objective	*Strategy/*	*Sub-Strategy*	*Action Points*	*XI Plan*			*XII Plan*					*Actor*
				Y1	*Y2*	*Y3*	*Y4*	*Y5*	*Y6*	*Y7*	*Y8*	
		d. Better Network for Evaporation Data	Network planning									ICAR, IMD, CWC, NIH, States
			Data collection									
		e. Raingauge data collection network through automated sensors	Network planning									ICAR, IMD, CWC, States
			Data collection									
	(ii) Re-assessment of situation	**1. Re-assessment of basin-wise water situation**										
		a. Develop or adopt comprehensive water balance based model	Study									CWC, NIH, Academic Institutes
		b. Fit models to basins, using current data.	Study									CWC, NIH, States, Academic Institutes
		c. Assess likely future situation, with changes in demands, land use, precipitation and evaporation.	Study									CWC, NIH, States, Academic Institutes
		d. Alter development Scenarios towards better acceptability	Policy									CWC, Planning Commission, States
		2.Classify basins										
		a. As open or closed/ closing	Study									CWC, NIH, States
		b. Encourage water harvesting in open basins.	Policy									CWC, MoA, States
		c. For closed basins, encourage water harvesting only if it is socially desirable, and if some other use can be curtailed.	Study									CWC, NIH, MoA, States

Objective	Strategy/	Sub-Strategy	Action Points	XI Plan			XII Plan					Actor
				Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	
	(iii) Researchable Issues	**1. Supporting Atmospheric Science Groups**										
		a. Downscaling of GCM or RCM to basin/Project level	Support	■	■	■	■	■	■	■	■	DST, MOWR, academic institutes
		b. Effect of Climate Change on Monsoons	Support	■	■	■	■	■	■	■	■	DST, MOWR, academic institutes
		2. Water and Climate related										
		a. Studying the sensitivity of different hydrologic types of water projects to different climate change scenarios	Study	■								CWC, NIH, academic institutes
			Evolving Strategies		■	■	■					
		b. Improvements required in hydrometric networks to incorporate climate change	Study	■	■							CWC, NIH, IMD, Academic institutes
(B) Increasing food and water security through increasing useable water	**(i) Reducing inadvertent evaporation**	**1. Minimizing inadvertent evaporation**										
		a. Evaporation from water logged areas	Guidelines	■	■							CWC, NIH, IARI
			Pilots		■	■	■					
		b. Evaporation from barren land	Guidelines	■	■							CWC, NIH, IARI
			Pilots		■	■	■					
		c. Evaporation from agricultural fields between crops	Guidelines	■	■							CWC, NIH, IARI
			Pilots		■	■	■					
		d. Evaporation from wet soil between crop rows in irrigated fields	Guidelines	■	■							CWC, NIH, IARI
			Pilots		■	■	■					
	(ii) Increasing storages in water use systems	**1. Use of ground water space as storage, through enhanced fluctuations**										
		a. Kharif channels	Guidelines	■	■							CWC, UP, CGWB
			Pilots		■							

Objective	*Strategy/*	*Sub-Strategy*	*Action Points*	*XI Plan*			*XII Plan*					*Actor*
				Y1	*Y2*	*Y3*	*Y4*	*Y5*	*Y6*	*Y7*	*Y8*	
		b. Pumping water from Terai to deplete ground water before floods	Guidelines									CGWB, NIH
			Pilots									
		c. Conjunctive use in time, with larger ground water use in bad years	Guidelines									CWC, INCID, CGWB
			Modelling									
			Pilots									
		2. More efficient use of vadose zone moisture storage										
		a. Conserving moisture through mulches and plastic sheets	Literature Review									CWC, INCID, IARI
			Pilots									
			Guidelines									
		b. Reducing gap between Kharif harvesting and Rabi sowing	Literature Review									INCID, IARI
			Pilots									
			Guidelines									
		3. Repeated use of storage during wet season										
		a. Dug out ponds in fields	Literature Review									Dry land Agriculture, INCID & States
			Pilots									
			Guidelines									
		b. Irrigation with dependable Kharif and small non dependable Rabi crops	Guidelines									Planning Commission, Gujarat, CWC, States
			Technology Transfer									
		4. Increasing storages and carry over storages										
		a. Encouraging construction of carry over storages	Policy									Planning Commission, CWC

Objective	*Strategy/*	*Sub-Strategy*	*Action Points*	*XI Plan*			*XII Plan*					*Actor*
				Y1	*Y2*	*Y3*	*Y4*	*Y5*	*Y6*	*Y7*	*Y8*	
		b. Clarifying the dependability related concept – reliability of outputs and not input dependability	Policy									Planning Commission, CWC
			Capacity Building									
		c. Changing the Reliability criteria regarding water availability	Proposal									CWC, States, Planning Commission
			Debate									
			Decision									
		d. Study possibilities of increasing dam heights	Studies									CWC, States
		e. Implementing a programme for raising heights and storages of dams	Proposals									CWC, Planning Commission, States
			Appraisal									
			Implementatio n									
		f. Developing methodologies and designs for raising dam heights	Capacity Building									CWC, States
		g. Listing of minor tanks where the full reservoir level can be raised without increasing dam heights by installing gates	Guidelines									CWC, States
			Studies									
		h. Implementing a programme of increasing capacities of minor tanks	Proposals									CWC, States
			Appraisal									
		I. Listing tanks and water bodies which can be effectively de-silted, and where the silt has a commercial use	Guidelines									States, MoWR
			Studies									
		j. Implementing the current programme of rehabilitating water bodies, with changed focus	Proposals									CWC, States
			Appraisal									
			Implementatio n									
	(iii) Understanding water use efficiencies	**1. Increasing water use efficiency**										
		a. Recognising and encouraging reuse of return water	Policy									INCID, CWC
		b. Computing basin efficiency	Study and Technology Transfers									INCID, CWC

Objective	*Strategy/*	*Sub-Strategy*	*Action Points*	*XI Plan*			*XII Plan*					*Actor*
				Y1	*Y2*	*Y3*	*Y4*	*Y5*	*Y6*	*Y7*	*Y8*	
		c. Decision support systems in canal irrigation	Pilot	■	■	■	■	■	■			CWC, CWPRS
		d. Automation in canal irrigation including soil moisture monitoring	Pilot		■	■	■	■	■	■	■	CWC, CWPRS
		e. Participatory management by water users for improved efficiency	Action Research		■	■	■	■	■	■	■	WALMIs, CADA, CWC
		f. Modernisation of canals and distribution systems	With proportionate regulators			■	■	■	■	■	■	CWC, States, Planning Commission
			With decision support systems			■	■	■	■	■	■	CWC, States, Planning Commission
	(iv) Encouraging water transfers from surplus to deficit areas	a. Expediting planning and implementation of schemes for inter-basin water transfers	Feasibility studies	■								NWDA, CWC, States
			General agreements		■							
			Preparation of DPRs			■						
			Prepare proposals for ownership, financing and implementation			■	■					
			Implementatio n				■	■	■	■	■	
		b. Formulating schemes for long distance transfer of surplus flood flows and their recharge to ground water, after considering costs and land acquisition problems	Study	■	■							NWDA, CGWB Planning Commission, CWC
			Pilot			■	■	■	■	■	■	
			Feasibility		■	■	■					
			Appraisal			■	■	■				
(C) Improving Intra-national Equity in usable water	**(i) Drought Management**	**1. Drought Management**										
		a. Conducting the economic carrying capacity studies considering land, water and livelihood to plan how much water is necessary to yield reasonable income	Studies	■	■							Planning Commission, CWC, NWDFA States
			Policy			■	■					

Objective	*Strategy/*	*Sub-Strategy*	*Action Points*	*XI Plan*			*XII Plan*					*Actor*
				Y1	*Y2*	*Y3*	*Y4*	*Y5*	*Y6*	*Y7*	*Y8*	
		b. Increasing the use of irrigation through in-basin development as also inter-basin transfers	Policy									Planning Commission, CWC Academicians, NCAER
			Proposals									
			Debate									
			Decision									
		c. Changing cropping patterns towards low water use crops	Policy									MoAC, Planning Commission, IARI
			Implementation									
		d. Adopting integrated farming systems	Policy									MoAC, Planning Commission, CWC
			Implementation									
		e. Water harvesting, provided this is socially desirable and provided that corresponding water saving is possible elsewhere in the region	Studies									MoAC, Planning Commission, IARI, NWDA
			Implementation									
		f. Encouraging non-agricultural developments of the type where not much water is required										MoAC, IARI, Planning Commission, Rural
		g. Enact enabling legislation to regulate ground water use during droughts	Policy									CGWB, States
			Proposals									
			Debate									
			Decision									
(D) Improving Societal sustenance under Climate Change	**(i) Dealing with changing flood and sea level regime**	**1. Estuarine Management**										
		a. Embark on a massive tidal hydraulics data collection programme.	Network planning									CWC, CPT, DoOD, Maritime Boards
			Data Collection									
		b. Increase modeling capacity about storm surge, tidal hydraulics, salinity and unsteady flow..	R&D									CWPRS, NIH, CWC, NWA
			Capacity Building									

Objective	Strategy/	Sub-Strategy	Action Points	XI Plan			XII Plan					Actor
				Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	
		c. Take up programme for planning tidal embankments to protect against tides with increased flood frequency and increased sea level.	Studies Proposals									CWC, DoOD Maritime Boards States
		d. Implement tidal embankments	Implementing interventions									States
		e. Study possibility of using some tidal channels for fresh water storage.	Action Research									WALMIs, States, CWC
		f. Implement the above with user participation.	Action Research									WALMIs, States, NGOs
		g. Study effect of sea level rise on ground water salinity, and mitigative measures like induced recharge.	Study Proposals									CGWB, CWC, States
	(ii) Adjusting to changing flood regime	**1. Floods to be used for ensuring dam safety in climate change situation**										
		a. New acceptability criteria need to be evolved. Suggestions included.	Proposal Debate Decision									CWC, Planning Commission, States BIS
		2. Floods to be used in planning flood control works										
		a. New acceptability criteria need to be evolved. Suggestions included.	Proposal Debate Decision									CWC, Planning Commission, States BIS
		b. Improved capacities for unsteady flow models to be used as routines	Capacity Building Use									NWA, NIH, CWPRS, CWC,
		c. Linking the digital elevation models for low lying areas with	Model development									NWA, NIH, CWPRS,

Objective	*Strategy/*	*Sub-Strategy*	*Action Points*	*XI Plan*			*XII Plan*					*Actor*
				Y1	*Y2*	*Y3*	*Y4*	*Y5*	*Y6*	*Y7*	*Y8*	
		hydraulic models to understand flood situations under different floods	Use									CWC
		d. Build capability of linking storm surge models, tidal hydraulic models and flood flow models										NWA, IMD, NIH, CWC, CWPRS
		3. Urban storm water drainage improvements	New Criteria									MoUD, Municipal Bodies, Cantonment Boards, States, CWC, IMD
			Guidelines									
			Modeling Capability									
			Implementation									
	(iii) Adjusting to increasing erosion and sedimentation	**1. Reservoir Sedimentation, Erosion control and River Management under climate change**										
		a. Use changed acceptability criteria and practice regarding planning. (Suggestions included).	Proposal									CWC, Planning Commission, States, BIS
			Debate									
			Decision									
		b. Use more liberal acceptability criteria. (Suggestions included).	Proposal									CWC, Planning Commission, States, BIS
			Debate									
			Decision									
		c. Prepare sediment budgets and accounts for each basin	Studies									CWC, ICAR
		d. Build a universal soil loss model depicting erosion and sediment transport etc. Prove the modal based on sediment flow and reservoir sedimentation data.	Model development									NIH, ICAR, CWC
		e. Actuate the above model for changed rainfall regime and changed management practices	Studies									NIH, CWC,

Objective	*Strategy/*	*Sub-Strategy*	*Action Points*	*XI Plan*			*XII Plan*					*Actor*
				Y1	*Y2*	*Y3*	*Y4*	*Y5*	*Y6*	*Y7*	*Y8*	
		f. Develop, through R&D effort, a combined unsteady flow hydraulics-cum-sediment transport model capable of depicting river erosion in each flood event. Use the model to test river management works	R&D	■	■							NIH, CWPRS, IITs, GFCC
			Model development		■	■	■					
			Use			■	■	■	■	■	■	
	(iv) Disaster Management	**1. Disaster Management**										
		a. Dam break or Embankment break studies done routinely. A management plan needs to be prepared.	Policy	■	■							CWC, NIH, CWPRS
			Implementation			■	■	■	■	■	■	
		b. Improve analytic capacities in regard to two dimensional unsteady flow hydraulic models.	Capacity Building	■	■							CWC, NIH, CWPRS, NWA
		c. Setup, through legislations, State and Central Dam Safety Services	Proposal	■								MoWR, States
			Debate		■							
			Legislation			■						
(E) Improved Water Quality Management	**(i) Improved Water Quality Management**	**1. Water Quality Management**										
		a. Programme of data collection on Surface and ground water quality	Data Collection	■	■	■	■	■	■	■	■	CPCB, SPCB, CWC, CGWB
		b. Setting up water quality models for each major river and aquifer	Modeling		■	■	■					CPCB, SPCB, CWC, CGWB
		c. Enhance the capacity of the institutional and legal mechanism to take action	Policy	■	■							CPCB, SPCB, State Governments , MoEF
			Legal		■	■						

Objective	Strategy/	Sub-Strategy	Action Points	XI Plan			XII Plan					Actor
				Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	
		d. Allow attractive financial packages combined with penalties to users/defaulters to build and operate modern effluent treatment plants and re-circulation arrangements in order to reduce penalties										MoEF, Urban Affairs
		e. Encourage direct use of partially treated domestic effluents in irrigating non food crops	Policy									MoEF, MoWR, States
			Implementation									
		f. Encourage public bodies/ industrial States to construct common effluent treatment plants through soft loans/ subsidies and technical support	Policy									MoEF, Ministry of Industries, States
			Implementation									
		g. Disallow the use of comparatively good waters for diluting pollution loads. Insist on treatment	Policy									MoEF, MoWR, States
			Implementation of policy									
			Installation of effluent treatment plants in critical areas									
		h. Disallow proposals for establishing, enhancing, or improving piped domestic water supply, unless these include effluent treatment	Policy									MoEF, MoWR, Planning Commission, States
			Implementation									
(F) Managing water relate conflicts	**(i) Strategies- Within Indian Basins**											
		a. Setting up of empowered basin Authorities	Proposal									MoWR, GoI, States
			Debate									
			Legislation									
		b. Setting of sub-basin or area authorities	Proposal									MoWR, GoI, States
			Debate									

Objective	*Strategy/*	*Sub-Strategy*	*Action Points*	*XI Plan*			*XII Plan*					*Actor*
				Y1	*Y2*	*Y3*	*Y4*	*Y5*	*Y6*	*Y7*	*Y8*	
			Legislation									
		c. Setting up of a permanent Water Tribunal	Proposal									MoWR, GoI, States
			Debate									
			Legislation									
		d. Encouraging mediation and voluntary arbitration	Proposal									MoWR, GoI, States
			Debate									
			Legislation									
	(ii) Strategies-Indian Inter-basin Transfers											
		a. Set up authority empowered to decide surpluses	Proposal									MoWR, GoI, States
			Debate									
			Legislation									
		b. Set up mechanism to appeal and settle decisions	Proposal									MoWR, GoI, States
			Legislation									
		c. Decide policies about implementation, ownership, etc.	Proposal									MoWR, GoI, States
			Debate									
			Legislation									
		d. Encourage negotiated solutions, after such empowerment	Policy									MoWR, GoI, States
			Implementation									
	(iii) International Conflicts and Discords											
		a. In short run, continue as usual.										MoWR, MEA
		b. Set up, comprehensive flood forecasting and flood wave transport models with other countries, for Indus, Ganga, Teesta and Meghana.	R&D									MoWR, MEA
			Modeling									
			Use									
		c. In long run, discuss more optimized Indus development possibilities, with Pakistan	Proposals									MoWR, MEA
			Discussions									
			Decision									
		d. Review interpretation of regime maintenance for Ganga, after climate change	Study									MoWR, MEA
(G) Water for improved health	**(i) Domestic and industrial Water**											
		a. Bridge Rural Urban divide	Policy draft									MoWR, GoI,

Objective	*Strategy/*	*Sub-Strategy*	*Action Points*	*XI Plan*			*XII Plan*					*Actor*
				Y1	*Y2*	*Y3*	*Y4*	*Y5*	*Y6*	*Y7*	*Y8*	
and sanitation	**Supply and treatment**	through improved definition of coverage, and through supply norms	Debate and adoption Implementation									States
		b. Piped surface water for clusters of villages with ground water quality problems	Policy draft Debate and adoption Implementation									MoWR, GoI, States
		c. Reinterpret priority for domestic water. Allow exchange of raw water sources	Policy draft Debate and adoption Implementation									MoWR, GoI, States
		d. Publish water accounts and audits of urban water supply systems.	Guidelines Implementatio n									MoWR, GoI, States
		e. Encourage Leakage Control programmes	Guidelines Implementation									MoWR, GoI, States
		f. Careful use of two pipe supply systems	Guidelines Pilots									MoWR, GoI, States
		g. Consider desalinization as an option, for water supply to urban coastal communities	Guidelines Pilots									MoWR, GoI, States
		h. Extend Subsidies and incentives for recycling and recovery	Guidelines Implementation									MoWR, GoI, States
		i. Review “zero effluent” policy in water short areas. Insist on return of treated effluent	Review Debate Implement									
		j. Regulate in house water withdrawals of industries, through royalties and licenses	Regulations Implement									
(H) Groundwater management	**(i) Groundwater management**	a. Reassess Ground Water position under climate change	Ad hoc change in current Model and methodology									

Objective	*Strategy/*	*Sub-Strategy*	*Action Points*	*XI Plan*			*XII Plan*					*Actor*
				Y1	*Y2*	*Y3*	*Y4*	*Y5*	*Y6*	*Y7*	*Y8*	
			Basin-wise and block-wise reassessment									
			classification									
		b. Legislation to clarify ownership and regulatory responsibilities for ground waters	Drafting									
			Debate									
			Legislation									
		c. Regulation of local ground water markets	Proposal									
			Debate									
			Implement									
		d. Regulate subsidies on power tariffs for agricultural pumping of Ground Waters	Proposal									
			Debate									
			Implement									
(I) Better Governance through Participation, updation of water policy related issues		a. Revisions in Water Policy,2002	Proposal									
			Discussions, NWB									
			Discussions, NWRC									
			Adoption									
		b. Legislation under entry 56, as suggested	Drafting									
			Public debate & consultations									
			Debate in Parliament									
			Adoption									
		c. Institutional adoption	Detailed Proposals									
			Discussions & finalisation									
			Training of Personnel									
		d. States to set up Water Regulators	Drafting									
			Public debate & consultations									
			Debate in Legislature & enactment									
		e. States to Change Water Policies.	Proposals									

Objective	*Strategy/*	*Sub-Strategy*	*Action Points*	*XI Plan*			*XII Plan*					*Actor*
				Y1	*Y2*	*Y3*	*Y4*	*Y5*	*Y6*	*Y7*	*Y8*	
		as suggested	Discussion									
			Debate and adoption									
		f. Deciding Central Financial Assistance for adopting to climate change	Detailed Proposals									
			Consideration and decision									
			Implementation									
			Review									
		g. Public Awareness Programme about water sector and climate change	Preparing guidelines									
			Selecting NGOs									
			Implementation									

2.2 A Preliminary Cost Estimate

Costs and Financial implications of the programme to mitigate effects of Climate change:

An Action Plan for measures to mitigate the effect of climate change in India has been worked out. Now, we try to give very crude estimate of the financial requirements of this programme. In this connection, following important points are brought out:

1. The costs mentioned cover the residual Eleventh Five Year Plan Period (three years) and the full period of Twelfth Five Year Plan Period (Five Years).

2. The costs mentioned are the additional costs required to be spent for mitigating the effects of the climate change, in addition to the normal water sector programmes of various Ministries, Departments of the State Governments, etc.

3. The costs, as mentioned, are the aggregate of the costs in the Central Sector and the State Sector. The subsidies from the Centre to the State, subsidies from the Central funds to the water users, etc. are also, therefore, included in this costs.

4. The costs to be incurred by private enterprise or by various water users, on their own, to maintain their facilities and services are not included.

5. The costs are distributed by the objectives, strategies and programmes to the extent possible. The costs are also segregated as "data collection costs" "software costs" and the "hard costs". The data collection costs would include both the soft costs, such as, costs involved in planning the data collection network, costs of instruments and setting up works, and operational costs. For other items, the software costs will include items such as studies, assessments, appraisals, preparation of guidelines, debates and discussions, research including action research, etc. The hard costs would include pilot implementation and prototype implementation of physical measures and facilities necessary for mitigating the climate change costs.

6. The Preliminary crude estimate presumes that within this period of eight years, the targets in regard to the physical works would include modernization of irrigation over 2 Mha, increasing storage capacities in large dams by 10 km^3, increasing storage capacities of minor dams by 10 km^3, drainage of water logged areas for 2 Mha and additional industrial and domestic effluent treatment plants capable of treating 0.5 km^3/year and 2 km^3/year of effluents respectively.

Table 2.2: A PRELIMINARY ESTIMATE OF COSTS

Sl. No.	Objective	Item	Estimated Cost (Rs. Crore)			
			Data collection	Software	Hard items	Total
1	Better understanding of water resources etc.	Data collection – Estuarine	200			200
		Data collection – Low rainfall areas	50			50
		Data collection – Himalayan – Permanent snow	100			100
		Data collection – Himalayan – seasonal snow	100			100
		Data collection – strengthening evaporation data	50			50
		Data collection – strengthening automatic rain gauge data	50			50
		Reassessment of water situation		200		200
		Basin classification		20		20
		Research support to GCM and RCM		100		100
		Research – Water and Climate related		100		100
Sub-Total (A)			550	420	0	970
2	Increasing food and water security	Minimizing inadvertent evaporation		50	2000	2050
		Increasing use of ground water storage		20	100	120
		Repeated use of surface storage		50	100	150
		Increasing storages – large projects		100	1500	1600
		Minor tanks		100	700	800
		Water bodies		50	500	550
		Increasing water use efficiency		100	500	600
		Modernisation of distribution		100	1500	1600
		Encouraging water transfers		100		100
		Flood flow transfers for GW recharge		50	300	350

	Sub-Total (B)		**0**	**720**	**7200**	**7920**
3	Improving Intra-national equity in useable water.	Drought Management		100		100
	Sub-Total (C)			100		100
4	Improving social sustenance under climate change	Estuarine Management under changing flood and sea level regime.		100	500	600
		Adjusting to changing flood regime		100		100
		Urban storm water improvement		50	300	350
		Adjusting to increasing erosion and sedimentation.		100		100
		Disaster management – Dam Break		100		100
	Sub-Total (D)		0	550	800	1350
5	Improved quality water management	Reusing domestic effluents in agriculture	50	100		150
		Subsidies for industrial treatment and recovery plants		20	100	120
		Subsidies to public bodies for domestic sewage treatment			5000	5000
		Encouraging common effluent treatment		200	3000	3200
		Discouraging dilution and encouraging treatment		20	200	220
	Sub-Total (E)		50	340	8300	8690
6	Improved Management of Conflicts and Discords	Indian Basins – Basin authorities		200		200
		Inter-basin transfers – empowerment		100		100
		International		50		50
	Sub-Total (F)		0	350	0	350
7	WATER FOR IMPROVED HEALTH AND SANITATION	Piped supply to cluster of villages with endemic water quality problems	0	50	200	250

		Study and pilot implementation of different two pipe systems in urban areas	0	50	200	250
		Study and pilot for desalinisation in coastal area, possibly using low grade heat from power plants	0	100	400	500
Sub-Total (G)			0	200	800	1000
8	Ground Water Management	Activities for re-assessment, legislations etc(Other activities already provided)		50		50
Sub-Total(H)			0	50	0	50
9	Better Governance through Participation, and updation of water policy related issues	Awareness programme about water and climate change		200		200
Sub-Total (I)			0	200	0	200
Grand Total (A to I)			**600**	**2930**	**17100**	**20630**

This cost of around Rs.20000 crore would be spread over 8 years ie. the residual three years of the XI plan and the full five years for the XII plan. While the annual break-up has not been worked out, the costs would be around Rs.5000 crore in the XI plan and Rs.15000 crore in the XII plan.

The costs, as mentioned, are the aggregate of the costs in the Central Sector and the State Sector. The subsidies from the Centre to the State, subsidies from the Central funds to the water users, etc. are also, therefore, included in this costs. While these have not been separately estimated, most of the implementation costs would be on account of the States. A significant part of this may have to be met from Central subsidies. We are not making any firm recommendation about the extent of the subsidies since; various administrative and fiscal considerations would be involved in deciding the subsidies. However, as a preliminary guess the Central sector expenditure, including the subsidies could be around 1/3rd of the total costs.

CHAPTER 3

POLICY MODIFICATIONS IN VIEW OF CLIMATE CHANGE CONCERNS

3.1 Background

India's water policy was documented in 1987, and was revised in 2002. The main purpose of revision was to incorporate the growing environmental concerns, larger need for information and growing complexity of the projects which increase the need for integrated water resource management.

In future, demands for water would increase considerably both on account of rising population and their rising food and domestic water needs, as also on account of larger industrialization and changing standards of living. Even without climate change, many areas and basins would become water stress and water would start operating as a major constraint on development. Changes in water policy which stress on new strategies of water management and on meticulous accounting of water situation would be necessary.

The likely climate change, and the concerns caused by the change shall further increase the stress and can make the future more uncertain. Also, a large programme of data collection and of planning and implementation of mitigative measures would have to be taken up. All of these have been discussed already. To meeting this situation, following changes in the water policy are suggested:

3.2 The Concept of Available Water

1. Currently, the water available in Indian rivers and aquifers alone is being considered as the water resource of India. Instead it needs to be recognized that the precipitation over India and the water being received from upper riparian countries through rivers and aquifers constitute the water resource of India.

2. As a corollary, the management of rain water and the management of the evaporation would be additional broad strategies available, apart from the current strategies of managing the rivers and aquifers.

3.3 Water Balance as a Tool to Understand the Unified Resource

a. The current policy already mentions that water is a unified resource. The total water balance of the country, its basins, sub-basins, areas etc. depicting the quantified hydraulic cycle should become the main tool for understanding the water situation. Water balances, water budgeting, water accounting, water audits etc. should be based on this hydraulic cycle and inter-action between rain water, surface water, ground water, evaporation etc.

b. The acceptability criteria in regard to new water developments need to be re-worked in view of the likely climate changes. In regard to the reliability of the project outputs, the main criteria would not be based on climate change. However, alternate likely climate change scenario would have to be used in the 'sensitivity testing' mode and in this mode a relaxed acceptability criteria would have to be satisfied. In regard to environmental acceptability, the hydro-ecological parameters and the likely changes in these parameters under the climate change scenario would have to be considered.

c. The acceptability criteria in regard to the existing developments would have to be similar to those of the new developments. However, considering the impracticability in changing the salient features of the projects in a short run, a long phased programme for making the necessary changes would have to be evolved.

d. In view of the increasing stress on available water due to various reasons including the likely effects of climate change, evaporation management would be a major strategy. This and the various possible methods for achieving this need to be spelt out in the policy.

e. Similarly, the increasing complexities of water management would make it necessary to manage the waters with the river basin as a unit in a holistic way and also to plan for inter-basin transfers of water. Although both these aspects and the related aspect of river basin management have been mentioned in the current policy, the larger stress would have to be laid on these aspects.

3.4 Covering Data Gaps

a) There is a large data gap in regard to the estuarine region. In this region, water levels change depending upon the river discharge and the tides in the sea. The flow direction also changes. Due to rise in sea water level, attributable to the climate change, and also to increased frequency of floods, again attributable to climate change, better data and its analysis would be required for planning mitigative measures. Hydrometric and salinity data would have to be collected for all important estuaries, i.e. estuaries of larger rivers as also estuaries of rivers where much industrial development is taking place. (Details in this regard are covered elsewhere).

b) The low rainfall areas as also the catchments of high altitude mountains streams are likely to be the areas which are going to be largely affected by climate change. Similarly, data about the parameters of the water balance and regime changes regarding high altitude lakes is insufficient. A large data collection programme about the hydraulic parameters and water use parameters would have to be launched in these regions.

c) The hydrometric net-work in high altitude mountainous areas is very sparse, when compared with the WMO norms. These areas are likely to be affected due to changes in the regime of glaciers, snow falls, and snow melts. A large programme of data collection is necessary.

d) The net-work for collecting data about evaporation and transpiration is insufficient. The climate change and the rise of temperature would largely affect the evapo-transpiration needs of the crops. Rainfed crops would use more water leading to less deep percolation and surface run-off. Irrigated areas would demand more water. For better water management a large supplementation of the evaporation data network including modern instruments for monitoring moisture flux would have to be mounted.

e) The data about short duration storm rainfall collected through self recording rain-gauges is already not sufficient. With increased frequency of intense storms attributable to climate change, additional data would be required.

f) Another gap in the basic water related data is about the morphology of the rivers. The river channels continuously undergo changes in their geometry due to erosion, deposition, changes in the meandering pattern etc. Anthropogenic changes also take place due to construction of reservoirs, sand mining etc. Accurate morphologic data is necessary for planning river management, erosion control and flood control. All these problems will become acute if strong frequencies and sediment load change. It is necessary to monitor the morphology through setting up of permanent river cross-sections and of surveying these at intervals like five years. Remote sensing studies can indicate shifts of the river and this can be checked after each monsoon.

3.5 Water Allocation and Water Rights

a) At present, water allocation of an inter-state river basin within States is decided either by a mutual agreement or through a process of adjudication. The process of settlement through agreement needs to be preferred.

b) Inter-State agreements need to be recognized and approved by the Union Government, utilizing legislative powers through legislation. While doing so, the Union may ensure that all affected or concerned States are a party to the agreement and that the concerns of the Union such as environment related concerns are not affected. Through this approval, the agreement would be converted in an enforceable document.

c) Guidelines for allocation of water amongst basin States may be finalized as an aid to reaching agreements or to adjudicated solutions.

d) Water needs to be recognized as a negative community in which usufruct rights can operate.

e) States need to be encouraged to lay down a policy for distribution of the water allocations to different regions of the States.

f) The water allocations of the States need to be converted in to legally recognized water rights of the users. These water rights need not be fully linked to ownership of the land but need not also be tradable. The water allocations could be subject to periodic reviews.

g) For faster settlement of adjudicated disputes, and for encouraging specialization, a standing water dispute tribunal may be considered.

3.6 Priorities amongst Uses

The first priority needs to be towards the core needs for essential water requirements for human health and hygiene. This could be of the order of 50 lpcd.

The priorities amongst other uses, such as the residual, non-core domestic water, irrigation, industrial water, ecologic and environmental requirements, navigational requirements, requirements for commercial fishery, recreation and tourism etc. will change from situation to situation, depending upon socio-economic conditions, market forces and established rights.

The priorities for the domestic water could be interpreted as the quantitative priority where demands exceed supplies, most dependable source amongst alternative sources and/or a source with the best quality of raw water amongst alternate sources.

3.7 Increasing Analytic Capacities

The analytic capacities of the Indian water resource personnel would have to be improved through a large scale quality improvement programme. Where necessary, international expertise as also commercially available international software would have to be obtained. For some important items, software development to suit the Indian conditions would have be made by using agencies like CWC, NIH, CWPRS, etc. Again the international expertise could also be used. However, where possible, the developments should be open format so that users can fully understand and make some modifications in the software. A large programme for training the water personnel in the various public and private agencies in India, including personnel of Indian Consultants, would have to be launched. Assistance and subsidies from Government of India should become available for this quality improvement programme. The areas where such quality improvement is essential are listed below:

a) Routine use of one dimensional non-uniform steady flow computations by water resources professionals.

b) Routine use of one dimensional unsteady flow computations by water resource professionals.

c) Use of two dimensional unsteady flow computations for dam break, embankment break etc. at least by the design offices and research institutes of all States and academic institutes.

d) Capacities for basin and sub-basin water assessments using models of hydrologic cycle based on water balance concepts. The models should be capable of depicting the different hydrologic behaviour as per soil, land use, type of crop etc. The models should preferably be distributed models. Either commercially available software is to be adopted or new software has to be developed as a national programme. Scenario development and testing its effect on the basin hydrology in an iterative way is to be a part of the water assessment exercise.

e) Capabilities in linking the unsteady flow hydraulic model for rivers with the storm surge model in the open seas and tidal hydraulic models in the estuaries have to be built up for enabling better forecasts and better planning of tidal embankments etc. These capabilities should be available in the reading research institutes. If possible, the salinity transport models also need to be linked to these.

f) Capabilities in regard to linking a universal soil loss type model with sediment transport and sediment trapping in reservoirs need to be built up. The model would have to be "proved", for each basin, to reproduce the observed sediment load in the rivers and the observed sediment deposition in the reservoirs. Thus, the model would yield a sediment budget. This model can be actuated with changed rainfall regime, crops, management practices etc. to predict sediment budget for different climate change scenarios.

g) Capabilities in modeling the water balance of glaciers and of modeling the snowmelt regimes, both for permanent areas and seasonal snow areas would have be built up.

h) For effective flood management, it is necessary to enhance the capacity of linking the digital elevation models of low lying areas with steady or unsteady flood flow models. Various proposals for flood control and their effect on both the hydrology of the basin and the hydraulics of the channels including the extent of flooded area can then be studied on such models.

i) The capability of combining the hydraulic models for flood wave propagation with the sediment transport models is generally not available anywhere. Much work is being done on the subject. Such models would be particularly useful for the Indian alluvial planes in the climate change scenario, since the additional sediment load and additional flood frequencies can cause severe erosion and conversion of meandering reaches into braded reaches. As a national programme, leading institutes should take this as a challenge. Such models, when developed, can predict the changes in the river morphology.

3.8 Stakeholder Managed Basin Authorities to reduce Conflicts

Legally empowered basin authorities need to be set up. All stakeholders including Governments and departments of the Government, water users and consumers of different types surrogates for environmental ecological interests etc. need to be represented in the authority. The authority would have wide powers in regard to approving development and management plans, directing changes in emergencies etc. The basin authority and the smaller area authorities would have powers in resolving smaller conflicts and imposing penalties for misuse, etc

3.9 Improving Water Use Efficiencies in Irrigation

a) The efficiencies of individual water systems need to be improved to ensure that the water withdrawn from the natural system, after considerable use of resources is used in an optimum way. The control and minimization of inadvertent evaporation of the withdrawn water would be the main strategy.

b) Anthropogenic water logging in irrigation commands leads to the loss of productive land to agriculture and also the large inadvertent water evaporation/evapo-transpiration of the swampy areas. A well planned drainage system would make the area available for productive use and would allow the re-use of the drained water. Schemes for drainage and management of water logged areas need to be planned and executed urgently to avoid increased water stress and to improve efficiencies.

c) Lining of water conveyance systems in selected reaches where large seepages leading to water logging would be occurring, is necessary.

d) In general, in closed basins, seepages are likely to be an important source for sustaining the larger ground water use conjunctively with the surface water. Such conjunctive use should be encouraged since it adds additional ground water fluctuation storage to the water system.

e) Participatory management of irrigation systems by public agencies, farmers and other stakeholders, and the eventual transfer of the treasury systems to the stakeholders will increase equity and reliability and would reduce losses due to over irrigation etc. A time bound programme for such participation and eventual withdrawal of the Government from day to day management of the lower systems should be planned.

f) As stated, return flows are an important resource if re-use is possible. However, if the returns are to “sinks”, such as saline aquifers, low coastal areas etc., re-use may not be possible. Returns, unless required for other purposes, need to be mopped up before reaching the scene.

g) For each large irrigation system, bench marking and performance evaluation studies for each water year should be done and the results publicized. The complete water budget and efficiency related data should be included in this study.

h) The “basin efficiency”, is a concept which is much more relevant to optimum water use than the “system efficiency”. The basin efficiency or sub-basin efficiency needs to be estimated through a rigorous exercise, using models similar to the water assessment models.

i) For closed basins, the basin efficiency needs to exceed 80%.

j) Irrigation efficiencies can be improved by managing in such a way that no over irrigation takes place and small doses and larger number of watering are provided. For this purpose, piped irrigation, use of sprinklers and drips, construction of storages at the users end for storing irrigation water between rotations etc. need to be encouraged. Subsidies could be made available for these.

k) Minimization of controls on canals which could be misused is an important strategy. Proportionate distribution and removal of small cross regulators could be encouraged if participatory management has become possible.

l) Automation, computer controlled decision support systems, on demand irrigation through creation of level pools in canals, using real time soil moisture data to decide irrigation doses etc. are important means of improving efficiency. In water scare and highly productive areas, these need to be implemented on a pilot basis. Subsidies would encourage this initially.

3.10 Increasing Usable Water

a) Increasing the usable water without importing water from other areas/basins is possible only in “open“ basins. In basins which are “closed” or are likely to become closed, no increase in usable water is possible except through reduction of inadvertent evaporation or return to sinks. The situation needs to be assessed for each basin.

b) For closed basins, increase in usable water in one area may lead to decrease elsewhere. Such changes in the pattern of use may be socially desirable, and can be made after the externalities are studied and discussed.

c) Water harvesting is an important method of increasing usable water and needs to be encouraged.

d) Larger storage and larger carry over storage become essential to increased water use. Where surface storage possibilities are low, ground water storages can be used in conjunction. Such possibilities include:

  - Anthropogenic enhancements in ground water fluctuations caused by pre-monsoon pumping and additional river bed recharge in monsoon, or through the concept of Kharif channels are possible strategies which need to be encouraged. Pilots for ground water depletion need to be implemented with subsidized financing and studied closely.

  - Conjunctively using unreliable surface water with more reliable ground water to enhance the total use. In this strategy, additional ground water withdrawal capacity is made available, but is activated only in years where surface water is not available.

e) If more water is used in the wet season and less is used in other seasons, water use can increase for the same storage availability. Such strategies which need to be encouraged include:

  - Use of dug out farm ponds which get filled up repeatedly in each rain spell, and the water used in between the spells.

  - Planning storages with irrigated khariff as the reliable main crop, and resorting to unreliable Rabi irrigation depending on the storage position at the end of the wet season.

f) Increasing storages in existing dams would be possible if the dam is spilling very frequently. In view of the larger water stress attributable to climate change and increased demands, a programme for such increases in the capacities needs to be taken up (see discussions in the report)

g) For minor, ungated tanks which spill frequently, installing low gates would allow increased storage without much cost in raising of the dam (see discussions in the report). A programme for locating, studying and implementing such proposals needs to be taken up.

h) The existing programme of restoration of tanks and water bodies needs to be reviewed with a changed focus and implemented (see discussions in the report)

i) Inducing ground water seepage through seepage tanks is very effective in the rocky areas of the peninsula where the geology is favorable. This needs to encouraged and subsidized. Since the conveyance is through the geologic formations and use through the private dug wells/bores, stakeholders participation is ensured.

j) Hydro-fracturing is another method of increasing local utilsable water and needs encouragement.

3.11 Inter-basin Transfers

a) Inter-basin transfers are an effective way of achieving better equity. If the transfer is from an open basin to a closed basin, increased water use is achieved. Such transfers need to be encouraged.

b) Inter-basin transfers of flood waters and the use of these waters to re-charge depleting ground waters in water stressed areas have been proposed. These need a more detailed study, preparation of a few feasibility reports and their appraisal.

c) Inter-basin transfers are not merely for increasing production. They are also an important means of reducing absolute poverty and increasing the economic carrying capacity of water resource over populated region, without recourse to distress migration. This aspect needs to be highlighted and studied.

d) Inter-basin transfers raise new issues about ownership, financing models, implementing responsibilities and revenue collection. Policies in this regard need to evolved.

e) Enabling legal measures (see details in the report) which empower an agency to study and detail the proposals for execution after calculating the available surplus, a procedure for appeals in this regard and a procedure for implementation are essential.

f) After empowering the agency to execute the transfers, negotiated solutions between the surplus and the deficit States involved in the transfer need to be encouraged.

3.12 Drought Management

Apart from water harvesting in basin developments and inter-basin transfers, integrated farming systems and non-agricultural developments also need to be considered.

The nexus amongst the resources of land and water on the outputs in terms of food, livelihood, energy and ecologic services has to be recognized in resource planning. Where livelihood support and poverty alleviation is a major problem, irrigated agriculture, with in-basin or inter-basin development may be necessary. Energy plantations in low rainfall area may consume rainwater and affect food and livelihood.

3.13 Environmental Impacts

a) In view of the additional stress which climate change may cause to both hydrology and to the ecology of the affected area, maintaining aquatic ecology through environmental flow requirements as decided after considering the needs of various uses and the trade-offs, will become even more important. Much work needs to be done for deciding an acceptable methodology.

b) Improved management of wet lands has to be a part of the water policy. The management of anthropogenic wet lands needs to be different from that of natural wet lands. Amongst the natural wet lands, the coastal wet lands, estuarine wet lands away from the coast, wet lands in middle reaches and the embanked flood planes need to be treated separately.

c) Anthropogenic wet lands (water-logged areas) need to be drained. The supply needs to be reduced and the returning water needs to be re-used.

d) Coastal wet lands and mangroves need to be conserved.

e) Embanked flood planes need to be maintained and the agriculture needs continued protection. New proposals for embanking urbanized and industrial areas may have to be implemented, but new proposals for embanking agricultural lands need careful balancing between the interests of agriculture and aquatic ecology.

f) Natural wet lands like jheels, beels, charlands need to be managed by balancing the interest of agriculture, ecologic conservation and commercial fishery.

3.14 Water Quality Management

a) A massive programme of data collection in regard to surface and ground water quality, including the micro-biological and heavy metal related parameters needs to be launched.

b) Water quality model capable of depicting point and non-point pollution loads, self purification, mass balance etc. need to be set-up for each basin and aquifer.

c) The models should be used to assess the water quality situation under increased loads, altered discharge regimes, changed temperatures, etc.

d) Necessary institutional and legal changes need to be made to take effective action against polluters.

e) Implement the "user pays – polluter pays" principle. Preferably have a three way charge: (i) a charge per unit of raw water withdrawn; (b) rebate per unit of treated effluent return and (c) a large fine per unit of pollution load return to the system.

(f) Subsidies/Incentives need to be given towards effluent treatment and re-circulation/recovery arrangements.

(g) Encourage use of domestic effluents for irrigating non food crops, without mixing with natural waters.

(h) Precious water resources should not be used for diluting pollution loads. Pollution needs to be avoided or treated.

3.15 Flood Management Strategies

Utilizing the model development capacities and the morphological data, the hydraulics of each major viewer needs to be modeled. Flooded area maps for historical floods, as observed, would be matched with the model. Using this model, likely flooded areas for different floods and different frequency floods need to be prepared.

3.16 Multipurpose Projects

In view of the increased water stress and shortage of storage sites, multipurpose developments become very important. The present trends towards single purpose development are perhaps due to institutional constraints, and this needs to be overcome. The tendency of the farmer/ irrigation departments to protect the historic dominance of irrigation needs to be changed. The compatibility amongst uses for irrigation, hydro power, domestic and industrial supplies etc. can be enhanced through innovative planning.

3.17 Disaster Management

a) Utilizing the capacity in unsteady flow hydraulic models, dam break studies should become a routine exercise for all dams, and especially for the unsafe dams. Emergency preparedness plans should be prepared and publicized.

b) Legally empowered dam safety services need to be set up in the States as well as in Centre. Dam safety would be a concern of the State, but for national important dams and for dams having significant trans-boundary hazard potential, the Central Dam Safety Service needs to be responsible.

c) Utilizing the capabilities in hydraulic and hydrologic modeling, basin-wise flood propagation models should be built and used for flood warning and flood forecasting with longer lead times. In regard to international basins, international cooperation needs to be extended and ensured.

3.18 Conflict Management – International basins

a) For the Indus basin, without disturbing the present arrangements, international cooperation towards a more optimum use of the basin under increased stress due to reducing resources, growing demands, and impaired ecology, needs to be promoted.

b) In regard to the Ganga, the regime changes due to climate change which was not foreseen earlier, need to be well documented.

3.19 Changed Acceptability Criteria

The planning and designing of water projects is so done that these plans fulfill the various acceptability criteria. These have been generally codified as standards or guidelines by the BIS, or through the various Circulars of the Government and the Planning Commission. In the changed circumstances, attributable to climate change and increasing demands, these guidelines need to be changed. While preliminary proposals in this regard are worked out already, these need to be quickly debated in the concerned fora and accepted. These criteria would be in regard to:

1. Reliability of success in regard to water availability.

2. Planning reservoirs for accommodation sediment.

3. Deciding floods for designing dams.

4. Deciding design floods for flood control and erosion control works.

5. Economic viability.

3.20 Domestic Water Supply

(a) Adherence to the millennium development goal is reasserted.

(b) The current definition about the provision of adequate water supply to rural communities needs to be re-visited to remove the large disparity between urban areas with piped water in or near the residence and the rural communities.

(c) The policy should aim at improved supply norms with flush toilet facilities in rural areas also; thus, bridging down the urban – rural divide.

(d) The present practice, in general, is to use ground water as the preferred mode for rural domestic supplies. While this needs to continue, rural areas with endemic ground water quality problems (such as fluoride or arsenic), need to be supplied piped surface water through a larger network. If treated ground water through local systems is done, the problem of disposing the concentrates should be tackled adequately.

(e) Urban domestic supplies need to be preferably from surface water. Where alternate supplies are available, a source with better reliability and quality needs to be assigned to domestic water supply. Exchange of sources between uses, giving preference to domestic water should be possible.

(f) Urban domestic water systems need to collect and publish water accounts and water audit reports indicating leakages and pilferages.

(g) Leakage control should be taken as a programme and subsidies made available.

(h) While reducing pilferages, the social aspects need to be kept in view.

(i) New piped water supply schemes need to be discouraged unless the sewerage and sewer treatment components are included.

(j) For urban domestic water supply, two piped systems, supplying treated water for bathroom and kitchens and raw water for gardening and flush toilets have limited advantage of saving water treatment cost and added risk of health hazard due to cross connections. Such systems can be used with care.

(k) For urban domestic waters supply, two piped systems, supplying treated water for bathroom and kitchens, and recycling the bathroom and kitchen effluents, after primary treatment, for flush toilets and gardens has limited advantage. While the quantity of treated water, and the quantity of sewage to be handled in the main treatment is reduced, the total pollution load in term of the weight of the BOD etc. is not reduced. The primary treatment is larger. Health hazards also are large. Much care and pilot studies are necessary before adopting this.

(l) Adaptive research, trials and action research on improved toilets, either not using water or using less water, need to be continued.

(m) For urban water supply in coastal areas, desalinization can be a viable option. Since this option increases the total usable water, it can be preferred, if the cost difference is not large.

(n) In coastal regions near thermal power plants, large low grade heat energy becomes available. This can be effectively used for desalinization and water supply. Since this option increases the total usable water, it can be preferred, if the cost difference is not large.

3.21 Industrial Water Supply and Water Treatment

(a) Industrial water supply needs to be on a lower priority than the core demand of the domestic water supply.

(b) Although water, including ground water, is a common resource and negative community, its regulation vests with the Government. Thus, even where the industries develop their own mechanism for supply and treatment, both charges similar to royalty and licensing would become necessary.

(c) Industrial water supply needs to be regulated on the basis of “user pays – polluter pays” principle, preferably with a three way tariff as already described.

(d) Recovery of industrial pollutants and recycling can be a capital intensive intervention. Subsidies and incentives are necessary.

(e) In water short areas, zero effluent solutions of industrial re-use would reduce the total resource. At times, it may involve invisible return of polluted water to the ground. Return of properly treated effluent to the system needs to be preferred.

3.22 Ground Water Management

(a) Under Climate change, the number of rainy days may decrease and the rain per rainy day may increase. This can reduce the deep percolation to ground water and increase the proportion of surface run-off. Thus, the ‘natural’ ground water recharge may reduce. This needs to be investigated through hydrologic modeling based on short time periods.

(b) In view of the changes in the inputs to ground water and in view of the higher demands driven by growing population and increasing temperatures, the ground water balance may increasingly become more adverse in areas which are marginal at present. Better norms for assessing likely future ground water position need to be decided on the basis of total basin hydrologic assessment supported by a total system model.

(c) Until results of (a) and (b) become available, on an ad-hoc basis, more stringent norms for deciding the “grey” and “dark” status of the ground water blocks need to be adopted.

(d) A massive programme for collection of ground water quality data and for linking the ground water quality models to the basin hydrologic models needs to be undertaken.

(e) The policy and the laws need to clear the uncertainties about the ownership and regulation of ground waters. All water, including ground water, needs to be considered as a negative community with usufruct rights to be regulated by the Government. However, limited domestic water supply needs of land owners and also of local citizens would not be subject to any regulation in regard to traditional ground water use for domestic supplies. In regard to irrigation of the owned land, limited use would not be subject to any regulation except in temporary emergent situations such as droughts. Local commercial use of ground water would be regulated by the Government (local self-Government, State or Union as the case may be) after keeping the externalities in view. Cess similar to royalties, can be charged on such commercial use.

(f) Under Climate Change, there will be a larger stress, both on the ground water resources and on energy. Power tariffs need to be regulated to reduce and limit the overall subsidy on the use of ground water for irrigated agriculture. The general principles in this regard would be as follows:

- Decide the economic cost per unit of energy at non-subsidized input prices and with fare return on capital for a new thermal power project.

- The general power tariff for rural agricultural power could be around 50% of this economic cost and could thus involve a considerable cross subsidization/ subsidisation.

- Use of electric power for agriculture in off-peak night hours may be encouraged. During this period, the tariff could be around 30% of this economic cost.

- During peak energy demand period, not exceeding six hours per day, the agricultural pumping power supply may be discontinued if subsidies have been allowed.

CHAPTER 4
LEGAL FRAMEWORK FOR COPING WITH CLIMATE CHANGE

4.1 Legislative Empowerment under Entry 56 of the Union List

In the present provisions, water is not a “state subject”.

The legislative capability of the states, in regard to inter-state rivers is limited by the enactment of the Union under entry 56. (About 90 percent of the territory of India is drained through inter-state river basins).According to the Author, enactment by Union, under entry 56, would be sufficient to correct the situation, and Constitutional changes are not warranted.

In any case, changes in the Constitution, about water related provisions would be very difficult.

Some of the issues about which the Union government needs to derive powers from legislation could be stated as follows:

1. Powers to approve proposals of the States in regard to water developments in interstate basins.

2. Powers to collect information about water and its use for various purposes in different States.

3. Powers to monitor the management of waters of an interstate basin by the State.

4. Powers to set up basins authorities who can direct the States in regard to the management of the basins waters in accordance with existing awards or agreements, allocations etc.

5. Powers to approve the interstate agreements reached by the basins States, and to convert the agreements into legal instruments, which cannot be modified unilaterally.

6. Powers to set up independent inspecting and licensing bodies to inspect and certify the safety of dams.

7. Powers to decide the availability of surplus water in River basins after consulting the co-basins States and to recommend inter-basin transfers of water to deficit basins.

A brief rationale for these is given below:

4.2 Powers to approve proposals of the States in regard to water developments in interstate basins:

At present, it is not illegal for any state **(A)**, in an interstate basin, to take any unilateral action, even if it is likely to affect the interests of another state **(B)**, in a significant way. It is for the affected state B to get such action stopped using some legal or other remedies. If there is no adjudicated settlement of the basin allocations, B can approach the Union, evoking the ISWD act and ask the Union to get A's action stopped through negotiations. If these fail, B can ask for a Tribunal, and when this is set up, it can request the Tribunal for a restraining order. If A's action seems to violate an adjudicated settlement or an interstate agreement, B can approach the apex court for a restraining order. In any case, the Union executive has no powers to intervene with a legal backing. This situation needs a correction. However, a judicious decision about what can qualify as a "significant adverse effect" would have to be incorporated. For example, consider a proposal where a small dam in the upper part of the Chambal (a river in the G-B-M basin) in Madhya Pradesh is to be built for industrial use. Most persons would agree that an objection by Rajasthan to this needs some consideration. Most would also agree that an objection by, say, Sikkim, also a member state of the G-B-M basin, to the specific proposal, may not warrant any consideration. The principles involved in such a common sense require delineation in the law.

4.3 Powers to collect information about water and its uses for various purposes in different States

This is a basic need for any water situation assessment. For interstate basins, the entry 56 would allow legislation by the Parliament. Alternately, for this, apart from entry 56 of the Union list, entry 45 of the concurrent list can also provide the necessary backup. The latter reads:

"45. Inquiries and statistics for the purposes of any of the matters specified in List II or List III"

4.4 Powers to monitor the management of waters of an interstate basin by the State

This again, is a basic requirement for water assessment. Monitoring would involve the giving of directions in urgent situations.

4.5 Powers to set up basins authorities who can direct the States in regard to the management of the basins waters in accordance with the existing awards or agreements, allocations etc.

With increasing complexity in water systems, increased demands due to population growth and economic growth, and the uncertainties of climate change, IWRM, and holistic basin management are becoming indispensable. For this, basin authorities are essential.

The amended ISWD act does provide for a mechanism to oversee the implementation of the award. However, the directions of that mechanism can themselves be questioned or flouted, and writs would have to be obtained from the apex court. Also, for basins or basin parts, where there are no awards, and where the overall allocations to the States may or may not be regulated by interstate agreements, no legally empowered mechanism may be available. This requires a correction.

4.6 Powers to approve the interstate agreements reached by the basins States, and to convert the agreements into legal instruments, which cannot be modified unilaterally.

Interstate agreements amongst states are a good way of resolving disputes, provided all concerned states are involved. The agreements follow the principle of equity and the parties are restrained to follow the agreement.

Such agreements do not have the force of an enforceable decree. If these are “contracts”, breaches are expected, and the remedies available may not be acceptable to all. These are not “treaties”, and even if these are so considered, the remedies available for breach of treaties, in the international context, are not at all available in the intra-state context. Instances when States wished to get out of such agreements are known. Hence, legal provisions are needed.

4.7 Powers to set up independent inspecting and licensing bodies to inspect and certify the safety of dams.

Dams are potential large hazards, and the safety of the citizens from anthropogenic dam break disasters concerns both the States and the Union. Sometimes, a dam in one state, or managed by one state, may be a potential hazard for another. Hence, the law is necessary.

4.8 Powers to decide the availability of surplus water in River basins after consulting the co-basins States and to recommend inter-basin transfers of water to deficit basins.

As the water stress increases, and as the possibility of the likely climate change increases, inter-basin transfers would have to be planned and implemented in national interests. Since, the concurrence of the States would be very difficult, particularly in the absence of any over-arching provision which does not require such a concurrence, a legal provision is necessary.

4.9 Inter-state water disputes

The adjudication process takes a very long time. Sometimes (as in the case of the Godavari) the delay is caused by the party States trying for a settlement on their own. Sometimes (as in the case of the Ravi and Beas) the delay could be due to other causes. However, in all cases, delays occur. Reforms to avoid such delays have been thought of, but have not been implemented as yet. The National Water Board considered a proposal for a standing water dispute tribunal, which can become an institution specializing in water law and which would avoid delays. This proposal also had a provision for arbitration or mediation as alternative conflict resolution, which could be tried before resorting to adjudication. However, this proposal was not favored. Reforms, both for allowing alternative conflict resolution mechanisms, and for speedy adjudication, appear necessary.

CHAPTER 5

INSTITUTIONS

5.1 General Approach to Institutional Issues:

If laws and policies provide a framework for the actions of the executive, institutional structures provide the enabling circumstances for the action.

The institutional structure in regard to water development and management in India has developed over centuries. It is shaped by the history, the laws, the policies, the changing concerns, and the changing role of the State, the NGOs, the private sector, and the individuals in the sector.

On one hand, the climate, which provides the basic environment for the human existence, is all-pervasive and affects all human activities. Thus, climate change can potentially touch every aspect. But, on the other hand, even the fast pace of these changes, in the future, would still be slow as compared to the fast evolution of the human civilization and economic development. At any given time, climate change related concerns would form but one of the many groups of concerns which would be driving the institutional changes.

In this background, internalizing the climate change concerns in the changing institutional structure would be far more effective than creating a new structure. For example, the creation of a “department (or office) of climate change” will cause delays and red tape; and more importantly, insulate the other department from the related concern. Adjusting policies (including strategies, programmes, action plans, guidelines, standards and procedures) and laws (including rules and regulations) to enable the existing and evolving institutional structure to more effectively deal with the matter is preferred.

This preferred course of action is not easy. Water bureaucracy or water professionals in public service in India tend to put the procedures and regulations far above the professional knowledge and professional propriety. The universal principles of hydraulics could be over-ridden by an old circular of the concerned authority, and so on.

Departments of the state may change from “Irrigation” to “Water Resources”, but the personnel of the line Department are unlikely to get unshackled from the history, and internalize the problem of making domestic water supplies available, as one of their prime responsibility. Instead, they may merely lay down conditions to protect their historical responsibility towards agriculture. A large programme for re-training, complete re-building of attitudes, etc. would become necessary.

Considering this, our general recommendations are:

1. Internalize climate change concerns in the existing institutional structure.

2. Embark on a massive re-training and attitudinal change programme.

3. Ensure or encourage procedures in which the water related departments in their annual reports to legislatures deal with actions taken to modify procedures in water related matters, to adjust to climate change. These would include:

    - Modified programmes for data collection
    - Modified programmes for capacity building
    - Modifications in working procedures
    - Modifications in research agenda and progress of research.

4. Set up, in the Center as also in the States, inter-ministerial and inter-departmental committees to review actions taken to modify procedures in water related matters to adjust to climate change.

5.2 Reducing the Role of Government in Water Sector

Traditionally, water management was a community activity and water was being treated as a common property. However, the role of Government also existed. Various historical documents in India such as the edicts of King Ashoka near the Sudarshan Tank in Saurashtra, passages in Chanakya's treatise, the role of the Cholas in the development of Cauvery Delta, the role of the Delhi Sultanate in developing the inundation canals on Yamuna are well known. While both these models co-existed until the recent years, the various irrigation Acts under the British regime established, or according to some researchers, usurped the rights of the communities to establish the right of the Government in regulating and managing the waters. Very similar patterns are obtained elsewhere.

The principle of Integrated Water Resources Management (IWRM) emphasizes the need for reducing the role of the Government in all aspects of water management and increasing the role of all stakeholders in jointly managing the resource. Such a change seems to be well in line with the changing role of Governments in most activities related to societal management, and the increasing role of civil society, even in a democratic governmental set up. The role of the Government in Water Sector can change slowly from that of a developer, owner, service provider and a mighty benevolent to that of an institution which lays down the policies, provides legislative and judicial support for dispute resolution and that of a regulator and an important stakeholders.

In this background, our recommendations are:

a) Basin, sub-basin and area level committees for management of water resources, by all stakeholders in a joint way need to be set up. Although the establishment of such basin authorities would have to be under Entry 56 of the Union List, the objective is not one of changing the focus of power from the States to the Union, but one of redistributing the powers of the basin States to the civil society in a regulated manner. The basin authorities could have various functions such as :

    - Approving development proposals after ensuring their compatibility with approved master plans, earlier settlements or awards etc. and after ensuring their technical social and economic viability as per the national standards and procedures.
    - Monitoring and ensuring that the water use is as per the agreed allocations.
    - Making day to day changes in water managements as per exigencies of the situations.
    - Regulating further developments in the basin, either by public or private entities, and charging water cess, pollution charges, etc. from these entities. (These charges are to be distinguished from the water price, which is, in fact, a water service charge which is collected by the Government in its present role as a service provider. The water cess collected by the RBA would be a tax and a royalty)
    - Managing and spending these collections for IWRM related activities, including water quality management, maintaining aquatic ecology, and subsidies, incentives and studies, for this purpose.

b) Setting up of single use stakeholder committees, such as the Participatory Irrigation Management Committees, in different tiers, for outlets, minors, distributaries, canals, project, etc.; stakeholder committees for urban domestic supplies at different levels; stakeholder committees for industrial supplies to an industrial estate etc.

c) Eventually turn over the system management up to the highest manageable level to the stakeholder committees.

d) The eventual large scale involvement of the nongovernmental members of the River Basin Authorities in the decision-making process.

e) Larger use of market forces in evolving competitive solutions to the routine management problems .Even where, for obvious reasons, the market forces cannot be allowed to reach financial solutions, the administered solutions could be somewhat in consonance with what the market would have done.

Also, where market forces can be used, many problems may not remain in the realm of public policy or strategy, if market forces are allowed to guide the decisions. For example, the maintenance, management billing and collection of the tertiary distribution, for irrigation or for domestic water can be privatized under stake-holder supervision, and in doing so, many staffing decisions would cease to be important pubic decisions.

5.3 The Role of Government in Regulating the Water Sector

The role of the Government, as a regulator of the water sector is a basic Governmental function and needs to be strengthened through institutional design. This role should not be interpreted as one of a price regulator.

Price regulation for water sector is considered as an important Governmental function today, and is considered as an important and politically sensitive issue. An administered price regime for water and irrigation has become a norm in India. This perhaps follows from the historical concept of the Government as a benevolent owner of water, with a responsibility of providing water services. Then, in order to meet its social responsibilities, Governments had to price water by considering the capacity of the receiver to pay, or to take back a reasonable cut from the benefits derived by the user etc. In accordance with these principles, the Government had to charge less from those who derived less benefit from irrigation, through, say, lower yields or an inappropriate economic choice of crops. Such policies, which may have been appropriate when the Indian agriculture was more of a subsistence operation. However, these created some dis-economies by slightly rewarding or tolerating economic inefficiencies. In any case, these concepts are almost outdated by now, since the market now drives agriculture.

However, water services are largely monopolistic. A user does not have a choice of purchasing either irrigation or domestic water from the most competitive supplier. Thus, price regulation would still be required, even if markets were allowed to function; but these would be mainly in view of the monopolistic nature of the market. The function of the regulator would then be to ensure that the prices promote efficiency, both in the supplier and the user, and that differences in prices, in space, is justified by local variations in costs of the schemes.

The current Indian situation represents a transition in the role of the Government. Currently, price regulation would be an important function but this regulation needs to be done, not so much for meeting the social obligations, but more for promoting equity and efficiency together. For example, assume that the current general average price of a project, per hectare of new surface irrigation, is Rs 150,000.It is impracticable to fix the irrigation price at around Rs 20,000 per year, which will allow a fair return on capital. After considering all aspects, the

Government, or the regulator, may perhaps aim to keep the general price at say Rs 3000 per hectare, or , approximately, Rs. 1 per cubic meter. But he may also consider a price regime in which:

- Projects, which are comparatively costlier, are not approved.
- If competition between sources is possible (say between surface and ground waters), this would be encouraged.
- The differences in input costs of the project due to its nature get reflected in price difference. Irrigation water from a storage project with tortuous canals in undulating topography, can be priced significantly higher than that of a simpler run of the river project in plains. Once it is accepted that the price is the price of a service and not a tax, it would also be realized that there is little logic in charging a uniform price irrespective of the project complexities.
- Similarly, the price of the dry season water can be more than the wet season water, to reflect both the scarcity value, and the additional costs involved. Similarly, price of water lifted by using energy needs to reflect the economic value of the energy.

As already stated, price regulation is but one of the regulatory functions of the Government. To summarise, the regulatory functions would include the following:

1. Ensuring that the right of all citizens and residents, to the minimum essential supplies of water for essential health and hygiene, is fully ensured.
2. Ensuring that the water available to the State for use is equitably distributed to between regions of the State, as also amongst the various types of uses, after considering various factors like their contribution to the resource, their needs, availability of alternate sources etc.
3. Monitoring that the actual use of the waters is in consonance with the broad allocations. Ensuring that the water budgets and water accounts, based on the hydrologic balances, are maintained, made available and published basin wise and scheme-wise.
4. Monitoring and ensuring that the environmental flows as desired in the allocations, are maintained.
5. Monitoring and ensuring that the water quality, as desired, is maintained in the surface and ground waters. Directing implementation of corrective measures such as water treatment plants.
6. Ensuring that a new regime of water rights of the users is created.
7. Regulating local ground water markets in such a way that it benefits the most, create conditions where private enterprise will grow, and also see that no significant harm is caused to others
8. Regulating the creation, review, and modifications, of water rights.

9. Regulating water prices for different uses.
10. Regulating a regime of royalties for the use of waters by the users, through their own costs.
11. Regulating a regime and the rates of fines or penalties for polluting surface and ground waters,
12. .Regulating the use of these fines or penalties towards measures for water quality improvements, through subsidies or investments.

At present, Maharashtra has set up a regulatory authority, and Uttar Pradesh is in the process of setting up an authority.

It is recommended that considering the increasing competition for water for different uses by different users and considering that the climate change may further worsen the situation, all states need to regulate their waters in order to promote efficiency and equity in a transparent manner. All states need to seriously consider the creation of an independent regulator, working within the general parameters as laid down by the Governments. While the broad functions are indicated above, the distribution of the functions between the Government and the regulator can vary from State to State. Also, when the legally empowered River Basin Authorities are created, they would have to share some of the regulatory functions.

CHAPTER 6
FINANCIAL POLICIES

6.1 Background

In this chapter, we will discuss the incentives, grants, concessions, subsidies etc. which appear necessary for a quick reform of the water sector in India to enable it to adjust to climate change.

Subsidies and incentives are required for short run solutions to problems, but in the long run, these themselves can cause problems by disturbing the play of market forces by causing anomalies etc. Similarly, continued grants from the Central Government to the States can cause problems, The recommendations in this chapter need to have a short time span of about 10 years, and need to be reviewed after, say, 5 years.

The determination of the extent of subsidies, grants, or soft loans is a complex process. The financial implications to the Centre as also to the states, the economic implications etc. need to be considered. Apart from the concerned water related Ministries, (MoWR, MoA, Ministries dealing with Urban and Rural Water Supply and Sanitation, MoEF), the Ministry of Finance and the Planning Commission would also have to be actively involved. Considering this situation, we refrain from giving any quantitative recommendations about the extent of the subsidies etc. Our recommendations only indicate the level of financial assistance.

Ss' High', 'Considerable', and' Significant '. The meaning is elaborated below:

Level	Likely Range of Financial Assistance	Implications on financial decision-making regarding the Reform
High	65% and above	The recipient would have only a small financial liability, and should readily adopt the desired change
Considerable	30% to 65%	Indicates a need for a considered mutual decision-making about adopting the changes
Significant	30% or lower	The recipient would have to accept the change on his own, with the subsidy acting as a significant inducement

6.2 Budget

A separate budget head may be created for climate change related activities of the Ministry of Water Resources. All expenditure of the Central

Government related to these activities including the grants to States will be met through this head.

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6.3 Financial Policies regarding Subsidies etc.

Relevant issues are highlighted and our recommendations are set forth below**.**

Data and Assessments:

1. All activities in regard to the various data collection, analytic capacity building, hydrologic assessments, research, etc. would be met from the central budget.
2. All expenditure on similar activities to be incurred by the States would receive a high level of Central financial assistance.
3. **Studies, Trials, Pilot implementation, Action Research:** All expenditure on pilot studies, field trials , action research activities and training programmes in India to be incurred by the States would be covered (except for land and staff) by a considerable Central financial assistance..
4. **Capacity Building and Training:** Expenditure involved on capacity building and training activities of the personnel of other private institutes, including consultants, which are in accordance with this report, would receive a high level of Central financial assistance.
5. **Water Saving Expenditure of Water Users:** Expenditure to be incurred by the users of water on efficiency improvement techniques would also receive a considerable Central Financial Assistance.

Sl. No.	Technique used by user or NGO's	Where applicable
1.	Use of plastic sheets or mulches, to reduce bare soil, evaporation, from rain fed land	List A
2.	Use of plastic sheets or mulches, to reduce bare soil, evaporation, from irrigated land	
3.	Construction of field channels	List B
4.	Lining of field channels,	List B
5.	Levelling of irrigated fields	List B
6.	Construction of "dug out ponds" in rain fed or irrigated areas	List A
7.	Resorting to furrow or basin irrigation, by giving up flood irrigation	List B
8.	Adopting sprinklers in irrigated areas, on Ground Water	List B
9.	Adopting sprinklers in irrigated areas, on surface irrigation, including storage at user's end	List B

10.	Adopting drips in irrigated areas, on Ground Water	List A
11.	Adopting drips in irrigated areas, on surface irrigation, including storage at user's end	List A

Notes:

a) If the area is under a CADA, separate CADA norms and procedures may apply.

b) Cost ceiling norms would be by MoWR.

c) Monitoring can be by the state agency (say WALMI) of the state, with checks by central agency (say CWC) and NGOs appointed by Centre

d) Regulation would be through the state agency regulating the programme.

e) Payment would be made directly by the centre, on basis of the authorization of the State agency.

f) List A : Areas in all basins excluding Ganga downstream of Patna and its tributaries, Bramhaputra, Meghna, other river basins of North East, the west flowing rivers from and excluding Tapi to Kanyakumari, and east flowng rivers between Godavari (excluded) upto Ganga.

g) List B: Areas in all basins excluding Ganga downstream of Patna and its tributaries, Bramhaputra, Meghna, other river basins of North East,and the west flowing rivers from (and excluding) Tapi to Kanyakumari.

6. **Water Saving Expenditure by States:** The expenditure incurred by the States on preparing feasibility studies and on implementing the approved proposals would attract a high level of financial assistance.

Sl. No.	Type of Activity
1.	Investigations, studies and preparation of feasibility reports, for drainage and reuse, system modernization, raising of live capacities etc., on the basis of this report, as accepted
2.	Implementation of approved projects
3.	Studies regarding water assessments, water use efficiencies, Basin efficiencies, water quality status, environmental flow requirements etc, as per the recommendations
4.	Preparation of master plans, flooded area maps, etc., as indicated in this report
5.	Preparation of individual scheme-wise feasibility Reports for flood control

6.	Preparation of proposals for modifications in exsisting dams and flood control works, as also urban storm water drainages for added flood safety or for tidal embankments in view of climate change, rising sea levels, etc,
7.	Implementation of these proposals as approved

Notes:

a) Cost ceiling norms would be by MoWR,

b) Costs qualifying as total costs would be estimated after excluding staff related costs.

c) Costs of outsourced work can be included full

d) The current thinking is that the grant component can be reduced after about 5 years

7. **Awareness:** A public awareness programme about the climate change, its likely effects on the water sector in India, and the steps being taken in this regard, would be launched as a joint programme regulated by the Center, in cooperation with the States and with assistance of NGOs selected at National and State level.. Cost incurred by the States, and by participating NGOs would be eligible for a high level of Central assistance.

8. **Water Quality:** Water quality management and the control of the pollution of the rivers and aquifers, is an important component of the strategies to meet the challenge from climate change. It is also recognized that the pollution abatement measures are very costly, and the industries and the local self Governments may not be able to meet the costs. Considering this situation, we recommend that f the cost of studying the feasibility of effluent treatment, recycling and reuse proposals, by the local Self Governments and industries would receive considerable Central financial assistance.

9. **Incentives for Effluent Treatment:** Once such proposals are agreed to, subsidies or grants would be necessary towards the implementation. We recommend a significant Central financial assistance towards these. However, this would be done provided the States also give a significant level of assistance from the State funds. and that, a financial closure, and the viability of meeting the O&M costs, and some interest on the residual capital, is demonstrated in the proposal. Also, as a pre-condition, the State Government is to agree that it would not support any urban piped water supply scheme or its extension, unless sewerage and sewage treatment forms an integral part, to be implemented simultaneously .

10. **Incentives to Industries for Reducing Pollution:** Industries cause considerable water pollution, and often, this involves pollution by heavy metals and undesirable chemicals, and with little possibility of self-purification. By not treating their effluents sufficiently, industries often flout the law and the

regulations. However, harsh action is difficult. Reasons for these may include the following, apart from the more obvious ones:

- The States would like more industrial and economic development and would not like to send signals which will slow it down.
- If strict action is taken by one State alone, the industry may move, or expand in another less strict State.
- Problems with industry may cause unemployment, lockouts, strikes and industrial unrest.

The problem is vexed but a solution which meets the concerns of both sides is to be found. We recommend:

a) Give large low interest loans to Industries, from Central and State funds, through the medium of a Public Sector bank.

b) Impose stiff fines for the pollution caused. The fine should be such that the total spendings on the interest on soft loan, interest on residual capital cost of the plant and the fine may be similar to the commercial interest, initially. The fine should become larger, progressively, if the progress of the treatment plat is slower than expected. In the longer term, building the treatment plant should become more attractive than not building it.

c) Tie up these arrangements through a well designed agreement amongst the industry, the bank and the State and Central Governments.

11. Incentives to Promote RBAs: We have placed emphasis on the creation of enabled River Basin Authorities, representing all hues of stakeholders. The RBA needs to be a legal entity, and eventually, it needs to sustain itself, financially, through the collection of the water cess, fines, and where relevant, a small electricity cess on hydropower. The financial policies, as envisaged, in ths regard are:

- Initially, all costs may be borne by the Centre as grants to the RBA.
- Initially the RBAs could have an administrative pattern similar to those of Govrnmental Societies, with dominance of the Central and State Governments on the Governing Council and the General Body; and with little financial autonomy. But, quickly this pattern should change, pari-pasu with the revenue collection and reduction in Governmental grants towards full financial autonomy (within the Governmental guidelines and regulatory powers) and with elected President and Chairman of the Governing Council.
- Even after full development, RBAs ,though largely autonomous, would be discharging some governmental functions. Even while the RBAs, at times, would be critical of the Government, the Central Government may cover their expenditure on data collection and analysis, research including policy research, publication of data analysis and research and the costs involved in the regulatory functions, through grants. All other costs including the staff costs, costs of water management if

undertaken, cost of assessing and supporting developmental schemes, etc, need not be covered under the grants.

12. **Larger Incentives to Reforming States:** The incentives to States and to the local Self Governments within a State need to be improved or reduced on the basis of the States capacity to carry out water sector reforms. Detailed guidelines would be necessary. However, some parameters to be consider could be as follows:
    - Is data being collected and shared with the public?
    - Is data being analysed?
    - Are water accounts based on water balances being worked out and published, state-wise, basin wise and schemewise?
    - Is a water sector performance report being prepared and published?
    - Is an external review of the performance and policies being carried out regularly?
    - What proportion of the irrigated areas is covered by the Water Users Associations? What is the rate of growth?
    - What is the proportion of revenue collection from water to the total O&M expenditure on existing irrigation? How much is the change in last 5 years?
    - Has a water regulator been set up? Is it functioning? Have the regulators findings been implemented?
    - What are the trends in the percentage areas under basin, furrow, border, sprinkler and drip irrigation?
    - Have legal water rights of users been created?

13. **Subsidized Agricultural use of Energy for Pumping:** We have already discussed this issue in Chapter 3, under “Ground Water Management” Our recommendations are given there. In short, subsidies, at a reduced level, would have to continue fir some time. The energy use at peak time need not be allowed in view of the subsidies, and subsidies could be larger if pumping is done at night. The other recommendation is that, as far as possible, separate circuits for agricultural pumping, and for other household rural use may be constructed so that other activities can continue even when the pumping is stopped during peak hours, or otherwise. This has been done in Gujarat.

14. **Subsidising Surface Irrigation through low Water Charges:** This appears inevitable at the present, but serious attempts need to be made to reduce the disparity. A water price of about Rs 1 per cubic meter (2008 price level) needs to be targeted by the States, and achieved, in a phased manner in, say, 5 years. This can be an important parameter in recognizing “Reforming States”,

in water sector.(Also, see our discussions in Chapter 5, about “The role of the Government in regulating water sector”)

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Report of Sub-Committee

on

Surface Water Management

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Contents

Abbreviations and Common terms

Abbreviation	*Full form*
B/C	Benefit/Cost
CBIP	Central Board of Irrigation and Power
CCRS	Center for Climate Research Studies
CFC	Chlorofluorocarbon
CGWB	Central Ground Water Board, Faridabad
CH_4	Methane
CO_2	Carbon dioxide
CPT	Kolkata Port Trust
CWC	Central Water Commission, New Delhi
CW&PC	Central Water and Power Commission, New Delhi
CWPRS	Central Water and Power Research Station, Pune
DDP	Drought Development Programme
DoOD	Department of Ocean Development
DPAP	Drought Prone Area Programme
DST	Department of Science and Technology
EAP	Employment Assurance Programme
EFR	Environmental Flow Requirement
EIA	Environment Impact Assessment
FAO	Food and Agriculture Organisation
GBM	Ganga-Brahmaputra-Meghna Basin
GCM	General Circulation Model/ Global Climatic Model
GFCC	Ganga Flood Control Commission, Patna
GFDL	Geo-physical Fluid Dynamic Laboratory
GHG	Green House Gases
GISS	Goddard Institute for Space Studies
GLOF	Glacial Lake Outburst Flood
GoI	Government of India
GPS	Geographical Positioning System
GSI	Geological Survey of India
hm^3 (MCM)	Hectometer (Million Cubic Metre) (10^6 Cubic Metre)
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research
ICID	International Commission on Irrigation and Drainage
ICIMOD	International Centre for Integrated Mountain Development
IIT	Indian Institute of Technology
IITM	Indian Institute of Tropical Meteorology, Pune
IMD	India Meteorological Department, New Delhi
INCID	International National Committee on Irrigation and Drainage
IPCC	Intergovernmental Panel on Climate Change
IWMI	International Water Management Institute
IWRS	Indian Water Resources Society
JGSY	Jawahar Gram Samridhi Yojana
km	Kilometre
km^3 (BCM)	Cubic Kilometre (Billion Cubic Metre) (10^9 Cubic Metre)
m	Metre
Mha	Million Hectare
mm	Millimetre
MoAC	Ministry of Agriculture and Cooperation
MoEF	Ministry of Environment and Forests
MoWR	Ministry of Water Resources
NCAER	National Council of Applied Economic Research

Abbreviation	*Full form*
NCIWRD	National Commission on Integrated Water Resources Development
NGO	Non-Governmental Organisation
NIES	National Institute of Environmental Studies, Japan
NIH	National Institute of Hydrology, Roorkee
NO_2	Nitrogen Oxide
NWA	National Water Academy, Pune
NWDA	National Water Development Agency, New Delhi
NWP	National Water Policy
O_3	Ozone
PIM	Participatory Irrigation Management
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
RBA	Rashtriya Barh Ayog
RCM	Regional Climatic Model
R&R	Resettlement and Rehabilitation
SPF	Standard Project Flood
SPS	Standard Project Storm
SWAT	Soil and Water Assessment Tool
UKMO	United Kingdom Meteorological Office
UNFCCC	United Nations Framework Convention on Climate Change
WALMI	Water and Land Management Institute
WMO	World Meteorological Organization

1 BACKGROUND

1.1 Introduction to India's Water Resources

The main Water Resources of India consists of the precipitation on the Indian territory which is estimated to be around 4000 km^3/year, and trans-boundary flows which it receives in its rivers and aquifers from the upper riparian countries.

Out of the total precipitation, including snowfall, the availability from surface water and replenishable groundwater is estimated as 1869 km^3. Due to various constraints of topography, uneven distribution of resource over space and time, it has been estimated that only about 1123 km^3 including 690 km^3 from surface water and 433 km^3 from groundwater resources can be put to beneficial use. Table – 1 shows the water resources of the country at a glance. Precipitation over a large part of India is concentrated in the monsoon season during June to September/October. Precipitation varies from 100 mm in the western parts of Rajasthan to over 11000 mm at Cherrapunji in Meghalaya.

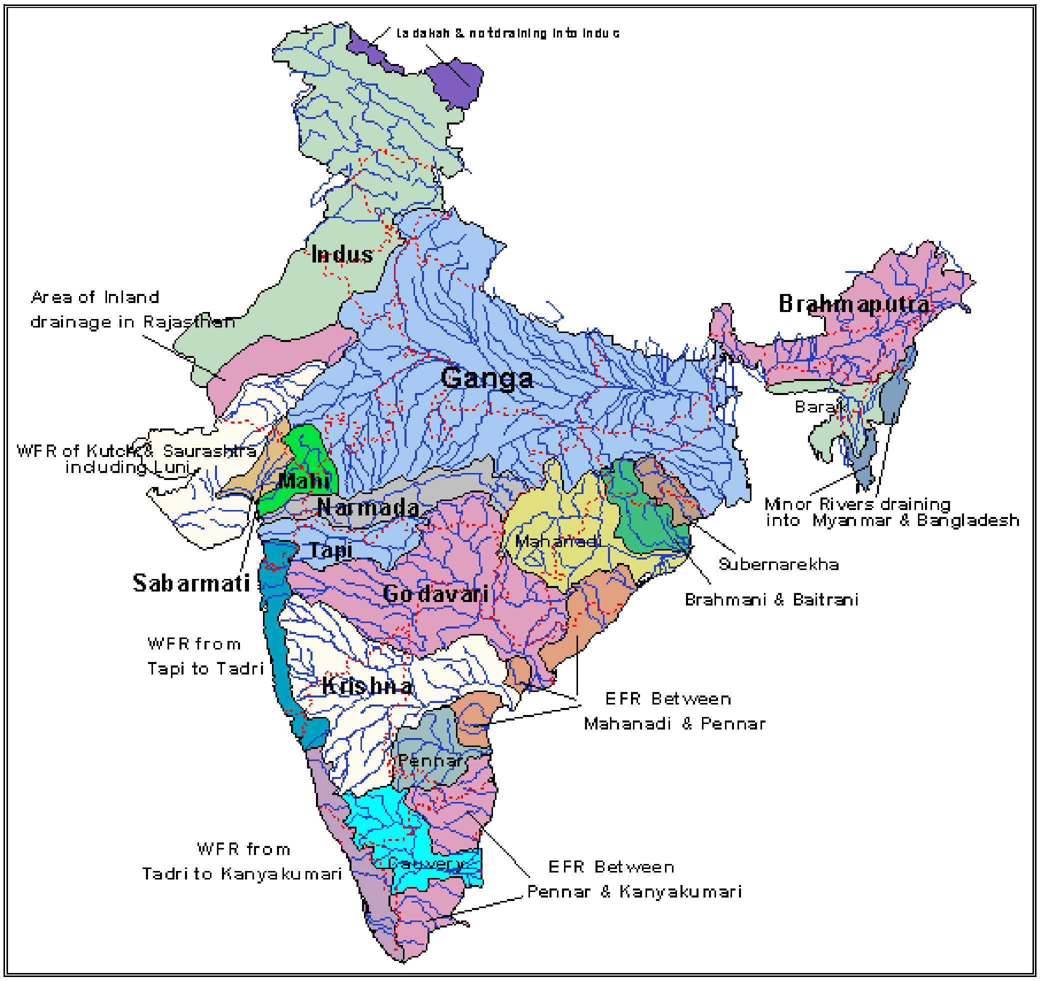
Table - 1 Water resources of India

Estimated annual precipitation (including snowfall)	4000 km^3
Run-off received from upper riparian countries (Say)	500 km^3
Average annual natural flow in rivers and aquifers.	1869 km^3
Estimated utilisable water	1123 km^3
(i) Surface	690 km^3
(ii) Ground	433 km^3
Water demand ≈ utilization (for year 2000)	634 km^3
(i) Domestic	42 km^3
(ii) Irrigation	541 km^3
(iii) Industry, energy & others	51 km^3

Extreme conditions exist in the country – there are both floods and droughts. Due to excess rainwater, floods occur in certain parts. It has been estimated by RBA that 40 Mha of area is flood-prone and this constitute 12% of total geographical area of the country. Droughts are also experienced due to deficient rainfall. It has been found that 51 Mha area is drought prone and this constitute 16% of total geographical area.

The population of the country has increased from 361 million in 1951 to 1130 million in July 2007. Accordingly, the per capita availability of water for the country as a whole has decreased from 5177 m^3/year in 1951 to 1654 m^3/year in 2007. Due to spatial variation of rainfall and consequent variation in runoff, the per capita water availability also varies from basin to basin. The distribution of water resources potential in the country shows that the average per capita water availability in Brahmaputra & Barak basin was about 14057 m^3/year whereas it was 308 m^3/year in Sabarmati basin in year 2000.

A map of the river basins of India is shown below:



The details of water resources potential of these river basins are given in Table - 2 below:

Table - 2 Water resources of Major river basins of the country

River Basin	*Catchment area *(km²)*	*Average annual potential (km³)*	*Utilisable surface water resources (km³)*
Indus	321289 (1165500)	73.31	46.00
Ganga	861452 (1186000)	525.02	250.00
Brahmaputra Barak and others	194413 (580000) + 41723	585.60	24.00
Godavari	312812	110.54	76.30
Krishna	258948	78.12	58.00
Cauvery	81155	21.36	19.00
Subernarekha	29196	12.37	6.81
Brahmani & Baitarni	51822	28.48	18.30
Mahanadi	141589	66.88	49.99
Pennar	55213	6.32	6.86

River Basin	*Catchment area *(km^2)*	*Average annual potential (km^3)*	*Utilisable surface water resources (km^3)*
Mahi	34842	11.02	3.10
Sabarmati	21674	3.81	1.93
Narmada	98796	45.64	34.50
Tapi	65145	14.88	14.50
WFR from Tapi to Tadri	55940	87.41	11.94
WFR from Tadri to Kanyakumari	56177	113.53	24.27
EFR between Mahanadi & Pennar	86643	22.52	13.11
EFR between Pennar & Kanyakumari	100139	16.46	16.73
WFR of Kutch & Saurashtra including Luni	321851	15.10	14.98
Area of Inland drainage in Rajasthan	-	Negligible	Not applicable
Minor Rivers draining into Myanmar & Bangladesh	36202	31.00	Not applicable
Total		**1869.35**	**690.31**

*Figures in parenthesis represent the total catchment areas including areas outside India.

India has a long history of water development. However, large scale water development started in the 19th century. Initially, a large number of "run off the river" type of diversion projects for irrigation got built at the foot hills of the Himalayas as also at the deltas of the peninsular rivers. However, later, the emphasis shifted to storage development, from 1940 onward. After the electric energy became available in the rural areas, i.e. after about 1975, a very large ground water based development took place.

By now, as per the published statistics of the CWC, a live storage of around 220 km^3 has been built in the various places. However, this information does not include the small (minor and small medium) storages. Currently, around 17 Mha are being irrigated from surface minor projects, and for achieving this, a live storage of about 60 km^3 would have been constructed through lakhs of such dams. Thus, the current live storage available in surface reservoirs in India would be around 280 km^3. In addition, around 60 km^3 of storage is under construction through the larger projects. However, this storage appears insufficient for meeting all the future demands.

Although the large scale ground water use in India is a unique feature, not noticed in most other countries, the groundwater development in some areas, is already leading to over-exploitation of the available ground water and consequently to falling trend in the ground water levels.

The main Water Resources of India consists of the precipitation on the Indian territory which is estimate to be around 4000 km^3/year, and trans-boundary flows which it receives in its rivers and aquifers from the upper riparian countries. For the latter, no ready quantitative estimates are available. However, estimates as projected by FAO are available. FAO estimate for China's total contribution is 347 km^3.This appears too large. After correcting this, the following estimate appears reasonable:

Table – 3 A preliminary estimate of average annual trans-boundary receipts

Country of origin	*Assumed receipt in India (km^3)*			
	Indus	*GBM*		*Total*
		Ganga	*Brahmaputra & Meghana*	
China	70	12	113	195
Nepal	0	210	0	210
Bhutan	0	0	95	95
Total	**70**	**222**	**208**	**500**

This preliminary estimate is merely for bringing out the role of trans-boundary flows in the water balance of India. It does not represent an officially accepted estimate.

It needs to be stressed that any Climate Change may alter both the precipitation received on the Indian territory as also the hydrology of the catchments in the upper riparian countries. Thus, the Climate Change in these countries, and the larger utilizations in these countries (including the additional demand driven by Climate Change) would alter the Indian Water situation.

1.2 Introduction to Climate – Climate Change & Anthropogenic Climate Change

Climate in a narrow sense is defined as "average weather", or more rigorously, as the statistical description in terms of mean and variability of relevant quantities of weather parameters over a period of time ranging from months to thousands or millions of years. The classical period is 30 years, as defined by WMO. These parameters are most often surface variables such as temperature, precipitation and wind. Climate change in IPCC usage refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that of UNFCCC which defines climate change as, "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods".

The earth's atmosphere - the layer of air that surrounds the earth - contains many gases. Short-wave radiation from the sun passes through the earth's atmosphere. Partly this radiation is reflected back into space, absorbed by the atmosphere and remainder reaches the earth's surface, where it is either reflected or absorbed. In turn the earth's surface, emits long-wave radiation toward space. The Green Houses Gases available in the atmosphere, which principally include CO_2, NO_2, CH_4, CFCs and O_3, absorb some of this long-wave radiation emitted by the Earth's surface and re-radiate it back to the surface. Thus GHG modify the heat balance of the Earth by retaining long-wave radiation that would otherwise be dispersed through the Earth's atmosphere to space. This effect is known as the greenhouse effect. Evidently, GHG have an important role in controlling the temperature of the earth and an increase in their concentration in the atmosphere would increase the temperature of the Earth. In addition, presence of excess quantities of CFCs affects the protective ozone layer which deflects the harmful short wave rays. The IPCC observed that global average air temperature near earth's surface rose to 0.74 ± 0.18^0 C in the last century.

1.3 A Short Status of Knowledge about Climate Change

Studies have been carried out by NIH to analyze the trends of variation in temperature over India/Indian Sub-continent and the results have been compared with global trend. An analysis of temperature data of 125 stations distributed all over India shows an increase of 0.42^0 C, 0.92^0 C and 0.09^0 C in annual mean temperature, mean maximum temperature and mean minimum temperature respectively over the last 100 years. However, the trends are varying on regional basis. It has been observed that the changes in temperature in India/Indian-Subcontinent over last century are broadly consistent with global trend of increase in temperature.

Scenarios of future climate change are usually developed using the GCMs with different scenarios of GHG emissions. GCMs are complex 3-dimensional models of the land, atmosphere and oceans. GCMs are invaluable tools for identifying climatic sensitivities and changes in global climate characteristics whereas the major problem of the current generation of GCMs is the limitation of their spatial resolution. A single grid of GCM may encompass hundreds of square kilometers and include mountainous and desert terrain, oceans and land areas. Usually, the output of GCMs is given for a scale much larger than that of even a large watershed. There are more than 200 GCMs available which have been developed by different agencies. Input data requirement for these GCMs are generally same but the output results vary and sometimes with slight variation in input parameters (which may be due to different data collection agencies) the results are contradictory giving confusing future climate scenarios. Despite recent improvements in modeling of the climate dynamics with complex and large-scale models, use of GCMs is still limited to evaluating regional details of climatic changes. For generating future climate scenarios on regional basis there are downscaling models called RCMs which use output of GCMs. However, RCMs do not give basin level scenarios.

1.4 Predictive Findings of Scientists about Likely Climate Change in India

Studies related to the impacts of climate change on various components of the hydrological cycle may be classified broadly into two categories: (i) studies using GCM/RCMs directly to predict impact of climate change scenarios (ii) studies using hydrological models with assumed plausible hypothetical climatic inputs.

IITM is active in studying long-term climate change from observed and proxy data as well as model diagnostics and assessment of climatic impacts, with a particular focus on the Indian summer monsoon. IITM used the Hadley Centre RCMs for the Indian subcontinent to model the potential impacts of climate change.

The RCMs have shown significant improvements over the global models in depicting the surface climate over the Indian region, enabling the development of climate change scenarios with substantially more regional detail. High-resolution climate change scenarios have been generated for different states of India. Some of the major findings concerning water resources are:

- The rainfall scenarios are dependent on climate scenarios.
- There are substantial spatial differences in the projected rain fall changes. The maximum expected increase in rainfall (10 to 30%) is for central India.
- There is no clear evidence of any substantial change in the year-to-year variability of rainfall over the next century.
- Surface air temperature shows comparable increasing trends by as much as 3 to 4° C towards the end of the 21^{st} century.
- The warming is widespread over the country, and relatively more pronounced over northern parts of India.

1.5 Findings of Scientists "if – then type”

The scientists of NIH have a made a literature survey to examine the findings of the various important studies in regards to climate Change and its likely effect on Water Resources of India. The results of these survey are extracted below:

Table – 4 Predictions about Hydrological Changes over India

Author	*GCM Used*	*Scenario in Brief*	*Effect on Rainfall*				*Effect on PET*				
			North India	*South India*	*North West*	*East and North east*	*North India*	*South India*	*North West*	*East & North east*	*Remarks*
Gosain A K and Sandhya Rao, 2003	Hadley Centre Regional Model – 2	Severity of extreme events such as floods and droughts in different parts of India increased.									Study area is India.
K Rupa Kumar, A K Sahai et al. 2006.	PRECIS.	A general increase in precipitation and temperature, for the country as a whole.	Slight decrease in Punjab, Rajasthan.	Slight decrease in Tamilnadu.		Maximum increase.					
Hassel and Jones 1999.	RCM.	A maximum anomaly of 5^0C seen in Central and Northern India during the GCM simulation was reduced and shifted to the North-West in the nested							Excessive drying of the soil.		

Author	*GCM Used*	*Scenario in Brief*	*Effect on Rainfall*				*Effect on PET*				
			North India	*South India*	*North West*	*East and North east*	*North India*	*South India*	*North West*	*East & North east*	*Remarks*
		RCM, with a secondary maximum appearing to the south east.									
IPCC 1990.	High resolution GCM.	The model simulated an increase in total seasonal precipitation.									By 2030 warming varies 1-2^{0}C throughout the year, precipitation generally increases throughout the region by 5-15% in summer and little in winter, summer soil moisture increases by 5-10%.
Lal et al. 1992.	Hamburg global coupled atmosphere-ocean circulation model.	Examined the possible climate change over northwest area (Thar desert).									
Lal and chander. 1993b.	ECHAM3 T-42.	Annual mean area averaged surface warming should range				More rainfall in North-east in enhanced					

Author	*GCM Used*	*Scenario in Brief*	*Effect on Rainfall*				*Effect on PET*				
			North India	*South India*	*North West*	*East and North east*	*North India*	*South India*	*North West*	*East & North east*	*Remarks*
		between 3.5 to 5.5oC over the region by 2080.				global temperature conditions.					
Lal and Bhaskaran 1993a.	ECHAM3 T-42.				No significant change in rainfall over the next 100 years.				Enhancement in evaporation rate.		Decrease in rainfall between 5-25% in winter whereas 10-15% increase in area averaged monsoon rainfall over the Indian subcontinent. The date of onset of summer monsoon over central India could become more variable in near future. More extreme rainfall events are projected.
Murari Lal et al. (Dinar *et al.*, 1998).	CCSR/NIES coupled A-O GCM. UKMO. GISS, GCM.	UKMO, GCM predicts a temperature increase of 16.2% for India, the GISS, GCM predicts an									Each of these three models predicts an increase in precipitation with a doubling of CO_2 levels from pre-industrial levels, but they predict

Author	*GCM Used*	*Scenario in Brief*	*Effect on Rainfall*				*Effect on PET*				
			North India	*South India*	*North West*	*East and North east*	*North India*	*South India*	*North West*	*East & North east*	*Remarks*
		increase of 10%, and the GFDL, GCM predicts an increase of 23.5%. Some recent studies, however, have indicated that the GCMs temperature predictions are too high (Dinar *et al.*, 1998).									differing magnitudes of increase at different times of the year (Dinar *et al.*, 1998).

Although the findings of each study are different the general consensus in these studies seems to be as follows:

- Temperatures may increase throughout India and particularly in Northwest and Southeast;
- As a consequence there may be an increase in potential evapo-transpiration;
- As a further consequence, there may be more glacial melt for some years, recession of glaciers and less melt later on;
- Summer monsoon precipitation may increase throughout, but this would be more marked in the Northeast;
- There may not be any increase or there may be a decrease in winter precipitation;
- Rainfall variability may increase;
- The date of onset of summer monsoon may become more variable;
- More extreme rainfall events are projected.
- Some further relevant information is in section 2.1 of this report.

1.6 The Purpose and Scope of the Report

The Prime Minister has unveiled the National Action Plan for Climate Change on 30-06-08 wherein eight missions including National Water Mission were launched. This Report is formed for the Sub-committee of surface Water Management as established by the High Level Steering Committee of the National Water Mission headed by Secretary (Water Resources).

The Report does not take any position about the causes and certainty of the Climate Change. However, the possible range of effects on Water Sector is culled out from other expert opinions. On this basis, the possible mitigative measures and the new strategies required for such mitigative measures are outlined. The possible changes in the acceptability criteria and the methodologies for planning different types of water projects are suggested. Programmes to mitigate effects of Climate Change are spelt out. These include data collection programmes, programmes for improving modelling and analytic capacities and programmes for eventual implementation. Researchable issues in water sector relating to Climate Change have been brought out. On this basis, some modifications in the NWP are suggested.

2 THE CURRENT SITUATION

2.1 Analysis of Present and Future Situation

2.1.1 The hydrologic regime

The precipitation is one of the important constituents of climate. Similarly, the presence of the water vapors in the climate, which depends upon the feed of the moisture from evaporation, both from the seas and the land, and the movement of this moist water, its condensation and the precipitation are part of the climatic process. The regime of the water in the hydrologic cycle, thus heavily depends on the climatic factors.

Another important factor which governs the hydrologic regime is the terrain, the geologic and soil related factors. These also, over the geologic time scale, are shaped by the climate; but, for the present purpose, we can ignore this connection.

The water regime also depends on the vegetation on the surface of the earth. Here the effects of climatic change could be two folds. Firstly the evapo-transpiration and the growth of the vegetation itself may change due to changes in the precipitation as also due to changes in the evaporation. Secondly over a longer time period, the type of vegetation which would grow naturally in a part of the earth itself may change either through an adaptive process or through destruction and conquest by other species.

2.1.2 Effects of climate change on water regime

The IPCC Report "Climate Changes and Water" edited by BATES EL (June 2008) deals with the observed and projected changes in climate as they relate to water. The table 3.1 "Observed changes in the run-off/stream flow, lake level and floods/droughts" (WGII Table 1.3) is reproduced below for reference.

Table 3.1: Observed changes in runoff/streamflow, lake levels and floods/droughts. [WGII Table 1.3]

Environmental factor	Observed changes	Time period	Location
Runoff/streamflow	Annual increase of 5%, winter increase of 25–90%, increase in winter base flow due to increased melt and thawing permafrost	1935–1999	Arctic Drainage Basin: Ob, Lena, Yenisey, Mackenzie
	1–2 week earlier peak streamflow due to earlier warming-driven snowmelt	1936–2000	Western North America, New England, Canada, northern Eurasia
Floods	Increasing catastrophic floods of frequency (0.5–1%) due to earlier break-up of river ice and heavy rain	Recent years	Russian Arctic rivers
Droughts	29% decrease in annual maximum daily streamflow due to temperature rise and increased evaporation with no change in precipitation	1847–1996	Southern Canada
	Due to dry and unusually warm summers related to warming of western tropical Pacific and Indian Oceans in recent years	1998–2004	Western USA
Water temperature	0.1–1.5°C increase in lakes	40 years	Europe, North America, Asia (100 stations)
	0.2–0.7°C increase (deep water) in lakes	100 years	East Africa (6 stations)
Water chemistry	Decreased nutrients from increased stratification or longer growing period in lakes and rivers	100 years	North America, Europe, Eastern Europe, East Africa (8 stations)
	Increased catchment weathering or internal processing in lakes and rivers	10–20 years	North America, Europe (88 stations)

Thus, observed changes are mostly based on data outside India and South-Asia except for temperature data. However, it indicates that the other parameters related to hydrology are likely to change and one can infer that some changes may also be expected in India. Specific India based studies have been mentioned late on.

Table 3.2 of the IPCC Report deals with the possible impacts of climate change without taking into consideration the adoptive capacity. This entire table is also reproduced below:

Table 3.2: *Examples of possible impacts of climate change due to changes in extreme precipitation-related weather and climate events, based on projections to the mid- to late 21st century. These do not take into account any changes or developments in adaptive capacity. The likelihood estimates in column 2 relate to the phenomena listed in column 1. The direction of trend and likelihood of phenomena are for IPCC SRES projections of climate change. [WGI Table SPM-2; WGII Table SPM-2]*

Phenomenon[a] and direction of trend	Likelihood of future trends based on projections for 21st century using SRES scenarios	Examples of major projected impacts by sector			
		Agriculture, forestry and ecosystems [4.4, 5.4]	Water resources [3.4]	Human health [8.2]	Industry, settlements and society [7.4]
Heavy precipitation events: frequency increases over most areas	Very likely	Damage to crops; soil erosion; inability to cultivate land due to waterlogging of soils	Adverse effects on quality of surface and groundwater; contamination of water supply; water scarcity may be relieved	Increased risk of deaths, injuries and infectious, respiratory and skin diseases	Disruption of settlements, commerce, transport and societies due to flooding; pressures on urban and rural infrastructures; loss of property
Area affected by drought increases	Likely	Land degradation, lower yields/crop damage and failure; increased livestock deaths; increased risk of wildfire	More widespread water stress	Increased risk of food and water shortage; increased risk of malnutrition; increased risk of water- and food-borne diseases	Water shortages for settlements, industry and societies; reduced hydropower generation potentials; potential for population migration
Intense tropical cyclone activity increases	Likely	Damage to crops; windthrow (uprooting) of trees; damage to coral reefs	Power outages causing disruption of public water supply	Increased risk of deaths, injuries, water- and food-borne diseases; post-traumatic stress disorders	Disruption by flood and high winds; withdrawal of risk coverage in vulnerable areas by private insurers, potential for population migrations; loss of property

[a] See Working Group I Fourth Assessment Table 3.7 for further details regarding definitions.

2.1.3 Adaptation to climate change

Adaptation to climate change can occur in two ways - one would be the natural adaptation in the earth's biosphere. In general there is not much information about the likely natural adaptation, which can take place in these ways. The human induced adoption are again classified by the IPCC technical paper on Climate Change and Water as "autonomous adaptations" which are adaptive measures, which the users would automatically resort to meet the change in demands and supply side; whereas the planned adaptations are the result of deliberate policy decisions. Table 3.4 of the Report describes some possible adaptive measures on both supply side and demand side and this is reproduced below:

Table 3.4: Some adaptation options for water supply and demand (the list is not exhaustive). [WGII Table 3.5]

Supply-side	Demand-side
Prospecting and extraction of groundwater	Improvement of water-use efficiency by recycling water
Increasing storage capacity by building reservoirs and dams	Reduction in water demand for irrigation by changing the cropping calendar, crop mix, irrigation method, and area planted
Desalination of sea water	Reduction in water demand for irrigation by importing agricultural products, i.e., virtual water
Expansion of rain-water storage	Promotion of indigenous practices for sustainable water use
Removal of invasive non-native vegetation from riparian areas	Expanded use of water markets to reallocate water to highly valued uses
Water transfer	Expanded use of economic incentives including metering and pricing to encourage water conservation

Adaptations can reduce the vulnerability of the society particularly to the changed situation in the short term. However, the adaptation capacity of the society depends on the economic development, and this capacity would also be different for different layers of the society. The poor, elderly, female, sick indigenous population may, in general, have less adaptive capacity.

Table 3.5 of the Report indicates some examples of adaptation in practice in different regions of the world. Extracts of this Table pertaining to Asia are presented below:

Table 3.5: Some examples of adaptation in practice.

Region	Adaptation measure	Source
Asia	Improvement to agricultural infrastructure including: • pasture water supply • irrigation systems and their efficiency • use/storage of rain and snow water • information exchange system on new technologies at national as well as regional and international levels • access by herders, fishers and farmers to timely weather forecasts (rainfall and temperature)	WGII 10.5, Table 10.8
	• Recycling and reuse of municipal wastewater e.g., Singapore • Reduction of water wastage and leakage and use of market-oriented approaches to reduce wasteful water use	WGII 10.5.2

2.2 The Importance of Climate Change to Indian Water Sector

2.2.1 The characteristics of Indian water situation

India, on the whole, is not well off in water resources. The country has 16% of the world's population, accommodated in 2.45% of the worlds land area. The total water resources available to India have been estimated to be around 2,000 km^3 and this is about 4% of the world's resources. This resource of about 2,000 km^3 includes some 500 km^3 which India receives from the upper riparian nations after their use. The other main issues which one needs to consider while projecting India's unique water situation include (A) Unlike most developed countries; the Indian population is still growing and except in a few southern states, there are not even preliminary indications of attaining stability of population, (B) India has, as compared to other countries of the world, a disproportionally large part of its land area under cultivation. With growing urbanization, driven by the economic forces, and also by population growth, the land not available for agricultural is increasing continuously. Thus, there is hardly any scope of increasing the area under cultivation. Both the food demands and the domestic and industrial demands of water are to be made within the severe constrains of water and land available, and without endangering the environmental water requirements. Also, (C) for most parts the climate is comparatively hot and the evapo-transpiration from land, whether from forest and wet lands or from lands use for food production, is considerable. Any change in the evapo-transpiration regime would directly affect the water demands in a larger way; and (D) a very large use of ground water, for irrigated agriculture, takes place in India.

2.2.2 Water and climate change: Indian concerns

In this background, the main water related concern of India could be listed as follows:

***The likely changes in the snow and glacial regime in the Himalayas*:** The effects would be both in terms of averages, as also in terms of intra annual distribution on the flows available. It is likely that due to the recession of the glaciers, the large and natural carry over availability, (which converts the more variable snow fall in the glacial catchments into a more stable melt of the glacial ice, through a slow process) may change. Thus the inter-annual variability of flows from the glacial area may increase considerably. Similarly, the reduction in the total mass of the stored water would result in smaller water available during spring and summer from the glacial storages. Another concern in this region is about the extent of snowfall and its melt. The snowfall in Himalayas occurs mainly through western disturbances which carry the moisture from the Mediterranean and Caspian Seas. Even though precipitation in the Indian summer monsoon may not reduce much, the precipitation through the western disturbances may show a reduction. Another concern of this area is in regard to timing of the seasonal snows. Currently, the seasonal snows melt from February up to August or September and the snow cover areas are at minimum around October end. However with increased temperature it is likely that the snowmelt in the spring season may increase and that in summer may decrease correspondingly. The increased spring snow melt would, in general, be a welcome feature since it might give considerable relief to the lower areas and the water resources projects by reducing the storage requirements and by increasing the run-off of the river potential of the diversion type hydraulic projects.

***In the alluvium of the Indo Gangetic plains*,** the main concern would be about increased evapo-transpiration demands which may further cause a large water stress in spite of some increase in the monsoon precipitation. The other concerns would be about the increased frequency of the disastrous droughts and flood. While the effects of the floods are comparably local, in that it mainly effects the population staying near the banks of the larger rivers, the effect of droughts are far more wide spread. The larger frequencies of droughts would mainly affect the western parts of the alluvial floods plains while the central and eastern part would be more affected by the increases in the flood frequency.

The erosion and shifting of alluvial rivers is again a serious concern. Whereas flood causes severe loss of income and related problems in the flood affected parts for a comparatively short duration of one or a few years, river erosion and shifting of rivers can cause problems, the effect of which will continue over a long span of years.

For the Indo-Gangatic alluvium, any change in ground water regime would cause a large concern. The ground water of the area is sustained mainly through the infiltration from rainfall in the monsoons as also from the significant infiltration which occurs in the Bhabbar belt i.e. boulder regions of the Himalayan foothills. The rivers, as they emerge into the plains and shed the boulders and the coarse sediments, causing this ground water recharge belts. If the precipitation regime changes, and if the number of rainy days show a reduction even without reduction in the annual precipitation, the ground water recharge is likely to be effected. In these plains, the ground water use is very considerable and in many places an unplanned conjunctive use between the surface and ground water has developed. Any reduction in the overall ground water would, on one hand, increase the pressure on surface water while on the other, reduces the base flow from ground water to the rivers in the spring and summer. This would severally affect the river ecology also. The reduction in the ground water level would affect the number of trees which dot much of the plains' landscape under cultivation of annual and seasonal crops. Reduction in such privately owned trees would affect both availability of the trees to the farmers as also the ecology of the area.

In the peninsular part of India, the main concern of India would be in regard to changes in variability of water yields, and the changes in the evapo-transpiration demands in agriculture. In the peninsular part of India much of the water use is based on water stored in the surface reservoirs since the low flows availability in the rivers are small. The ground water use is also large, particularly in the basaltic terrains where cracks in the rock and inter trapped beds increase the infiltration, and the water holding capacities. However, the ground water in these areas dissipates fast and not much base flow would normally be available beyond the spring season. Any increase in the inter-annual variability of rain would reduce the safe yield of the surface reservoirs since the dependable monsoon flow would reduce even if the overall flow has not reduced. Already there is a considerable water stress in many of the peninsular basins and this situation would worsen, both because of fast increasing demands and because of a changed precipitation regime.

Thus in short the Indian concern could be abstracted as follows:

Table – 5a Region-wise concerns with respect to Water Resources due to Climate Change in India

Regions of India	*Concerns related to*				
	Snow & Glacier	*Larger variability of Flows*	*Frequency of Extreme Events*	*Ground Water Regime Changes*	*Changes in Potential Evapo-transpiration*
Himalayas	Very Important	Important	Very Important	-	-
North & North West alluvial plains	Very Important	Very Important		Important	Very Important
Central &	-	Important	Very	Important	-

Regions of India	*Concerns related to*				
	Snow & Glacier	*Larger variability of Flows*	*Frequency of Extreme Events*	*Ground Water Regime Changes*	*Changes in Potential Evapo-transpiration*
Eastern Plains			Important		
Western Peninsular India	-	Very Important	Very Important	Very Important	Very Important
Eastern Peninsular India	-	Important	Very Important	Important	Important

The concerns can also be expressed in another way, for different water planning problem, by different regions. This is shown as below:

Table – 5b Region-wise concerns with respect to Water Resources due to Climate Change in India

Regions of India	*Water availability and reliability of out-puts*	*Safety against floods and river erosion*	*Safety against droughts*	*Sustainability against sedimentation*	*Adjustments to rise of sea level*
Himalayas	-	Very Important	Important	Very Important	
North & North West alluvial plains	Very Important	Very Important	Very Important		
Central & Eastern Plains	Important	Very Important	Important	Very Important	Very Important
Western Peninsular India	Very Important	Important	Very Important	Very Important	Very Important
Eastern Peninsular India	Important	Very Important	Important	Important	Very Important

2.3 Need for Reassessment of Water Resources

2.3.1 Background

Assessment of the water resources is the first step in understanding the state of water resources. This state is essential for all water resource related activities such as efficient management of the resources, planning of the water resource for future use, re-adjustment of water use plans considering the changed supplies and demands etc.

Water assessment consists of (i) a hydrologic study to establish the likely natural water availability of the basin/region/area; (ii) an engineering study to decide what water developments and what changes in the management practices are likely to take place in future, after considering the hydrologic and engineering possibilities and the socio-economic desirability, (iii) an assessment of the resultant flows that would continue to be available in future, after the planned uses and management changes; and (iv) deciding on the acceptability of the resultant flows from the environmental and cultural aspects, and changing the water use plans to obtain an acceptable situation.

The first assessment of the natural flows available in India was made by first Irrigation Commission (1901-03). After Independence, this was revised by Dr. A.N. Khosla, the then Chairman of CW&PC by broadly using the water balance principle in year 1949. Many subsequent revisions have already been made, the NCIWRD (1999) did not make any fresh assessment but slightly modified the current CWC assessment. At present, the natural water resource of India is estimated at around 1869 km^3, and out of this 690 km^3 is considered useable from surface waters and another 433 km^3 is considered useable from the ground waters.

2.3.2 Deficiencies

The main deficiency of the current assessment is that it ignores the principle of the unified nature of the water resources and tends to treat the surface and the ground waters as two separate resources. The links between the precipitation, evaporation and run-off are not explicitly modeled and used in the assessment. Similarly the important inter-actions between the surface waters and the ground waters, through artificial recharge from irrigated areas and possible recharge from river beds on one hand, and the contribution of the groundwater to the surface source through base flows on the other hand are somewhat ignored. After these limitations came into prominence in the late 1980, CWC partially corrected its procedures so that the historical utilizations through ground water sources are also considered in the computations of the ‘natural' flows from the ‘observed’ flows. Similarly, CWC took a stand that the assessments of natural flows for the country/basin/region, as worked out by correcting the observed flows for anthropogenic changes and utilizations, both from surface and ground waters, represent the total water potential and not the potential of the surface water alone. The NCIWRD has also upheld this stand in its report. The CGWB also now assesses the ground water potential of districts/basins etc. separately as that derived from the natural infiltration from the rainfall and from the artificial irrigation induced recharge. However, the methodologies used are still based on separate assessments and later correlating these to the extent possible.

The NCIWRD had already noticed that for some basins, the water assessment, as made by these processes apparently indicate large anomalies. For example, (see table 7.3 (b) of NCIWRD Report) for the Cauvery basin, the natural water resource is assessed at 21.36 km^3 for an average year. However, the useable resource (utilizable surface water and 2/3 replenishable ground water) is assessed at 27.20 km^3, even after accounting for an export of 1.3 km^3. This does not appear possible. Such anomalies are also observed for other basins such as Krishna, Pennar and Vaigai. After considering this situation, the NCIWRD had recommended reassessment of the water resources to be done by the CWC. This has perhaps not been done.

2.3.3 Notes regarding reassessment

This re-assessment, based on the complete modeling of the hydrologic cycle in the land phase is very important on its own. Such a re-assessment has to be done by setting up a hydraulic model for the whole basin. The inputs would consist of the historical series of rainfall and potential evapo-transpiration values. The changing land use and the agricultural use would have to be modeled to assess the actual evaporation from each land use. Hydrologically, the forests, the grass lands, the barren lands, agricultural lands and irrigated lands would behave somewhat differently in regard to their root zone water holding capacities, potential evapo- transpirational requirements etc., and have to be modeled separately. Even under the agricultural use, the hydrologic behavior of paddies and other ponded crops would be different from the dry crops, and this has to be modeled. Where irrigation is provided, the additional evaporation required for meeting the crop water demand, and its conversion into river and ground water withdrawals, leakages, seepages and return flows to surface water and ground water are necessary. In addition, all imports and exports to and from the basin under study are also to be considered in the model. The model either has to be distributed one, or is to be made as a distributed model through an assembly of a large number of lumped models.

Non - agricultural uses such as domestic and industrial uses are also to be modeled in terms of withdrawals, returns and anthropogenic evaporation. In the historical calibration mode, the model would have to be verified at various gauge and discharge sites to ensure that the model outputs more or less match with the actuals. Once the model is calibrated, new developments, changed methods of management and changed inputs can be used to see if the basin can support such changes and to judge if the resulting situation is acceptable.

2.3.4 The task

Such a scientific assessment of the water situation is not easy and has to be taken up as a large programme. However, this is the only methodology which will help us to chalk out for the future plans, with a large level of confidence, and to ensure that the plan is both feasible and acceptable. When one considers the climate change situation, the use of such assessment tools becomes inevitable. The changes in the precipitation regime and the evapo-transpiration regime can easily be studied on such models. Land use changes, as planned, through human activities, such as additional irrigation, changing cropping patterns etc. could be incorporated in the model. If necessary other land use changes such as conversion of marginal barren lands into agricultural land because of population pressure, conversion of forest lands into agricultural lands due to de-forestation, conversion of forest lands into grass lands as nature's response to climate change etc. all can be modeled as possibilities, and the effect can be studied.

Water resources planning, development & management is a multi- disciplinary activity. There is a need for developing various scenarios at the basin/ national level keeping in view the back & forth linkages of various inter – disciplinary impacts. Such scenario development exercises are to be an essential part of the water assessments.

2.3.5 Models and tools

Methodologies and tools are already available to some extent. The NAM and MIKE – BASIN model already have some provisions for conversion of rainfall to run-off and for assembling run-off from different catchments. However this model is not a distributed one although it can be made distributed by modeling large number of catchments. The SWAT model (which incidentally was used by the IIT, Delhi Group for studying climate change over India) is a distributed model in which the land use at each pixel can be specified. It works as a hydrologic model monitoring the water balance. However, the data requirements are very large and the calibration provisions appear somewhat inadequate. The ICID, as a part of their policy support programme (CPSP), developed a simple hydrologic model which depicted the different hydrologic behavior of each land use type. This model named as the BHIWA model is a lumped one, but was made partially distributed by modeling sub-catchments and their junctions separately. Calibration/verification could be done for a time series of five years monthly data. After calibration the models were used for water assessment under different likely future scenarios based on different development and management strategies. The results of such assessments have been published for the Sabarmati and the Brahmani basins. Similarly, the IWMI worked on five basins of peninsular India to convert a monthly series of 15 years of observed flow data into a monthly time series of natural flows, by modeling the hydrological effects of all man-made changes such as surface storage filling, withdrawals for various purposes from surface and groundwater, anthropogenic evaporation and evapo-transpiration and returns to surface and ground water. The delays between the ground water recharge and the base flows due to the characteristics of the ground water reservoir were also modeled. This calibrated model was then used for assessing the future situation. The BHIWA model of ICID, models the full hydrologic cycle for each land use, and has a capability of studying changes due to changes in rainfall and potential evapo-transpiration regimes as well as land use changes, however, the calibration process requires considerable time and experience. It seems to be well suited for assessments under future climate change situations. The IWMI model is faster, can accommodate longer time series but models only the anthropogenic changes and is not a complete hydrologic model. The SWAT model can also be used and its distributed nature is a big advantage. However, some simplification and meticulous data preparation may be required. The NAM – MIKE basin model, on a GIS platform can also be useful. The NIH and CWC together can even attempt to develop a tailor made model for the Indian water assessments.

The mountainous areas, and in particular, the high altitude areas, are likely to be more sensitive to climate change. Also, in such areas, on one hand, data is sparse, and on the other hand, large variations in parameters like land cover, slope, slope direction (aspect) etc. cause adjoining areas to behave much differently. Larger modeling effort would be necessary, to depict these complexities (See 5.1.3 also.)

2.3.6 Priorities for basin water assessments

Basin-wise water assessments, to some extent, are already available. However, as discussed there are important deficiencies and there is a need for better re-assessment, including futuristic scenario development. This task is large and important and some prioritization is necessary.

In general, all closed, nearly closed or water-short basins would require an immediate re-assessment. Similarly, basins which may be surplus, but where much of the surplus is proposed to be utilized through inter-basin transfers etc. (for example basins like Godavari, Mahanadi, Brahmani, Baitarni etc.) would also require a proper scientific re-assessment at an early date so that the planning exercises can be reviewed and finalized. Basins or sub-basins which are likely to be surplus even after the proposed inter-basin transfers could be assessed slightly later; but even for such basins, assessments for the non-flood or low flow season may have to be done on larger priority. The Brahmaputra and Meghna arms of the the GBM basin or the sub-basins of Kosi, Adwara group of rivers etc. may come in this category.

3 ADOPTIVE AND MITIGATIVE MEASURES: THE NEW STRATEGIES

3.1 Introduction

As we have discussed, the supply of water, through the natural availability, is either constant or is likely to decrease because of climate change. On the other hand, the demand for water is increasing on account of both the rise in population and the changing economic conditions, leading to larger per capita demand through changing food habits, larger industrial water requirement, and larger proportion of the communities adopting piped water supply and sewerage systems. The demand would further increase on account of climate change which would increase the potential evapo-transpiration due to increased temperature.

In such a situation, both supply side and demand side management, has to be resorted to. The supply side management would require a larger supply of useable water. This would involve larger storage development, and larger reuse of returning water. The demand side management would involve more efficient use and distribution of water in such a way that a smaller proportion is “lost” and a larger proportion is “used”. Demand side management can also involve recycling of water within a water use system. In general, the supply side management, could be some what costlier, but is more likely to succeed provided, the scheme is well engineered. On the other hand, the demand side management may be combatively cheaper, but since a very large number of measures have to manage the demands, it is more time taking and more difficult to execute. It also is likely to take more time, since public awareness and change of habits is a slow process. However, both these types of management strategies are considered in this Report.

3.2 Increasing the Quantum of Usable Water

3.2.1 The background

It is normally considered that the water resources of India are around 1869 km^3, and of this, 690 km^3 can be used from surface waters and 433 km^3 can be used through ground water sources. The NCIWRD has shown how the return flows from the uses of water, contributing to both surface and ground water become additional source available for use, so that the total quantity of useable water can increase further.

When one talks about “Useable water”, it begs a question as to what constitutes the use of water. If the use is defined in terms of withdrawals, then returns are to be counted as an additional resource. In terms of scientific hydrology, only the anthropogenic evaporation, which short circuits the land phase of the natural hydrological cycle, is a use. However, from engineering viewpoint, returns to “sinks”, which cannot be used further, are also to be added to re-use. See our discussions under “Water use efficiency”.

3.2.2 The broad strategies

Under the scenario of climatic changes, there would be an increased stress on water and there would larger need for increasing the useable water. The possible strategies in this regard are listed below:

1. Water Harvesting

It needs to be understood that any measure for using water such as construction of dams, small or large, ground water structures like wells or tube wells, water harvesting structures, etc. do not create any new water resource. The natural water resource of any area depends purely on the climatic patterns, and interaction of these climate patterns with the terrain and geology. The engineering or agricultural means of intervention can merely change the possible quantum of water use.

Even in regard to water use, one needs to consider if the basin as a whole is "closed" or "Open". A basin in which all or most of the water is being used for a desirable purpose, including its non-use for maintaining the ecology, is considered as a closed basin. Some basins are not fully closed, but their water is already allocated and the engineering or other means of using the remaining water are already in progress. Such basins are nearly closed and would have to be treated as such. Additional water use, in terms of evaporative use, is possible only in the open basins.

Thus, any means of additional water use, including water harvesting or new engineering projects, if implemented in a closed basin, would not produce any additional useable water. These would only change the geographic pattern of use. Thus, people in the upper catchment, who have not been able to use any water of a nearby stream or aquifer would benefit from such use, but they would also be depriving someone else who cannot now get the water which he was using. Such redistribution of useable water may sometimes be socially desirable. But it is to be done with full knowledge that benefits are only re-distributive and not additional.

On the other hand, if inadvertent evaporation could be managed and reduced, additional use would be possible. Similarly, in such a basin, the return water is going to a sink (such as a low level area near the sea or a saline ground water body), and if this could be avoided by some means, additional water use could be possible.

2. Promoting larger carry over storages

(See the separate section, 3.4 Increasing Storage and Carry over Storage)

3. Enhancing ground water fluctuations and using the ground water space as storage

In many basins, the availability of reasonably good storage sites (which is a natural endowment related to the topography of the area) are not available. For example, very few storage sites are available in the Ganga basin in general, and the Indian part of the Ganga basin in particular, as compared to the flow of the river. However, in the Gangetic alluvium, with its large depth, a considerable storage as available in the parts below fluctuating ground water table can be used. A very important planning strategy used by Uttar Pradesh for the Madhya Ganga and the Eastern Ganga projects was that of providing a "Kharif Channel". The 'run off the river' during the wet season, was diverted for Kharif irrigation. There was no discouragement to the paddy crop which results in a large ground water recharge. The canals are closed after the Kharif and the built up of the ground water was used for Rabi and summer irrigation through shallow deep wells. Thus, the natural ground water fluctuation was artificially enhanced and this ground water space was used to moderate the flow fluctuations. A similar, but somewhat unplanned strategy of conjunctive use of ground water is apparent in many other places. This needs to be encouraged.

Near about Bhabar and Terai regions originally lowering of ground water in the summer by over exploitation, and induced infiltration in the Bhabar zone from river beds in the early floods was proposed. This idea seems to be attractive on paper, and large scale pilot studies are necessary for this type of novel conjunctive use to augment the storage available through ground water space.

Conjunctive uses of surface and ground water have also developed, automatically in the north-western part of India, where the ground water storage is used as "within the year". However, if larger investments on more number of ground water structures are made, the ground water can be used as carry over for improving the reliability of the more variable surface water availability. To illustrate in simple terms, consider a surface water project designed for the success of irrigation, only in 50% of the years. In these 50% of the years, only surface water would be used and ground water would be built up. In years where surface waters are not available, the already constructed ground water structure would be activated to provide additional ground water for use. Only in few years where surface waters are very deficient and ground water levels have also gone low, water use would have to be curtailed. Thus, the ground water space would provide for the carry over allowing large use of waters.

4. More efficient use of the storage in vadose zone

Already where the two seasoned irrigation, Kharif and Rabi, are practiced, there is a considerable savings possible in the first Rabi irrigation if the gap between the crops is reduced and the soil moisture as trapped in during the Kharif is not allowed to be evaporated. In such a practice, where the vadose zone water gets conserved, which otherwise would have evaporated through capillary action. Such strategies need to be encouraged in future. Many times Rabi cultivation is done on a plot which was not under cultivation in Kharif or early Kharif is harvested much before. Uses of plastic sheets, mulches, etc., can reduce root zone evaporation of vadose zone water.

5. Repeated use of storage during the wet season

If projects are planned for comparatively larger use in the wet season and comparatively smaller use in the dry season, larger use becomes possible because the demands adjust to availability in a better way. However, this is always not possible because for smaller rivers in the drier parts of the country (where stress is more), the flow is not steady in the wet season. More water is available during the rainy spell of a few days, but in between rainy spells, the availability decreases. Strategies are available to overcome this. For example,

- In the peninsular dry lands, the dug out ponds in a part of the farmer's fields, can be constructed. In every significant spell of the rains, the pond gets filled in, and this water is used in between the two spells. The Centre for Dry Land Agriculture, at Hyderabad, has studied this in detail. At times the storage of the pond is used upto four times within one monsoon and this allows much larger wet season use.

- In a similar way, many medium irrigation projects, in the dry region of Saurashtra were planned, with the assistance of World Bank, for a predominantly wet season (Kharif) irrigation as a supplement to the effective rain fall over the command. In a year, where the rain is good and is well distributed within the wet season, not much irrigation would be required and the reservoir would be full by the end of the monsoons even after Kharif irrigation. If the rain is deficient, or if it has withdrawn early, some Kharif irrigation would be possible, but not much water would be left for Rabi irrigation. The projects were so planned that with some repeated use of storage, large and reliable Kharif irrigation, supplemented by smaller and unreliable Rabi irrigation could be done, while increasing the usability of water.

Such Strategies need to be further developed and used in future.

6. Inter-basin or long distance transfer of water

The water availability in India varies both in space and time. While some basins have much larger water availability, as compared to their area or to the population in the basin, some other basins have combatively much smaller water availability. Considering the situation, a National Perspective Plan for water transfers, was drawn up and necessary studies to finalise the Plan, are being conducted.

GoI is investigating transfer of river water from water resources surplus basins to deficit basins. There are two component of the proposal viz. (a) Himalayan component and (b) Peninsular component. Under Himalayan component there are 14 schemes out of which 13 schemes are transferring water either to Ganga basin or from Ganga basin.

Under the peninsular component, GoI is investigating 16 no. interlinking schemes for transfer of river water from water resources surplus basins to deficit basins in peninsular and other basins.

Inter-basin transfers should be recognized as an important tool for increasing usable water, as also for increasing the economically sustainable carrying capacity of water short regions, and thereby, reducing the absolute poverty, and discouraging distress migrations. Strategies like inter-basin water transfers would have to be considered with added gravity, and may have to be implemented expeditiously, to improve the situation.

3.3 Improving Water Use Efficiency

3.3.1 Note on water use efficiency

The water use efficiency is a term that is used simultaneously in a loose sense as also in a mathematically defined scientific sense. The dictionary meaning of efficiency (Concise Oxford Dictionary) is two fold; firstly efficiency is a quality of being efficient, that is, productive, effective, competent, capable etc. Secondly efficiency is the ratio of useful work done to total energy expended. In similar lines, when related to water use system, productive, efficient, competent or capable water use can qualify a system as efficient. But in a mathematical - scientific way, the ratio of water use for the purpose for which it is meant to the water "expended" can be said to be the efficiency of water use.

When considering a particular water use system, such as surface irrigation system, the irrigation efficiency can be conceived as the conveyance efficiency (volume of water made available at the outlet divided by volume of water released at the canal head), distribution efficiency (volume of water delivered to the field divided by volume of water drained from the outlet), the field application efficiency (volume of water delivered to the root zone divided by volume of water delivered at the field). The overall project efficiency would be the product of these three efficiency components.

3.3.2 Water use efficiencies in India

The IWRS Theme Paper on "Efficiency of Water Resources" 2004 (IWRS 2004) gives more information about typical efficiencies in Indian Surface Irrigation systems.

Table – 6 Water use efficiencies in Irrigation system in India

#	*Particulars*	*Observed irrigation efficiencies of Projects (in percentage)*				
1.	Conveyance efficiency	Nazare	Manyad	Nirguna	Asola Mendha	Kalote Mokashi
a)	Main canal	92	84	85	94	86
b)	Distributary/Minor	79	83	75	75	89
c)	Field channel	68	64	72	No field channel	67
	Overall conveyance efficiency (Ec)	49	44	46	70	51
2.	Field Application efficiency (Ea)	77	69	83	58	59 (Paddy) 52 (Groundnut)
3.	Project Efficiency (Ep)	38	31	38	41	30

Recent studies about the water use efficiency in the Pili Dam Irrigation Project in Uttar Pradesh (WALMI, U.P., 2008) indicated the conveyance efficiency of the main canal as 58%. The efficiency of the distributary was 57%, while those of the minors varied from 54% to 73%. The field application efficiency was 54% for Kharif and 70% for Rabi. The overall irrigation efficiency was 43.5% in Kharif and 37.7% in Rabi.

The low efficiency of water use through surface system irrigation has been a cause of much concern and discussions. There is no doubt that surface irrigation efficiency system should be productive and competent, and thus efficient. The water is delivered in the canals and on to the outlets and to the fields after a large use of resources-financial physical etc. and this costly water should mainly be used towards the performance, for which it is meant, e.g. to transpire itself through the plants and allow for healthy growth of the plants for human use.

3.3.3 Is water lost?

However, the water that is lost in the process of the surface irrigation system is not all “lost”. These losses can be classified as:

(A) Inadvertent evaporation, which does not serve any useful or the desired purpose.

(B) Seepage of water to the ground water table,

(C) Leakage of water into the surface drainage system.

Out of these, the inadvertent evaporation is the real loss during that particular phase of hydrological cycle. Human interventions with the hydrologic cycle are for causing additional transpiration for the growth of plants in the fields, or other beneficial uses and not for other types of evaporation-transpiration, which would not give any significant benefit to humans. This inadvertent evaporation is mainly made up of three components i.e.

(a) Evaporation from anthropologic swamps, wet lands (Water logged areas)

(b) Lake evaporation from reservoirs; and

(c) Wet soil evaporation from fields as distinct from the transpiration from plants grown.

The surface irrigation systems need to be efficient in minimizing these inadvertent evaporations.

3.3.4 The seepage

The seepage from canals, particularly for unlined canals accounts for 40% to 50% of discharge at the canal head. This includes 15% to 20% in main canal and branches, 10 to 20% in distributaries and 10 to 20% in water course. The data given (IWRS, 2004) indicates the losses as follows:

Table – 7 Seepage losses in Canal systems

#	*Project*	*Seepage losses in Canals system (mm/day, from wetted area.)*
1.	Harsi Canal System (M.P)	130 to 630
2.	Sarda Canal System (U.P.)	158 to 210
3.	Kaldiya Irrigation Scheme (Assam)	447 to 709
4.	Pazhassi Irrigation Project (Kerala)	289 to 552
5.	Kangsabati Irrigation Project (W.B.)	236 to 1840

The seepage from irrigation system to the ground water need not be considered as a loss in the hydrological sense. This water would allow conjunctive use of water in the command, or ground water use outside the command where this ground water would flow within the aquifers or would support additional base flow from the ground water storage into the surface drainage system. These base flows could either meet the environmental flow requirements or would be capable of being picked up and used elsewhere.

Similarly, the leakage of water into the surface drainage would normally be capable of being picked up and used elsewhere.

The main water loss from the surface irrigation system is through canal seepage. The quantum of seepage depends more on wetted surface area of the canals. A large number of observations about such losses are available in general, for unlined canals. This loss is about 170 mm/day, from the wetted perimeter whereas for a concrete lined canal the loss could be around 30 mm/day from the wetted perimeter. The age and the state of repairs of the lining make a considerable difference to this seepage through the sides and the bed of the canal.

There is no doubt that canal systems need to work properly and needs to be efficient. However, there are limits to increase in the efficiency. Also, in water short areas where ground water use has developed much of the canal seepage does not lead to any un-useable return and all the losses which are not in the form of inadvertent losses really entail loss of energy (the seeped water would have to be lifted again to the surface by pumping) and loss of money; but not to the loss of useable water in itself.

3.3.5 Managing canal seepage

Please refer to the discussions about efficiency. As stated therein, the main emphasis has to be in reducing inadvertent evaporation. The considerable area under water logging, mainly from major surface irrigation system, is the main cause of such inadvertent water loss. Water logging in itself results from leakages from canals as also from the practices of over irrigation. Although no definite estimate of such water logged area is available, the estimate made by the Working Group in 1980s indicates the figure to be around 6 Mha. There are indications that by now the water logged area would have declined both due to efficient management and due to larger water stress and larger ground water use. If one assumes the area to be 4 Mha., assumes an annual additional and inadvertent evaporation 1.5 m., India would be loosing, every year, 60 km^3 of water from such areas. The strategies to either save or use the water or re-use this water would consist of:

a) For each large irrigation system, a complete water assessment, water accounting and benchmarking needs to be done periodically. This water assessment should give an account of the water diverted to the command, water received as rainfall, water applied through ground water withdrawals, evapo-transpiration from the area attributable to the rainfall, surface irrigation, ground water irrigation etc., separately and the general inputs to and outputs from the groundwater. For this purpose, the regeneration contributed by the area to the river system would also have to be assessed.

   Since, such an assessment of the command area hydrology would be a somewhat a difficult and infrequent exercise, a simpler water accounting exercise for the surface irrigation system alone needs to be done every year. This would include an account of the water diverted in each season, the water lost through seepages etc. from the primary and secondary water conveyance system, water delivered at the outlets, water lost through field channels and through the irrigated fields to groundwater and surface water systems and the likely additional evapo-transpiration (over and above the effective rainfall) in each season. The benchmarking studies and the performance evaluation studies for the system should include these water accounts also.

   Both the periodical water assessments of the large commands and the annual water balances, including the computations of efficiencies (conveyance, distribution, field application, overall system as also the total command area water use efficiency including use of returns) need to be published.

b) More meticulous management of the primary irrigation system through use of computer aided systems so that canal deliveries match actual demands. Automated operation of canal system, using “on demand irrigation”, demand estimation systems based on distributed soil moisture information, use of more frequent and small dosage for irrigation to prevent water leakage below root zone, etc.

c) An efficient drainage system as an in-dispensable adjunct to irrigation. The seepage/leakage/over irrigation gets collected in such drainages. This drained water can then be reused.

d) As an alternative or as a supplement, more efficient conjunctive use of ground water can be made in such a way that the ground water wells acts as vertical drainage to reduce water logging.

e) In general, canal lining may not be considered as a method of seepage management, because, in most water-short situations, the seepage leads to larger conjunctive use, which may have already developed.

Lining is costly, and although it may improve the project efficiency, it would not increase the usable water. However, lining would be necessary in some problematic reaches, particularly where the canal full supply level is much above the general ground level, and the canal banks are permeable. In such situations, the excessive seepage, otherwise, can lead to water logging and consequent inadvertent evapo-transpiration, and may also affect the structural stability of the bank.

f) A large number of surface irrigation systems built in the earlier days are becoming difficult to maintain because of lack of maintenance and also because not enough was done to continuously modernize the system. The demands and the demand patterns are changing due to high priority domestic and industrial demands growing at a fast pace, and also because the crops and the cropping patterns are changing. The inadequate duties and deltas assumed earlier, often, do not meet the full evapo-transpirationl requirements of the crops. Programmes like CAD, NWM etc. have been taken up the GoI have also been encouraging preparation of proposals for modernization of Irrigation Projects. However, the State Governments are perhaps finding it difficult to prepare and implement such proposals, perhaps because this give benefits to the same area which was historically benefited and thus do not improve the regional balancing. A National programme for giving grants and loans for such canal modernization programmes, somewhat on the line of AIBP, seems appropriate.

3.3.6 Participatory management by users

It is well recognized that the efficiency of public water use systems, as well as the satisfaction of the users can be considerably increased if the system is managed through participation of the users. This will ensure larger equity in water distribution. Also the tendency of the upstream users to use more than their share of water through over irrigation, etc. would be checked to a considerable extent. The water users would normally be supplied water on a volumetric basis and if any individual user wants to use the water for more water intensive crops, he would have to either reduce the area. or to look for alternate sources of water. Already many States have effectively encouraged participatory management and even turn-over of the tertiary systems to the users have been seen. Considering that faster changes in cropping patters and water requirements would take place in a climate change situation, it is necessary that the faster responding participatory management is used all over India. A programme for full implementation of PIM has to be taken up as a national programme.

3.3.7 Water lost to sinks

What then is that part of water which really is lost to use in the land phase of hydrological cycle through the irrigation system? This is:

a) Inadvertent evaporation as already explained;

b) The water added to a ground water aquifer, the water of which is of such a bad quality that its use is not possible;

c) Water which returns through the seepage and ground water base flow or through leakage, but which appears at a place where because of its location it does not allow any further use. For example, the water which returns at a very low level in the coastal area cannot be picked up either because there is no land or demand nearby for which it can be used or because the estuary where it re-appears is already saline;

d) That part of ground water base flow, from the coastal aquifers which directly discharges to the sea.

3.3.8 The basin efficiency concept

Using this logic, the IWMI has proposed the use of the "basin efficiency" concept. For water surplus basins or areas, the efficiency is not a very relevant concern. For water short basins, the basin efficiency would be the ratio of total waters not lost (inadvertent evaporation plus un-useable returns, to sinks) to the total water withdrawn.

Any reduction in availability, increase in water demands or large variability in the supplies, resulting from a climate change, would lead to larger water stresses. Water use system would have to be more efficient, both in terms of project efficiency and in terms of basin efficiency under these circumstances, but the main stress in efficiency improvement has to be in minimizing the inadvertent evaporation from such systems.

3.3.9 Limits of efficiency improvements

Efficiency improvement would require both soft and hard measures. These are mentioned below:

Soft measures:

1. Strict Rotational Supply
2. Awareness about water saving measures
3. Awareness about the need for co-operation amongst users.
4. Participatory management by all stakeholders.
5. Penalties, fines, etc. for over-irrigation, out of turn use, etc.

Hard measures:

1. Lining of conveyance and distribution systems.
2. Installing proportionate distributors, and minimizing controls which can be mis-used.

3. Computer aided decision support, or automated systems.
4. "On demand" irrigation through computer controlled level pools.
5. Larger number of small, calculated irrigation doses, preferably on real time soil moisture information.
6. Better field application method
    - Discontinuing "field to field" irrigation.
    - Leveling of fields.
    - Constructing field channels.
    - Discouraging flood irrigation.
    - Encouraging furrow and basin irrigation.
    - Encouraging piped distribution systems at secondary level.
    - Installing sprinklers or drips. Creating field storages to store water between canal rotations.
7. Installing drainage in irrigated areas

The hard solutions are costly, and can save wastage, but as discussed, may not always increase the usable supply. The soft measures are generally less costly, but more slow in receiving acceptance. Again, although these will increase productivity and equity, these may not always increase the usable supply. Increasing the system efficiencies (if defined as the percentage ratio of 'irrigation water used effectively for crop growth' to 'total water diverted for use') by 20% through these measures appears very difficult. Also, since we are really concerned with the total effective use, including the use of returning waters, in or outside the system, it is not an appropriate goal.

The general conclusions are:

- Water conveyance systems need to be made and managed much more efficiently.
- When calculating efficiency as a ratio, in mathematical / scientific terms, define both the numerator and the denominator properly.
- The Basin efficiency concept is scientifically superior, since the effective use of the return flows gets counted, and this encourages the optimum use of water, through conjunctive use, re-cycling and re-use.
- Attempts should be made to increase the basin efficiencies, in potential or actual closed basins, to say 80% and above. The reduction of inadvertent evapo-transpiration, reducing returns to sinks, and conjunctive use, re-cycling and re-use would be the main strategies.

- System efficiencies of any individual conveyance system also need to be improved, for better energy efficiency and improved management of financial resources. However, the externalities, in regard to uses outside this system, also need to be evaluated.

3.4 Strategies for Management of Glaciated and Snow Bound Areas

A large monitoring and data collection progamme has already been included. Research in glacier mass balance, physics and energy balance is also included.

Apart from this, no management strategies are available at local level. Perhaps, pilot studies in creating ice dams or cold water lakes, in areas vacated by receding glaciers, could be thought of, on a pilot basis.

3.5 Strategies for Management of High Altitude Lakes

High altitude natural lakes in the Himalayas depend on a delicate balance between the inflows from snowmelt, and the outflows through evaporation, and to rivers,. They support an ecosystem, and also regulate the flows. Since the climate change would alter the delicate balance, a close monitoring would be necessary. Increasing temperature may enhance the risk of eutrophication. Changes in the period of “lake turning” may also affect the lake ecology. The strategies for conserving the lake and its ecology would have to be worked out on a case by case basis.

3.6 Increasing Storage and Carry over Storage

3.6.1 The role of storages in India

The changed variability of flow availability is a serious concern for all areas where the water use is mainly through storages. With the exception of the Eastern Gangetic plains and in North-East, much of the current surface use of water in India is already based on storages. In Eastern India, the water use is based both on the runoff of river and storages. Even in the better endowed rivers like Brahmani, Mahanadi, Godavari, etc., storages have played a very important part. A few rivers like Subernarekha do not have much storage available to back up the use. But, here, the whole water development seems to be constrained for want of storages. In the rest of the peninsular India as well as in the North-west (Indus Plain), storages already are the mainstay of the surface water use.

3.6.2 The “Over the Year” Storages

If and when the entire actual variability of flows increases, “carry over” or “over the year” storages, which utilize the waters available in a “good” year, by storing them for a long period, and use these in a “bad” year, would become very attractive.

The current Indian strategy of storage development does recognize the importance of carry over storages, but due to economic and other reasons, the carry over storages were not preferred. Thus, although a considerable active storage capacity of around 280 km^3 has been created in India (as compared to the available annual use of around 2000 km^3), most of the storages are of the "within the year" type. The notable carry over storages are a few; Bhakra, Rihand, Narmada Sagar, Srisailam- Nagarjuna Sagar, etc. to mention the most. The Indian policies did not discourage carry over storages in anyway. Some of the early storages like Bhakra and Rihand have carry over. However, for years, as a routine, most storages were planned as "within the year" storages where the storage is just enough to support the full use of the 75% dependable inflow. It is difficult to say why this occurred perhaps, carry over storages were considered uneconomical and therefore undesirable without a case-by-case analysis. More likely, the concept of the reliability of the output got mixed up with the concept of the dependability of the inflows. The correct interpretation of the reliability, where the reservoir outputs are needed to be reliable, and no restriction, (other than those based on economic and other considerations) was required to be enforced on the utilization, was often ignored. In short, the policy of "75% dependability" was misinterpreted as one discouraging carry-over storage. This perhaps reduced the number of carry over storages.

3.6.3 Increasing storage by raising of dam heights

Very large numbers of storage tanks are without carry over. There are many dams and reservoirs where water availability is not a constraint at the Dam site, but smaller water uses are planned because the command is small or because of water allocation being less. Such dams fill up with much reliability and often overflow. Raising of the height of the dam and full reservoir level of the reservoir, may be possible in cases where water availability is much more than that of water use, and where no carry over was earlier provided but it is possible and necessary in the changed economic and changed conditions to provide a carry over. Additional submergence and additional R&R related problems would crop up. But in future, with much better R&R package and a more socially relevant R&R Policy, acuteness of the problem is likely to be less than what it was in the past 30 years. Such exercise is necessary to list the reservoirs where the additional storage including carry over storage can be provided by raising the dam height. Innovative method of construction and design would also have to be developed to allow such change of design, partly in the rigid dams, after considering the problem of "locked stress".

3.6.4 Increasing storage in small dams through gated spillways

Basically, India has lakhs of small dams and minor tanks. These have a considerable storage capacity and the total storage in these dams could be of the order of 60 km^3. Most of these are ungated storages. The spillway is mostly in the form of long waste weir and the channel which makes the natural system on the downstream. The full reservoir level is normally one or two meters below the design maximum water level during the floods and this flood lift over the waste weir allows the flood to flow down. This design was very appropriate considering the low level technology required, dearth of technical man power, dearth of electric power, etc. These environments are fast changing. Since the top levels of such weirs are already provided free board over the maximum water level obtained during the floods, it would be many times possible to provide gated spillways over the waste weir. If the present design is to be maintained, falling shutters could be installed. Wherever possible, the waste weir design can be changed and a shorter waste weir with higher gates, operated automatically by electric power, even from a control room situated away from the dam, could be thought of. If today's technologies are used in regard to data and command transmission, it would be possible to increase the storage capacity of these minor dams without any additional raising of the dam type and land acquisition, etc., and without any additional risk of mal-operation.

This strategy, of course, would not be successful if the water availability at the tank is not sufficient. Again a large scale programme to check the hydrology (water availability) of a very large number of minor tanks is taken up systematically a list of minor tanks where such possibilities exists, can be made and massive programme of providing gates, etc., can be taken up.

3.6.5 Restoration of tanks and water bodies

The restoration of tanks and water bodies is a current programme, which is based on not so much of increasing the capacity through the raising of the full reservoir level of the dam, but more on repair of tanks and on desilting of the tank. In general, the creation of additional capacity through desiltation is far more expensive than the creation of such capacity through new tanks or through raising of tank levels. However, where the silt removed from such minor water tanks has an economic use, such possibilities do exist. This would happen, more often, in the peri-urban areas. In such areas, the material can be used for brick making or for filling up of low lands for the purpose of urbanization etc. The current programme requires refocusing on these lines.

3.6.6 Induced ground water recharge

The utilizable water can be increased by inducing ground water recharge during the wet season and then using the recharged ground water in the dry season. Such induced recharge through irrigation has already been discussed as part of the conjunctive use strategies (see 3.1.2, sub-paragraph 3). Induced recharge is also further possible in other ways. For example:

- Recharge through seepage tanks is possible under favorable geology. In general, engineers earlier would discard sites where the reservoir bed would leak. However, such leakage or seepage, recharges open wells and ground water table on the downstream and allows larger use of this tank waters transmitted through ground water. Small seepage tanks have been quite successful in Maharashtra and Karnataka. In the dry area of Kutch, some irrigation tanks seem to have converted themselves into recharge tanks. In basins which are not "closed", like the Godavari, the Tapi, etc. considerable additional use from such seepage tanks is possible.

- Large projects for diverting surplus monsoon flows of rivers to the deficit area, and storage of this surplus waters for artificial recharge by spreading or reverse pumping, and its subsequent use in the non-monsoon period has been advocated. This strategy has a limited applicability and can be tried on pilot basis. However, the diversion canals would have large capacities, which would be used only for a few flood days in a year.

- Hydro fracturing is a method for inducing recharge at a micro level in rocky and dry areas. This can support horticultural plantation if small depressions of the hydro fracture land are created with a tree in each depression.

3.7 Strategies for Evaporation Management

3.7.1 Managing water logging in canal commands

The main strategy for reducing that part of the evaporation-transpiration, which is inadvertent evaporation, and which does not serve much useful purpose, is to not allow the development of anthropogenic water logging, and of draining and reusing such water. This is discussed in the chapter on wetlands. Also see para 3.2.5.

Other means of managing inadvertent evaporation, which need to be part of an overall strategy and policies, are as below:

3.7.2 Larger use of drip irrigation

In drip irrigation where water is delivered exactly to the root zones of the plants, there is little wetting of the soil surface between the rows of the plants/ trees. Thus, in the initial stage of the growth of the plants /trees the total evaporation is considerably reduced as compared to application methods in which the soil is wetted. However, there is a note of caution. Once the trees grow, and the canopy of the trees cover the entire area, the transpiration from the trees would more or less equal the evapo-transpiration needs of the entire field area and there would be no reduction in evaporation- transpiration after this stage.

3.7.3 Evaporation from agricultural fields

Evaporation from agricultural fields, between crops, which depletes the root zone soil moisture, through capillary action, as also through the growth of weeds, can be prevented by the use of plastic sheets or mulches.

3.7.4 Evaporation from Fallow Lands

Land which is fallow during the monsoon season (wet lands or other lands in urban areas which are not made impervious) also uses considerable water. This is due to wet soil evaporation and also from the temporary growth of shallow rooted grasses and bushes which cover the area after the first few showers, and which wither away soon after the wet season. De-weeding, plastic sheets and mulches can reduce and prevent the inadvertent evaporation, and conserve water for better uses.

3.7.5 Managing reservoir evaporation

Evaporation from man-made lakes and reservoirs is another inadvertent loss of water. Technologies for reducing reservoir evaporation, based on mono-molecular films etc., have been tried. So far, these are not very successful, and are costly. Their environment impact may also require a further study. However, these provided some relief in conserving lake waters under severe drought conditions.

In comparatively shallow and flat reservoirs with a small deep pool, it is possible to compartmentalize the reservoir in a shallow (but large area) and deep (but small area) compartment. After the flood season, the shallow compartment is emptied first and is dried up before spring and hot whether sets in, so that the evaporation loss during this period is confined to the first compartment. Such techniques have been used in Gujarat in a few cases, and can be planned and tried elsewhere.

3.8 Strategies for Drought Management

Drought is a temporal phenomenon indicating a lack of water in that particular time as compared to the other periods. Areas which frequently suffer from droughts are classified as drought prone. However, in the method adopted by the CWC, such areas which frequently suffer from meteorological droughts, but which have large proportion of irrigated area are not considered as drought prone, since the situation has been improved through irrigation. As many as 99 districts, spread over 14 states, were identified by the CWC as drought-prone in the country. Most of the drought-prone areas so identified are concentrated in the states of Rajasthan, Karnataka, Andhra Pradesh, Maharashtra and Gujarat. Mall et. al. 2006 quoting Sinha Ray and She Wale indicate the following large historical droughts occurring in India.

Table – 8 Drought years with % area of the country affected by drought

Year	*Area affected by drought (as percentage area)*		
	Moderate drought	*Severe drought*	*Total*
1877	30.6	28.9	59.5
1891	22.4	0.3	22.7
1899	44.1	24.3	68.4
1901	19.3	10.7	30.0
1904	17.5	16.9	34.4
1905	25.2	12.0	37.2
1907	27.9	1.2	29.1
1911	13.0	15.4	28.4
1913	24.5	0.0	24.5
1915	18.8	3.4	22.2
1918	44.3	25.7	70.0
1920	35.7	2.3	38.0
1925	21.1	0.0	21.1
1939	17.8	10.7	28.5
1941	35.5	0.0	35.5
1951	35.1	0.0	35.1

Year	Area affected by drought (as percentage area)		
	Moderate drought	Severe drought	Total
1965	38.3	0.0	38.3
1966	35.4	0.0	35.4
1968	21.9	0.0	21.9
1972	36.6	3.8	40.4
1974	27.1	6.9	34.0
1979	33.0	1.8	34.8
1982	29.1	0.0	29.1
1985	25.6	16.7	42.3
1987	29.8	17.9	47.7

They noted that during the last 50 years, there was no occasion when the percentage area of the country affected by drought was more than 50. In 124 years, probability of occurrence of drought was found maximum in West Rajasthan (25%), Saurashtra and Kutch (23%), followed by Jammu and Kashmir (21%), and Gujarat (21%).

The main strategy followed by the Government in drought proofing seems to be the provision of reliable irrigation. For example large tracts of land in Punjab, Haryana and now parts of Rajasthtan which are subject to frequent meteorological droughts have been drought proof through irrigation. In the rain-fed areas of the country the main strategies adopted, as mentioned by Prabhakar and Shaw (2208) are the various drought proofing programmes like DPAP, DDP, EAP, JGSY etc. The Authors have suggested that drought prediction and communication and drought monitoring needs to be improved and the coping capacities of the communities need to be enhanced in view of the Climate Change.

The CWC's publication on Water-shed management (2004) gives information about a very large no. of similar programmes in different States. However, there seems to be a need for better coordination in regard to these operations. These publications mention that such projects run the risk of loosing their momentum and coming to halt as soon as the funding is over.

3.8.1 Nexus between Water, Land, Livelihood and Energy

In drought proofing of drought-prone areas, the water, land and livelihood problems need to be considered together. In India, many water stressed areas have considerable rural population densities. Even if there is more diversification in the livelihood pattern in rural areas in future, with manufacturing and service sectors expanding in these areas, the bulk of the population would still have to derive its livelihood from the land they possess. With little water resource, the productivity of the land and hence their income would be limited. In many cases, the economic carrying capacity of such areas may be less than the population in the area. The possible strategies for improving this situation would be:

- Conducting the economic carrying capacity studies considering land, water and livelihood to plan how much water is necessary to yield reasonable income.

- Increasing the use of irrigation through in-basin development as also inter-basin transfers.

- Changing cropping patterns towards low water use crops.

- Adopting integrated farming systems.

- Water harvesting, provided this is socially desirable and provided that corresponding water saving is possible elsewhere in the region.

- Encouraging non-agricultural developments of the type where not much water is required.

When planning land use under resource constraints, this nexus amongst land, water, food, livelihood, energy and ecology, has to become an important consideration; particularly when the water resource becomes limited. The use of resources, and levels of output per unit area, could be as follows:

Table – 9 Use of Water Resources vis-à-vis output for different land use

Land Use	*Water Consumption*	*Livelihood support*	*Food production*	*Energy*	*Ecologic services*
Forests	High	Considerable	Low	Some	Large
Wetlands	Very High	Low	Low	Low	Very Large
Grasslands	Medium	Low	Low	Low	Considerable
Arid Areas	Low	Very Low	Low	Low	Considerable
Rainfed Agriculture, including pastures	Medium	High	Medium	Some	Low
Irrigated Agriculture, including pastures	High	Very High	High	Considerable (Ethanol, etc.)	Medium
Rainfed Energy Plantation	Considerable	Considerable	Low	High	Low
Irrigated Energy Plantations	Very High	Medium	Low	Very High	Medium

This is a typical allocation problem, where we would like to increase the production value, within the limits on available land and water, while fulfilling the minimum needs of livelihood and food for all, and the minimum needs of ecologic services. If one does not look at the problem holistically, and neglects say, the use of rainwater by rainfed energy plantations, or the need for livelihood and poverty alleviation, or the ecologic services of a wetland, one may obtain an inferior solution.

In general, where livelihoods are more important, irrigated agriculture may be a better strategy, where land and water are plentiful and livelihoods are not a problem, energy plantations may be superior, and so on.

3.9 Strategies for Improved Management of Wet Lands

3.9.1 Classification of wet lands

In general, the shallow to deep lakes and swamps, areas which are under flood water for a comparatively long duration and with some regularity etc. would qualify as wet lands. Deep lakes and reservoirs would not normally qualify as wet lands. However, fringes of those reservoirs, which fill up regularly, and where large shallow water tracts provide habitats to birds, etc., can also be considered as wetlands.

Wet lands can be classified in various ways. For example:

- Natural or anthropogenic – the anthropogenic wet lands would consist of reservoirs fringes, or water logged/saline areas resulting from irrigation. Paddies, rainfed or irrigated, also are anthropogenic wetlands.

- Lakes and swamps - In general where the water depths are small and the area is covered with considerable vegetation, it could be called a swamp.

- Inland or estuarine/coastal - The inland wet lands could consist of Jheels/ Beels etc. which are connected with the river system, get supplies from the river flood water and are partially or completely drained once the river recedes. However, the draining of water would take a considerable time since the back flow into the river would be restricted. On the other hand, flood plain areas on the banks of river, including low level islands in the river (Diara lands) which would receive flood waters when the river is above the bank full stage, would remain under water for a prolonged period from say a fortnight to a few months, and would become dry as the river recedes would also qualify as wet lands. Where the wet lands are in the estuarine or coastal region, this would have salinity and tides as additional environmental factors and would have to be classified separately.

3.9.2 Alternative strategies for wetland management

The alternative strategies available for management of wet lands, which may not be compatible with each other, are as follows:

a) Wet land ecologies are important and fragile. Leave the wet lands alone so that this ecology would be in good health;

b) As far as possible, manage wet lands in such a way that the land becomes available for use in agriculture and food production. Where possible, provide flood control and irrigation. Provide an efficient drainage system to keep the land dry and without salinity;

c) Wet lands provide an excellent opportunity for a fish culture, including, in case of estuarine and coastal wet lands, an opportunity for the commercially attractive brackish water fisheries.

3.9.3 Preferred wetland management strategies

There are strong lobbies, which would advocate each of these strategies. The societal preferences also change with time and from situation to situation. Considering these, a prescriptive strategy is difficult to evolve. However, following general guidelines are indicated:

a) Where the wetland is anthropogenic, follow the strategy at ‘b’ mentioned above, particularly for the water logged areas. This would ensure that the drained wetland is available for irrigated agriculture as originally planned. It would also save inadvertent evaporation of water, and not allow the growth of diseases like malaria. The saving of the inadvertent evaporation would be extremely relevant strategy in the phase of climate change since the demands would be increasing.

b) Where wetland is natural and in the coastal/estuarine region, the strategy at a) mentioned above would be most relevant one. Wet land in these areas support a very important eco-system consisting of migratory fish like Hilsa, Salmon, etc., and consisting of many types of mangroves. The preservation of mangroves is of particular importance in the face of an increased frequency of cyclones, since mangroves would protect the coast from tidal attacks and also lead to larger sedimentation and thereby to the process of delta building, which could counter the erosion. These wetlands, thus, provide an unusually large types of environmental services: they act as carbon sinks, build up deltas, support typical ecologies, protect the coast, etc. A good many of such wetlands, as in the Sunderbans, have been deforested, embanked (Zamindari embankments) and brought under agriculture, before about a 100 years, and their services have been lost. Where possible, these may be re-planted with suitable mangroove species native to the area.

c) For some estuarine wet lands which are away form the coastal or mangroves zones the strategies at b) or c) could also be followed. This would depend much on the local preference. For example, for the Wembanad wet lands in Kerala, in spite of a strong lobby preferring commercial fishery, the strategy of agriculture development was followed; whereas for the parts of Chilka lake wet land, the fishery interests seem to have prevailed. These strategies, in general, are compatible with the views of MoEF, as reflected in their draft notification document “Regulatory Framework for Wetlands Conservation”, currently opened for comments.

d) For the natural wet lands which are on the inlands, a very careful analysis would be required before deciding on the strategy. For example, for the Loktak wet land in Manipur, all the three interests were powerful. The wetland ecology of Loktak, with its floating islands and animals, ecological preservation was an important strategy. However, the agriculture and fishery interests also could not be ignored. Similarly, for large areas on the banks of the Ganga and Brahmaputra and their major tributaries, the flood plains would have been, in the historical context, playing an important role in the river ecology. Many migratory fish breed during the onset of the floods. The small fingerlings which cannot stand high velocity flows would take shelter over the comparatively calm flood plains and grow there while the river is in the over bank stage, and rejoin the adult fish in the main river as the floods recede. Flood plains would also contribute nutrients, both to the land and to the river for sustenance of ecology. Thus, the inland wetlands were also important for ecological conservation; but, this made them not available for agricultural use in Kharif and early Rabi. As the land availability came under population pressure, long embankments got built and the flood plains were made more fully available for agricultural use. The society, in the last two centuries, thus exhibited a preference towards strategy b) over strategy a). This cannot either be ignored or undone. However, at the current stage, before building embankments to protect new flood plains, a careful weighing of the current preferences would be necessary. In short, the preferred strategy would be:

- Where flood plains are already protected by embankments, continue to maintain these.
- Where new urban or industrial areas near riverbanks are to be protected, build local embankments.
- Where large new agricultural areas on riverbanks are sought to be protected against floods, do not do so without carefully weighing and adopting the strategy at a) which prefers ecological preservation.
- While managing inland Jheels or Beels, do not prefer the strategy at b) except at the high level foreshore lands of the Jheels. Prefer the strategies at a) and c).

In the phase of increased frequency of floods under a climate change scenario, flood plains and lakes in the flood plains would have an important role of moderating the floods. The strategies, which do not cut off, or drain these wetlands, would, apart from ecological conservation, give some relief to the lower riverine areas by moderating the floods.

3.10 Strategies for Coastal and Estuarine Management

3.10.1 Estuaries as wetlands

Much of what has been stated in the earlier sub-chapter on “Strategies for improved management of wetlands” is relevant to coastal and estuarine management. Some additional information and strategies are mentioned below:

3.10.2 Dearth of hydraulic information

There is a large dearth of hydraulic information in regard to the tide levels, flows in both directions, etc. for the estuarine areas. The only information available is near the inland ports. For example, much information is available for the Hooghly river in view of importance of the Kolkata port. Some fragmented information is available through the Nautical Department of the State Governments who maintain information about tides, etc., for minor ports. The CWC hydrometric network does not cover the estuarine areas. With both the raise in flood frequency and the raise of sea levels, getting proper hydraulic information for the zones becomes very important. We have separately recommended a massive data collection programme by setting up a data collection network, collecting data about tidal levels, changing flows in both directions, salinity and sediment movements from sea to land and vice-a-versa, etc.

3.10.3 Tidal embankments

While, in general, the strategies outlined by us do not prefer large scale flood embankments for protecting inland areas (see chapter on "Strategies for improved management of wet lands"), we recognize that the large programmes of planning, improving or building tidal embankments in the coastal and estuarine lands may have to be taken up in future. In the phase of climate change and raising sea level, this would be inevitable. In the absence of tidal embankments, some shifting of the population at higher levels may become necessary. Similarly, some industries may have to be shifted. Such shifts would be causing much socio-economic distress. The quantum of sea level rise as projected for India does not warrant such shifts, and protection through embankments appear more desirable.

3.10.4 Management of mangroves

With more stress on available water, both due to the effects of climate change and due to raising population, the conflict amongst water users would become more acute, and the non use of water for maintaining ecology may suffer. However, large trade offs towards use of water may affect the coastal ecology and the mangroves. Through migratory fish and through the nutrients supplied by the estuaries, the coastal areas are a link between the land ecology and the ocean ecology and both may get affected. Therefore, maintenance of environmental flows has to be included in the strategies for these reasons.

3.10.5 Commercial brackish water fisheries

Estuaries offer excellent environment for commercial brackish water fishery. Such fishery is an economic enterprise producing food and is similar to agriculture. It is to be recognized that such commercial fishery may not be complimentary to the ecological conservation which would imply the conservation of the native flora and fauna alone, and not the growth of alien flora and fauna as may be involved in the commercial fishery. Even after recognizing this, strategies favoring commercial fishery such as culture of some prawn species, etc., needs to be encouraged after ensuring that it does not harm the natural ecologies.

3.10.6 Using deltaic channels for seasonal storage

In many tidal and delta areas of the larger Indian rivers, such as the Sunderbans, many criss-crossing smaller tidal channels have saline water during the low flow periods and fresh waters during the flood periods. At the end of the flood period, the local agriculturists block such channels on both sides and covert the channel into a low level fresh water body. This provides them with fresh water for domestic, cattle and agricultural uses in the low flow season, within the saline environments. Such local initiatives need to be converted into well-engineered programmes. In the phase of climate change and water stress, such a programme would be of much relevance.

3.11 Flood Management Strategies under Climate Change

3.11.1 Safety against floods

In water development and management, safety against floods comes into play in two ways:

1. Water developments such as dams have to be safe against floods. Any dam and reservoir can become a potential hazard for the downstream population, if under the flood situation or otherwise, it collapses and creates a man made floods on the downstream.

2. Water development and management also includes providing an enhanced safety against floods so that the population in the flood prone area has reduced flood related risk. Such an improved safety against the floods in a flood prone area is not merely for maintaining the status quo in regard to economic activities but also to give boost to the economic development. Once a reasonable protection is provided, investments which otherwise may have gone into other areas in view of the flood hazard would get attracted to the protected areas and give a boost to the economic development.

Studies in regard to climate change scenarios predict that the frequencies or probability of floods may increase and floods of the same magnitude may become more frequent. This has a direct relevance to the decisions about the floods to be used in planning practices for both the above-mentioned types. These are discussed below:

3.11.2 Floods to be used for deciding the spillway capacities of the dams

The Present Practice

The present National practice is as follows:

i) Large dams which have a hydraulic height exceeding 30 m. or which have a live storage exceeding 50 hm^3 are designed for PMF. The PMF is a hypothetical flood which would be produced if the PMP is received by the catchment while it is conducive to flood production. The PMP represents the notional upper limit of the precipitation producing capacity of the weather systems which can occur in the region. In practice, the PMP is estimated by transposing the storm experienced by a region much larger than the project catchment and maximizing it for more rain like situation like higher moisture content, etc. within the range of credibility.

ii) Medium dams which have a hydraulic height between 12 m and 30 m and which have a gross storage between 10 hm^3 to 50 hm^3 are designed to safely pass the SPF. The SPF is a large flood which can characteristically occur in the basin under the SPS. The SPS is the large storm which can be considered as a characteristic of the region. In practice, the SPS is also estimated by transposing the Storm experience of the region larger than the catchment. However, large maximization is avoided, and some outstanding storms which may be beyond the characteristics of the region may not be considered.

iii) Small dams which have a hydraulic height less than 12 m and storage less than 10 hm^3 are designed to safely pass a flood with the return period of 100 years. Thus, some risk is accepted in the planning of such dams.

For all dams, large, medium or small, the flood is impinged when the reservoir is full. This builds in some additional conservative practice. Further, if the dam is gated, an emergency condition in which 10% of the gates are inoperative is also considered with relaxed safety criteria.

Likely Changes in Flood Estimates

It is difficult to judge, at present, how the estimation of the PMP and SPS would change with climate change. That floods of given magnitude will become more frequent, is not the same as the assumption that the maximum storm producing potential of a region, may increase in the climate change scenario. This may or may not happen. Already the PMP and SPS are estimated by pulling together the experience of large storm events in the general region much larger than the catchment. This is necessary because the large storms are rare, and their limits cannot be judged without pooling of that inadequate information. Inspite of methodical documentation of the procedures by bodies like the WMO, the exact determination of PMP (and SPS) remains to be somewhat subjective and even nebulous. Further judging the effects of climate change on these estimates, without hard data about the increased unusual precipitation events would become too subjective, and should perhaps be avoided.

In regard to the return period storms, some mathematical treatment based on the trend analysis of flood peak data of the past, may be possible, even though the establishment of the significance and confidence limits for the trend would pose somewhat difficult problems. Research needs to be undertaken in this regard.

Suggested Changes in Criteria and Practice

Considering this situation, the following is suggested:

a) For large and medium dams, continue with the present practice of designing the spillway/flood lift, etc. to safely pass the PMF and SPF. However, the hydrologists and the hydro-meteorologists may have to be slightly liberal, in case of new dams, in deciding the transposability limits of the storms, etc. Further, when unusually high storms are observed in the region, check the hydrologic safety of existing dams in the region and take mitigative measures such as establishment of flood forecasting systems, flood operation policies which allow pre-depletion of the lake or delayed fillings as per rule curves, etc. If these are not enough, evaluate hazard and augment spillway capacity, flood lift, etc.

b) For new small dams, which are currently designed for 100 year floods, start a practice of designing these for 150 year return period floods, on an ad-hoc basis, until better methods of estimating the 100 year flood under the changed flood regime becomes available. (See further discussions in the Chapter 4)

3.11.3 Floods to be used for planning flood control structures

The present practice

The present practice, in general, is as follows:

a) Urban areas, industrial areas etc. require a flood protection against the flood of 1:100 years.

b) Rural areas and agricultural lands are to be protected for floods of 1:25 years.

Effects of Climate Change

Climate change may change the frequency distribution of floods. Please see our discussions about the need for research in establishing these changes. On one hand these frequency distribution may change and on the other hand the economic gap between the rural and urban residents, as also the gap in their aspirations would become smaller in the future.

The Suggested Changes in Criteria and Practice

Considering both these aspects following changes in the planning of flood protection works is suggested:

Table – 10 Suggested changes in return period of flood for planning of flood protection works

	Desired Return Period considering the changed regime after climate change	*Ad-hoc Return Period to be used on historical data not reflecting climate change*
Urban Areas	100 years	150 years
Rural Areas	50 years	75 years.

3.11.4 Drainage in urban areas

With increased frequency of extreme events, urban drainage congestion related problems may become more important. The economic loss, and the social distress caused by, say, the Mumbai 2005 storm, were catastrophic. The strategies need to include:

- Laying down standards for hydrologic design of drainage systems in urban areas. For example, in a 100 year rain, inundation need not exceed 6 hours and 1 m, etc.

- Deciding the short period storm rainfall from a larger base of automatic rain gauges.

- Laying down detailed guidelines about the use of simple CIA formula. The constant 'C' is to be linked to the hydrologic soil type (curve no.) for agricultural areas. It should also reflect the valley storage available. Detailed guidelines as available in, say, South Africa need to be adapted for Indian urban areas.

- Commercial software as available for urban flood wave propagation, (hydrologic-hydraulic models) needs to be used as a routine practice.

- Until the urban areas are made reasonably safe, public awareness about likely drainage congestion, etc. needs to be built up. Drills about desired responses need to be held.

- Strict measures for clearing of drains and waterways, and removal of encroachments and emergent acquisition of land/properties for effecting proper drainage measures need to be enforced through legal and procedural changes.

3.12 Strategies about Multipurpose Water Projects

Although multipurpose water developments have been preferred, as a policy, for a long time, single purpose projects have been flourishing. The various water uses from a project can either be conflicting/ competing, or complementary. As water stress grows, as a result of climate change or otherwise, one needs to reduce the competition and increase the Complementarities. For example:

1. Where there is ample land for irrigation, go for the dam power house, and a barrage for irrigating lower lands below the power house, rather than high level canals from reservoir.

2. Supply reservoir water for Municipal use, and supply treated effluents to supplement irrigation.

3. Do not consider either reservoir fishery or recreation, as mere byproducts, incidentally available when the project is operated for the 'main' use of irrigation or hydropower. If operated after considering

requirement of all (for example, having a higher minimum level to support fishery or recreation), the total benefit may increase.

4. Hydropower interest may require considerable water to be passed through the power house, in spring-summer, when reservoir is low; whereas irrigation peak demand would be in Autumn-winter. By changing the cropping pattern as also by resorting to pumping back in spring-summer, the compatibility can be increased.

And so on.

Reasons which seem to promote single purpose projects, perhaps, are mainly institutional:

- The erstwhile irrigation departments have not internalized the other water concerns. They act in a biased way, more to protect the basic or historic interests rather than finding a solution more relevant to the future.

- Private developers of hydropower only cater to short term commercial interests.

- Whatever its economic benefits, revenue generation from flood control is insignificant. It gets neglected

In future, hydropower from storages, with its clean status and excellent peaking performance, would be very much in demand. But innovative institutional models need to be evolved, so as to make these as multi-purpose projects.

3.13 Strategies about Erosion Control and River Management

3.13.1 Background

In general, traditionally, erosion control measures are planned in a way similar to the flood control measures. Also in general no "design floods" are used in their planning since their planning is not yet reduced to a mathematical procedure. Often, for more important works hydraulic model studies are conducted, and when this is done the flood values would become important.

Whereas losses consequent to floods generally occur only in the crop season that is loss, at most, continue for a few years if the flood covers the land with coarse sediment, bank erosion changing course of river leads to loss of productive lands which is almost perpetual. While some land is lost, the rivers also build up new lands through the process of erosion and deposition. However the process of building up the land, recognizing such land, and allotment of the land to those who lost their land in erosion, and the land actually being productive, is a long drawn process. The land erosion and deposition process would be further accentuated in the climate change scenario on account of two factors:

- The rainfall intensities (typically say the 1 hour 25 years return rain) and thus the tendency of rain to erode may increase. This can lead to larger soil erosion and larger sediment deliveries to the streams. When these sediments travel to the middle reach of the river, the braided length of the river; which is more vulnerable to unpredictable changes in the course and to bank erosion, would increase. Correspondingly, the meandering reach of the river which is more predictable in its changes would reduce.

- The frequency of the floods may increase and this will accentuate the erosion problem.

3.13.2 Suggested change in practice

Considering this situation, it is recommended that river training and erosion control works need to be designed at least for a 50 year return period flood in terms of the changed flood regime. In view of the difficulties in estimating this regime, on ad-hoc basis a 75 year flood, as based on the historical data may be used in testing the erosion control and river training works. However, for protection of strategic areas, such as urban and industrial areas, even larger flood values can be used.

3.14 Strategies for Water Quality Management

3.14.1 Background

The quality of India's surface and ground water is already endangered due to pollution. Class A waters are available only in few mountainous and forest areas while near most urban centers, water is not fit for bathing. There are few reaches where septic conditions develop in the low flow season or where the pollution load of heavy metals, fertilizers and chemicals pose a hazard. The ground waters also have micro-biological levels near urban centers. Endemic ground water pollution and non anthropogenic process through arsenic or fluoride is also common. After climate change, if withdrawals increase, the situation may worsen. The possible strategies are:

- Undertake a massive programme of data collection on surface and ground water quality. The microbiologic and heavy metal related parameters need to be covered, and the quality monitoring needs to cover the whole river and aquifers, and not just the sites near urban areas.

- Set up water quality models for each major river and aquifer. The models should depict both the point and the non-point pollution. Self purification, mass balance, etc need to be covered. The model should be capable of depicting changed situation in regard to increased loads, altered discharged regimes, changed water and air temperatures, etc.

- Enhance the capacity of the institutional and legal mechanism to take action against the polluters. Implement the "user pays – polluter pays" principle. Preferably have a three way charge: (a) a charge per unit of raw water withdrawn; (b) a rebate per unit of treated affluent return to the system and (c) a large fine per unit of pollution load return to the system.

- Put in place a system of sizeable subsidies to the users who wish to build and operate modern effluent modern treatment plants and re-circulation arrangements.
- Encourage partial treatment of domestic effluents and its direct use in irrigating non food crops, without allowing the effluent to mix with the river or aquifer waters.
- Do not encourage the use of comparatively good waters for diluting pollution loads. Insist on treatment.
- Do not encourage proposals for establishing, enhancing, or improving piped domestic water supply, unless these include effluent treatment.

3.15 Disaster Management Strategies

3.15.1 Dams as potential hazards

As already stated, dams and reservoirs can constitute a serious hazard if they fail. Strict guidelines have been laid down for either eliminating or minimizing such hazards to an acceptable level. However, a large number of existing structures built before such strict guidelines were put into practice, are under designed. The situation would deteriorate further if, after climate change, the flood regime changes. Difficulties in deciding the changed values of such floods, particularly the hypothetical floods of PMF and SPF have already been discussed. The possibility of the hazards of failure becoming more significant cannot be denied.

3.15.2 Dam-break analysis – as a routine

In many countries, dam break analysis is a usual drill to be followed in planning any reservoir. These results are then used in planning contingencies of failure. In India this is not a usual practice and such analysis is done only for dams which are potentially unsafe, on a case by case basis. The reason for the Indian practice is that the analysis itself may create a doubt in the public mind about the safety of the structure, even though the structure fully meets the prescribed standards. However, the information environments in India are changing, and with larger availability of information and transparency of the process, misinterpretation may reduce. After considering this and the possibilities of increased hazards, it is recommended that the dam break analysis, analysis of failure of river training works etc. should be done in a routine way, and emergency preparedness plans may be drawn up.

3.15.3 Equipping for dam-break analysis

In simple dam break situations, where the flow is likely to be confined to the main channel and the nearby areas, the problem can be treated as a one dimensional. MIKE-II and NWS-DAM BRK models or the HEC model can be used as the hydrodynamic 1-D models. The capabilities of using these models need to become wide spread.

For modeling the spread of the flood waive in the flood plains and rivers in the event of a failure, two dimensional hydrological models are essential. Today, capabilities of using such models, (some of which are commercially available) are limited to a few universities and research stations like CWPRS and CWC. If a nation wide programme for such analysis is to be followed, the capabilities would have to be spread all over so that this becomes a routine design office practice. Also development of appropriate model within India appears desirable.

3.15.4 Empowered Dam Safety Services

Once it is recognized that dams can be potential hazards, and that the risks may increase with climate change, and that the interest of the Dam owners (Governmental, Public, or Private) in this regard are secondary to these exposed to the potential hazard, the need for regulation becomes self evident. The following Strategies are recommended:

- Set up empowered Dam Safety Service, in all States, as also in the Center, through legislative action. All of these will use uniform, nationally acceptable, safety standards.

- All dams of large size (to be specified) as also dams near interstate borders, where a significant cross-boundary hazard is likely, would be covered by the Central Dam Safety Service.

- All other dams having a significant hazard potential, would be covered by the States Dam Safety Service.

- A Joint Safety Mechanism for dams located on Inter-State rivers would need to be established.

3.16 Conflict Management Strategies

3.16.1 Introduction

Under the Climate Change situation, water allocation conflicts, within individual users, within users of different classes, within interest groups of the different types of uses, (including the use and non-use), amongst States of India, and amongst co-basin Nations, will all become more acute. However, the silver lining would be that the users would realize that it is not the action of others, but uncontrollable forces, which have aggravated the situation; and therefore, a commonality of interest in co-operation, could be established.

3.16.2 Managing conflicts within India, and, within a basin

The Principles of Integrated River Basin Management, and of Integrated Water Resources Management, would provide the main strategy. These principles are already included, without a direct reference, in the NWP (2002). The strategies need to include:

- Setting up of empowered Basin Authorities, not as an inter-governmental body amongst the States and Center alone, but as a body of all stakeholders including the Governments. This could be somewhat on lines of the recommendations of the NCIWRD (1999).

- Setting up some sub-basin or area authorities, under the management of the Basin Authorities. These bodies can have local quasi-judicial powers in regard to inter-user conflicts, somewhat on lines of the co-operative societies.

- Setting up a Permanent Water Tribunal, with both Judicial and Domain Expert members, for inculcating the growth of specialization, and for faster and more efficient conflict management.

- Encouraging solutions through mediation and voluntary arbitration, after a failure of negotiations, and before resorting to adjudication.

- Enacting, by the Union legislature, one or more acts, using the entry 56 of the Union list, to enable these changes.

3.16.3 Conflicts, within India, in regard to Inter-basin transfers

Inter-basin transfer proposals constitute an important method of increasing the usable waters. These cold involve storage in aquifers also. However, these give rise to conflicts. Some such conflicts, involving the use in non-basin states, have been solved in the past, through agreements amongst states; but the process is becoming difficult as water stress grows, and as political situation becomes fluid. The suggested strategy is:

- Through a Union legislation, set up or empower an authority with powers to decide the availability of surplus water in River basins after consulting the co-basins States and to recommend inter-basin transfers of water to deficit basins.

- Set up a mechanism through which the decision of the authority can be challenged, and the matter settled. The Standing Water Tribunal can be one such mechanism.

- Lay down policies about the ownership, financing and revenues, etc., in regard to such transfers and about the implementation of the scheme.

- After arming itself in this regard, the Center needs to encourage the States towards negotiated settlements.

3.16.4 International water conflicts

We have already brought out that climate change may alter the cross boundary flows, which the Indian rivers and aquifers receive, from the upper riparian. Similarly, the flows from India to the lower riparian may also get altered. Conflicting situation could become more acute, but, as stated, a commonality of interest in mitigating the situation would prevail. Considering this, the following strategy is suggested:

- India's international water management is governed, in a large way, through existing treaties and agreements. No short-term actions are necessary in this regard. Continue, as usual.

- In view of the larger flood related concerns, have larger co-operation in regard to flood warning and forecasting. Set up, if possible under SAARC or other umbrella, comprehensive flood forecasting and flood wave transport models:

    a) China-India-Pakistan in regard to the Indus basin.

    b) Nepal-India-Bangladesh in regard to the Ganga arm of the G-B-M basin

    c) India-Bangladesh in regard to the Meghana arm, as also for Teesta and Lower Brahmaputra.

- In the long term, we need to co-operate more, towards working out a more optimum and more integrated solution for Indus Water Management. Demand growth both, driven by climate change, and much lager concerns about the ecology of the Indus Delta and its effects on the Kutch, need to be kept in view. If a better solution with gains to both is possible, it is worth working for.

- The Ganges Water Treaty mentions the need for maintaining the river regime. We need to understand that climate change was not reasonably foreseen at that time, and the operation of this general clause may have to consider those circumstances.

3.17 Public Awareness and Community Preparedness

There is a need for making authentic relevant information about Climate Change concerns easily available to the people of India, and to sensitize them about the issues involved and about how the issues are being tackled. A large scale campaign would be necessary. This would have to be done jointly by the Central and State Governments, and the services of NGOs may have to be utilized in the campaign. This aspect has been further discussed in the report of the Sub-Committee on Policies and Institutional Reforms.

4 CHANGES IN ACCEPTABILITY CRITERIA OF WATER PROJECTS

4.1 Introduction

The Water Development Projects, as planned, get executed only when they meet some acceptability criteria. The criteria can be classified as:

1. Reliability with which the water in sufficient quantity is available for use after considering the inter-annual variability of available water.

2. Acceptability criteria in regard to reservoir sedimentation.

3. Acceptability of the performance of flood control works.

4. Acceptability of design floods for safety of dams.

5. Acceptability of the environmental impacts of the Project.

6. Acceptability of the social impacts of the Project.

7. Acceptability of the economic performance of the Project.

Successfully meeting all the acceptability criteria simultaneously is the crux of the problem of planning water development projects. The exact criteria have been partly specified and are partly not specified in quantitative terms. Also, as the projects are getting more complex, some updating of the criteria is already due.

The likely climate change scenarios further change the planning environments. Under these conditions, the climate related concerns are also to be incorporated in the criteria. An attempt in this regard has been made in this chapter.

4.2 The Process of Changing the Acceptability Criteria

As stated above the acceptability criteria in regard to planning of water projects have been evolved over time; some criteria are well documented while others are not. These criteria would have been evolved initially as the agency practices of the CWC, would have been discussed in various fora such as CBIP (which used to serve as a common platform for water professionals in the Center as also in the States). Some of these criteria have later on been included in the various Standards and Guidelines of the Bureau of Indian Standards. Some would have been accepted by the Planning Commission and would have been included in their circulars. Some would have been reflected in the Reports of the various Commissions such as The RBA, NCIWRD etc.

While concerns related to Climate Change would need a re-look and modification in these criteria, and while there is a considerable urgency in making such modifications, it may not be proper to make such modification only through the Authority of the High Level Steering Committee (headed by

Secretary, Water Resources) of the National Water Mission or even by the Prime Minister's Council on Climate Change.

Since, these criteria concern the large body of Water Professionals in India, a larger National debate may be necessary before accepting the changes. The proposals as given in this Chapter, and as modified by the concerned Sub-Committees and the HLSC, could therefore be considered as important and studied proposals which would be further debated in the Commission meeting of the CWC, as also in the various other fora, and may even have to be put up to the National Water Board. Involvement of the Planning Commission and of the Bureau of Indian Standards may also have to be ensured. The exact procedure involving both a wide debate and a quick decision making would have to be decided carefully.

4.3 Reliability in Regard to Water Availability

4.3.1 The present methodology

The Present methodology and criteria is as under:

a) Simulate the performance of the water projects for a series of years, based on the historical or current hydrological inflow data and planned demands. The minimum length of simulation studies from say 10 years for a diversion project to 40 years and more for carry over project.

b) If, in any year in the simulation, the full demands can be met, the year is termed as successful. If full demands cannot be made, the year is termed as failure.

c) The reliability is computed as the percentage ratio of the successful years to the total number of years for which the system is simulated.

d) The minimum reliability, as specified, is:

- Irrigation use – 75%
- Hydro-electric use – 90%
- Domestic or Industrial water supply – near 100%

4.3.2 Need for updating

As stated some updating is due even without considering climate change, the risk handling capacity of the Indian farmers and the growth in availability of crop insurance will allow a slightly lower reliability. Failures can be counted separately for each crop/crop season rather than for the year as a whole. Isolated hydro power projects are not built any more and integrated operation of power projects in a grid is possible.

The concerns related to climate change also need to be incorporated. We do not know for sure as to what water related changes will take place, but we have a fair idea of the more likely scenarios.

4.3.3 The suggestions for changes in acceptability criteria

Considering this, the following methodology and criteria are suggested:

For more important Projects:

a) Simulate the performance of the water projects for a series of years, based on the historical or current hydrological inflow data and planned demands. The minimum length of simulation studies from say 10 years for a diversion project to 40 years and more for carry over project.

b) If, in any year in the simulation, the full demands can be met, the year is termed as successful. If full demands cannot be made, the year is termed as failure. However, for agriculture use, keep track of failure for each crop season such as perennial, Kharif, Rabi, hot weather, two seasonal, etc. Also, depending upon the cropping pattern and economics, decide on one crop season as the principal crop season which needs to yield a reliable income to the farmer, and allow the other crops season as an unreliable, giving additional income wherever the "end of wet season" storage allows its irrigation.

c) For each broad region of India, such as Himalayas, Northern and North western alluvial plains, Central, and Eastern alluvial plains, Western Peninsula, Eastern Peninsula, North East, etc. not more than three climate change scenario would be prescribed in terms of:

i. Changes in water inflows in terms of the averages and the variability.

ii. For Irrigation - Changes in the command area rain fall in terms of the average and the variability.

iii. For Irrigation – Changes in the evapo-transpirational requirements in terms of averages.

d) Repeat the simulation for each of the climate change scenarios.

e) Use the following changed reliability criteria:

- For Irrigation use, the reliability of the project towards the "principal crop / season" would be, on the minimum, at say 70%, instead of the current 75%, when the series which does not consider Climate Change is used. Such a slight reduction is desirable since the risk averseness of the Indian farmers would have reduced over time, and since a smaller reliability will lead to larger usability of the depleting resource. This percentage has to be substantially lower than the once specified in the "without Climate Change" case; to depict the uncertainties in regard to the actual Climate Change.

- For irrigation use, in a sensitivity type analysis, when the series appropriate to any of the climate change scenario is used, the reliability of the project towards the "principal crop / season" would be, on the minimum, at say 60%. This percentage has to be substantially lower than the once specified in the “without Climate Change” case; to depict the uncertainties in regard to the actual Climate Change.

- For hydro-power use, the reliability, without considering climate change, for the firm power, would be 90%. However, the firm power requirement of the Project can be changed from season to season if grid operations can accommodate such a change.

- For hydro-power use, the reliability, while considering climate change, under any of the specified scenarios, for the firm power, would be 80%. However, the firm power requirement of the Project can be changed from season to season if grid operations can accommodate such a change.

- For domestic and industrial water use, the reliability, without considering climate change, for the firm power, would be near 100%.

- For domestic and industrial water use, the reliability, while considering climate change, under any of the specified scenarios, for the firm power, would be say 90%.

For other Projects:

While the procedure outlined under “For more important Projects” would have to be followed for all Nationally important Projects, (both in case of new important Projects and for reviewing the likely performance of existing important Projects) it would be too cumbersome to follow these elaborate procedure for all other Projects, such as minor and medium irrigation projects, the smaller of the major irrigation projects etc. For such Projects simpler procedures would have to be evolved. These simpler procedures could also involve some type of a sensitivity analysis of the Project under changed circumstances. As per the current practice, simulation under a long series of flows which does not take Climate Change in account would have to be done. However, elaborate preparation of the alternate inflow and demand series under Climate Change scenario could perhaps be avoided through the simplified procedure. For minor and medium Projects, even more simple procedures would have to be evolved after studying the results of the elaborate procedure on a few Projects in each region and for different ranges of capacity/inflow ratio. A research type of study, in this regard, is already being proposed.

4.4 Acceptability Criteria in Regard to Reservoir Sedimentation

4.4.1 Need for updating

The increasing erosivity of storm rainfall may lead to larger soil erosion and larger delivery of sediments to the rivers in the scenarios after climate change.

Climate change is not the only reason for changes in the quantum of sedimentation in the rivers. The fast changing land use, on one hand, and the progress of large number of programmes for control of erosion in water sheds would change the quantum of sediments. The data available through the stream gauging network and through the surveys of reservoirs has shown that trends do exist.

4.4.2 Present methodology

The present method of planning for sedimentation of reservoirs is based on the concept of “full service time” and “feasible service time”. The reservoir is required to yield its full outputs, as planned for the “full service time”; and this has to be fifty years for irrigation and twenty five years for hydro-electric use. Beyond the full service time and up to the feasible service time, the outputs may progressively reduce. But efficient operation without any blockage of outlets etc. has to continue for the feasible service time, which is hundred years. These procedures are sound and robust and can be continued after some adjustments of sediment rates.

4.4.3 Suggested changes in methodology

Considering the situation, following measures need to be taken:

(i) For each basin, establish sediment budget indicating the production of sediments from different sub-catchments, flow of sediment, deposition of sediment in the reservoirs in the basins, and the flow of sediments into the ocean systems. This sediment budget would be balanced with the observation at sediment measuring sites and re-surveyed reservoirs. An initial attempt in this regard was done long back by Dr. Dhruvanarayana, who estimated a sediment budget for India when not much data was available.

(ii) Expand the sediment budget into a sediment production, movement and deposition models. For this established the soil erodibility from soil data, slopes by inversing elevation data, land uses from satellite data and rainfall erosivity from meteorological data. Fit a universal soil loss equation, couple it with delivery ratios and trapping efficiencies and trace sediment budget. Calibrate the model with available data of sediment flows and reservoir sedimentation.

(iii) Stimulate the model for changed rainfall intensities and changed land uses to predict trends in sediment production. Use the future likely sediment data, after considering the trends in the data both for planning new reservoirs and for analyzing the likely performance of existing reservoirs.

(iv) Conduct further research on coupling of unsteady flow hydraulic models and the sediments transport models. Such a coupled model should be able to project the changes in the geometry and bed configuration of an alluvial stream in a flood event. Such models are as yet not available although attempts are made. If India can develop such a model which works, it would yield large benefits in terms of planning river control works in the face of changing sediment inputs.

4.5 Acceptability of Performance of Flood Control Works

After considering all these aspects, (see separate chapter) following changes in the planning of flood protection works are suggested, in view of climate change possibilities and other considerations:

Table – 11 Suggested changes in return period of flood for acceptability of performance of flood protection works

	Desired Return Period considering the changed regime after climate change	*Ad-hoc Return Period to be used on historical data not reflecting climate change.*
Urban Areas	100 years	150 years
Rural Areas	50 years	75 years.

It needs to be brought out that no change in the desired return period in regard to the urban areas is being suggested. While this will continue to be 100 years, on an adhoc basis, it is being assumed that a 150 year return period flood, based on the historical data, may be some what similar to the 100 year floods with the likely increased frequency of flooding. As soon as larger database or better methodologies for deciding the frequency under the Climate Change become available, we can switch back to the 100 year return period. Similarly, the desired return period for the rural areas is proposed to be increased from the current preference of 25 years only to reflect the better economic conditions of the rural area, and is not related to Climate Change. Again on an adhoc basis, it is assumed that a 75 year return period flood, based on the historical data, may be some what similar to the 50 year floods with the likely increased frequency of flooding.

Another way of incorporating a seemingly conservative practice, in the face of a likely climate change, would be to use the same return periods as are considered relevant after ignoring the climate change, but of using the “upper confidence values”, instead of the “expected values” as at present. On one hand, this alternative appears less of a basic change, and would therefore be more acceptable. But, on the other hand, the confidence bands are related to sampling errors attributable to considering a short data sample from a very, large population, and not to either the data quality or trends in data. Thus, if a long data series is available, the bands would be less wide, and the allowance to be made for climate change would reduce.

4.6 Acceptability of Design Floods for Safety of Dams

Considering the situation, (See separate discussions in the relevant chapter) the following procedure/ change is suggested in view of the possibility of climate Change, and other considerations:

- For major and medium dams, continue with the present practice of designing the spillway/flood lift, etc. to safely pass the PMF and SPF. However, the hydrologists and the hydro-meteorologists may have to be slightly liberal, in case of new dams, in deciding the transposability limits of the storms, etc. Further, when unusually high storms are observed in the region, check the hydrologic safety of existing dams in the region and take mitigative measures such as establishment of flood forecasting systems, flood operation policies which allow pre-depletion of the lake or delayed fillings as per rule curves, etc. If these are not enough, evaluate hazard and augment spillway capacity, flood lift, etc.

- For new small dams, which are currently designed for 100 year floods, start a practice of designing these for 150 year return period floods, as based on the historical data which may not reflect the effect of climate change, on an ad-hoc basis, until better methods of estimating the 100 year flood under the changed flood regime becomes available.

4.7 Acceptability of the Environmental Impacts of the Project

At present EIA is done and on this basis the project acceptability is decided. Both for updating this procedure and for incorporating the climate change concerns following additions are suggested:

- Specify the EFR which needs to be provided, season-wise. Specify the flushing flood requirements.

- Conduct an analysis for with project and without project situations to bring out the main hydro-ecological parameters such as the timing of the annual rise and fall, number of days for which the river stage above the bankfull stage, the velocity and depth of flow during the low flow period etc.

- Discuss how the hydrological parameters are likely to change with project and without project conditions, if the climate change occurs.

- Decide the acceptability on the basis of the EIA, availability of EFR, without considering the climate change and the changes in the hydro-ecological parameters likely because of the climate change.

4.8 Acceptability of the Social Impacts of the Project

The present methodology requires that the displacement and rehabilitation of population should be as per the specified policies. No changes are suggested in these to incorporate climate change concerns.

4.9 Acceptability of the Economic Performance of the Project

At present, B/C analysis is done and the minimum B/C ratio is specified. Changes in methodology are due somewhat in lines with the Nitin Desai Committee Report after some updating.

No major changes, apart from updating, are considered necessary. If B/C ratio after climate change are calculated, the cut-offs under the scenario can be significantly lower. In particular, under climate change scenario, for schemes in drought prone areas, schemes in tribal areas, and for schemes of the flood control or erosion control type, B/C ratios less than 1 (say 0.8) could be considered acceptable to protect the sections vulnerable to climate change and also to encourage economical development.

5 PROGRAMMES TO MITIGATE EFFECTS OF CLIMATE CHANGE

5.1 Data Collection and Analysis Programme

5.1.1 Introduction

The data collection and analysis situation requires further and massive improvement in view of the climate change concern apart from the concerns of growing complexities. Special data collection programmes would have to be launched in regard to:

- Improved basin-wise water situation assessment through water balances

- Developing water assessment models capable of incorporating changes in precipitation and evaporation regimes and land use changes.

5.1.2 Data collection in estuarine region

a) For collecting data regarding the coastal and estuarine water and salinity situation, modern technologies would have to be used for round the clock recording of tidal water levels and the changing discharges in both directions.

b) A massive data collection programme for the estuarine region to know the tidal levels, tidal hydraulics and salinity regimes.

5.1.3 Data collection in areas sensitive to climate change

Some regions of India with deficient water supply and where the climate change affects would further deteriorate the situation need to be identified. Low rainfall areas where evaporation needs will increase would be one such region. The densities of hydrometric stations would have to be increased for such regions.

The snow bound and glaciated areas have been identified by various scientists working in the field as areas which are sensitive to Climate Change. ICIMOD (2007) has brought out that against the normal WMO recommended normal density of 1 meteorology station for every 100 km^2 to 250 km^2 of the mountain region; the actual density in the Himalayan region, above 1000 m altitude is around 1 station per 10000 km^2. This indicates the scarcity of the data in the Himalayas. The immediate tasks could be one of increasing the density at least five times to meet the WMO standards under “very difficult condition”, and then to continue further strengthening. Similar order of increase for the hydrometric stations would be required. For a few glaciated catchments, complete data about snow and ice physics, climate parameters, flows and sediment flows as also the mass balance and energy balance may have to be collected. On the basis of such data, snowmelt and glacier-melt models suitable for high altitude (above permanent snow line) Himalayan valley glaciers may have to be developed. Similarly for seasonal snow areas snow melt models which consider the effect of air temperature, lapse rate, slope and aspect may have to be developed for general regional use.

Other problems of these high altitude areas, which would get accentuated by Climate Change, are:

- GLOF;
- Floods caused by landslides/glacier moraine dams and their bursts;
- Increased sediment load in reservoirs due to landslides etc.

All the available data of such occurrences may have to be pooled and regional methodologies for estimating their effects in probabilistic terms may have to be worked out.

Measurement of discharges, in hill streams, is another problem which needs to be overcome. Resource limitations may not permit a dense network of discharge sites, since this is costly. However, a few observations on different streams, and their correlation with permanent stations, would be necessary. This can be done by roving parties, making the observations for about a week, and moving on. Again, for each observation, the snowmelt, the glacier melt, the base flow from ground and the quick surface flow may have to be distinguished. Methods utilizing nuclear hydrology, and using both the unstable and the natural stable isotopes may come handy for this purpose.

5.1.4 Better network for evaporation data

Modern instruments which would monitor parameters like evaporation/water flux, soil moistures etc. would have to be incorporated in a much larger way in the hydrometric network.

5.1.5 Better network for river hydraulics

With Climate Change, river flooding and river erosion problems will increase. A close monitoring of the changes in the hydraulic carrying capacity of the rivers becomes important. Even today, the lack of this information (except at the few discharge sites) is an important information gap in understanding floods and erosion related behavior.

The total length of the larger rivers, in areas where floods and erosion may occur, could be around 70,000 km. Abot 7000 river cross sections can be pemenantly set up, and located and marked (through pillars) on the ground, as also on a grid. Every year, by superposing the remotely sensed data, information about actual flooding, as also about erosion and deposition can be systematically marked. Every 5 years, as a programme, the river cross sections can be taken, using GPS, echo sounders etc. By simple non uniform steady flow computations, the water level profiles for different disharges can be computed. This will help in detecting morphologic changes, and changes in carrying capacities.

5.1.6 Preparation of maps of flooded and flood prone areas

Using the river geometry and the flood area maps, it would be possible to judge the discharges at any point of the stream network. For this, the DEM would have to be linked to the flood flow model. After the model gets proved in the process, flood prone areas for a given flood frequency could be mapped from the model, for the changed hydraulics.

This would be an aid to planning or modifying the flood protection works. Again, the proposed flood management plan can be studied on the model. If, an unsteady flow model is linked to the topography, effects of these, on the upstream and downstream, can be studied.

5.2 Programmes for Improving Modeling and Analytic Capacities

(i) Improved capacities for unsteady flow models to be used as routines.

(ii) Monitoring the complete sediment balance of river basins, and linking these models to sediments production models like universal soil loss equations.

(iii) Linking the digital elevation models for low lying areas with hydraulic models to understand flood situations under different floods.

(iv) With rise in flood frequency one hand, and rise of see water levels on the other hand, the problem of protecting the estuarine and coastal lands would become important. The capability of linking storm surge models, tidal hydraulic models and flood flow models would have to be built up through a large programme covering all coastal states.

5.3 Programmes for Eventual Implementation

1. Raising storage capacities of large dams wherever feasible;
2. Raising live storages of minor dams, even without raising the dams, by a massive programme of installing gates where feasible.
3. Programme for restoration of small water bodies can be revised with a changed focus.
4. Programme of adopting automation in irrigation systems including automation based on sensing of soil moisture in the root zone.
5. Programme for reducing inadvertent evaporation from waste lands, fallow lands and agriculture land between crops, through use of plastics, mulches etc.
6. Programme for enhancing seasonal ground water fluctuations through conjunctive use of surface water in wet season and ground water in dry season.

7. A large scale programme of reusing partially treated municipal domestic effluents directly for irrigation of non food and food crops, without mixing these with natural rivers/aquifers.

8. At present, drip irrigation seems to be the only method by which the evapo-transpiration of crops can be reduced. The drip irrigation would have to be promoted in a large way. Innovative solutions for adopting drip and rotational surface irrigation would have to be promoted.

5.4 Programme for Changing Acceptability Criteria

This has already been discussed in Chapter 4.

5.5 Researchable Issues in Water Sector relating to Climate Change

Researchable Issues in Regard to Climate Change: Many researchable issues in regard to climate change lie outside the domain of water sectors and would have to be conducted by atmospheric science groups. Amongst these, two issues which need to be looked into by the Indian atmospheric science community has particularly relevance to Indian water sector are:

- The methodologies for effective downscaling from Global or regional scale climate models to basin or project scale models of say, 20' x 20' to 10' x 10'.

- Studying and understanding the likely effect of Climate Change on the south-west and north-east monsoons over India after considering the tele-connections between the southern and northern hemi-spheric circulations.

While these issues in atmospheric sciences have to be resolved outside the water sector, the water related Institutes need to give financial support and need to watch and monitor such research papers. However, some essential research would have to be done in regard to:

1. Studying the sensitivity of different hydraulic types of water projects to different climate change scenarios, and abstracting simple rules in this regard.

2. Improvements required in hydrometric networks to incorporate climate change.

3. Building sediment yield models using the universal soil loss models equations and the observed sediment data in rivers and reservoirs. Using these models to predict sediment load changes under changed precipitation regime, land use and agricultural practices.

6 PRELIMINARY PLAN OF ACTION AND COSTS

6.1 Plan of Action

An Action Plan based on this report is given in the following pages:

Note that this Action Plan mentions a list of actors which may not be exhaustive. Also the actors, as mentioned, are mainly Governmental. This merely indicates that these actors have to get the necessary work done and not that they have to do the work themselves. Outsourcing to consultants and other Institutes and even privatization in implementation using Private capital can be allowed or even encouraged. Involvement of Academic and Research bodies, private or public, in items involving research is very desirable, and there involvement in studies also is possible.

Table – 12 Preliminary Action Plan for Surface Water Management in view of likely Impacts of Climate Change on Water Resources

Objective	*Strategy/*	*Sub-Strategy*	*Action Points*	*XI Plan*			*XII Plan*					*Actor*
				Y1	*Y2*	*Y3*	*Y4*	*Y5*	*Y6*	*Y7*	*Y8*	
(A) Better understanding of Water Resources, particularly aspects likely to be affected by Climate Change	**(i) Data Collection**	**1. Estuarine Region**										
		a. Coastal and estuarine water and salinity and tidal water levels and the changing discharges in both directions.	Network planning									CWC, DoOD, Maritime Boards, States
			Data collection									
		2. Areas Sensitive to Climate Change										
		a. Low rainfall areas	Network planning									CWC, IMD, States
			Data collection									
		b. Himalayan region, above permanent Snow line, and glaciated areas	Network planning									GSI, CWC, NIH, States
			Data collection									
		c. Himalayan region, seasonal snow areas	Network planning									GSI, CWC, NIH, States
			Data collection									

Objective	*Strategy/*	*Sub-Strategy*	*Action Points*	*XI Plan*			*XII Plan*					*Actor*
				Y1	*Y2*	*Y3*	*Y4*	*Y5*	*Y6*	*Y7*	*Y8*	
		d. Better Network for Evaporation Data	Network planning	■								ICAR, IMD, CWC, NIH, States
			Data collection		■	■	■	■	■	■	■	
		e. Raingauge data collection network through automated sensors	Network planning	■								ICAR, IMD, CWC, States
			Data collection		■	■	■	■	■	■	■	
	(ii) Re-assessment of situation	**1. Re-assessment of basin-wise water situation**										
		a. Develop or adopt comprehensive water balance based model	Study	■								CWC, NIH, Academic Institutes
		b. Fit models to basins, using current data.	Study		■	■						CWC, NIH, States, Academic Institutes
		c. Assess likely future situation, with changes in demands, land use, precipitation and evaporation.	Study			■	■					CWC, NIH, States, Academic Institutes
		d. Alter development Scenarios towards better acceptability	Policy		■	■	■	■				CWC, Planning Commission, States
		2.Classify basins										
		a. As open or closed/ closing	Study	■								CWC, NIH, States
		b. Encourage water harvesting in open basins.	Policy		■							CWC, MoA, States
		c. For closed basins, encourage water harvesting only if it is socially desirable, and if some other use can be curtailed.	Study	■	■	■	■					CWC, NIH, MoA, States

Objective	Strategy/	Sub-Strategy	Action Points	XI Plan			XII Plan					Actor
				Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	
	(iii) Researchable Issues	**1. Supporting Atmospheric Science Groups**										
		a. Downscaling of GCM or RCM to basin/Project level	Support									DST, MOWR, academic institutes
		b. Effect of Climate Change on Monsoons	Support									DST, MOWR, academic institutes
		2. Water and Climate related										
		a. Studying the sensitivity of different hydrologic types of water projects to different climate change scenarios	Study									CWC, NIH, academic institutes
			Evolving Strategies									
		b. Improvements required in hydrometric networks to incorporate climate change	Study									CWC, NIH, IMD, Academic institutes
(B) Increasing food and water security through increasing useable water	**(i) Reducing inadvertent evaporation**	**1. Minimizing inadvertent evaporation**										
		a. Evaporation from water logged areas	Guidelines									CWC, NIH, IARI
			Pilots									
		b. Evaporation from barren land	Guidelines									CWC, NIH, IARI
			Pilots									
		c. Evaporation from agricultural fields between crops	Guidelines									CWC, NIH, IARI
			Pilots									
		d. Evaporation from wet soil between crop rows in irrigated fields	Guidelines									CWC, NIH, IARI
			Pilots									

Objective	Strategy/	Sub-Strategy	Action Points	XI Plan			XII Plan					Actor
				Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	
	(ii) Increasing storages in water use systems	**1. Use of ground water space as storage, through enhanced fluctuations**										
		a. Kharif channels	Guidelines									CWC, UP, CGWB
			Pilots									
		b. Pumping water from Terai to deplete ground water before floods	Guidelines									CGWB, NIH
			Pilots									
		c. Conjunctive use in time, with larger ground water use in bad years	Guidelines									CWC, INCID, CGWB
			Modelling									
			Pilots									
		2. More efficient use of vadose zone moisture storage										
		a. Conserving moisture through mulches and plastic sheets	Literature Review									CWC, INCID, IARI
			Pilots									
			Guidelines									
		b. Reducing gap between Kharif harvesting and Rabi sowing	Literature Review									INCID, IARI
			Pilots									
			Guidelines									
		3. Repeated use of storage during wet season										
		a. Dug out ponds in fields	Literature Review									Dry land Agriculture, INCID & States
			Pilots									
			Guidelines									
		b. Irrigation with dependable Kharif and small non dependable Rabi crops	Guidelines									Planning Commission, Gujarat,
			Technology Transfer									

Objective	*Strategy/*	*Sub-Strategy*	*Action Points*	*XI Plan*			*XII Plan*					*Actor*
				Y1	*Y2*	*Y3*	*Y4*	*Y5*	*Y6*	*Y7*	*Y8*	
												CWC, States
		4. Increasing storages and carry over storages										
		a. Encouraging construction of carry over storages	Policy									Planning Commission, CWC
		b. Clarifying the dependability related concept – reliability of outputs and not input dependability	Policy									Planning Commission, CWC
			Capacity Building									
		c. Changing the Reliability criteria regarding water availability	Proposal									CWC, States, Planning Commission
			Debate									
			Decision									
		d. Study possibilities of increasing dam heights	Studies									CWC, States
		e. Implementing a programme for raising heights and storages of dams	Proposals									CWC, Planning Commission, States
			Appraisal									
			Implementatio n									
		f. Developing methodologies and designs for raising dam heights	Capacity Building									CWC, States
		g. Listing of minor tanks where the full reservoir level can be raised without increasing dam heights by installing gates	Guidelines									CWC, States
			Studies									
		h. Implementing a programme of increasing capacities of minor tanks	Proposals									CWC, States
			Appraisal									
		I. Listing tanks and water bodies which can be effectively de-silted, and where the silt has a commercial use	Guidelines									States, MoWR
			Studies									

Objective	*Strategy/*	*Sub-Strategy*	*Action Points*	*XI Plan*			*XII Plan*					*Actor*
				Y1	*Y2*	*Y3*	*Y4*	*Y5*	*Y6*	*Y7*	*Y8*	
		j. Implementing the current programme of rehabilitating water bodies, with changed focus	Proposals									CWC, States
			Appraisal									
			Implementatio n									
	(iii) Understanding water use efficiencies	**1. Increasing water use efficiency**										
		a. Recognising and encouraging reuse of return water	Policy									INCID, CWC
		b. Computing basin efficiency	Study and Technology Transfers									INCID, CWC
		c. Decision support systems in canal irrigation	Pilot									CWC, CWPRS
		d. Automation in canal irrigation including soil moisture monitoring	Pilot									CWC, CWPRS
		e. Participatory management by water users for improved efficiency	Action Research									WALMIs, CADA, CWC
		f. Modernisation of canals and distribution systems	With proportionate regulators									CWC, States, Planning Commission
			With decision support systems									CWC, States, Planning Commission
	(iv) Encouraging water transfers from surplus to deficit areas	a. Expediting planning and implementation of schemes for inter-basin water transfers	Feasibility studies									NWDA, CWC, States
			General agreements									
			Preparation of DPRs									
			Prepare proposals for ownership, financing and implementation									

Objective	Strategy/	Sub-Strategy	Action Points	XI Plan			XII Plan					Actor
				Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	
			Implementation									
		b. Formulating schemes for long distance transfer of surplus flood flows and their recharge to ground water, after considering costs and land acquisition problems	Study									NWDA, CGWB Planning Commission, CWC
			Pilot									
			Feasibility									
			Appraisal									
(C) Improving Intra-national Equity in usable water	**(i) Drought Management**	**1. Drought Management**										
		a. Conducting the economic carrying capacity studies considering land, water and livelihood to plan how much water is necessary to yield reasonable income	Studies									Planning Commission, CWC, NWDFA States
			Policy									
		b. Increasing the use of irrigation through in-basin development as also inter-basin transfers	Policy									Planning Commission, CWC Academicians, NCAER
			Proposals									
			Debate									
			Decision									
		c. Changing cropping patterns towards low water use crops	Policy									MoAC, Planning Commission, IARI
			Implementation									
		d. Adopting integrated farming systems	Policy									MoAC, Planning Commission, CWC
			Implementation									
		e. Water harvesting, provided this is socially desirable and provided that corresponding water saving is possible elsewhere in the region	Studies									MoAC, Planning Commission, IARI, NWDA
			Implementation									

Objective	*Strategy/*	*Sub-Strategy*	*Action Points*	*XI Plan*			*XII Plan*					*Actor*
				Y1	*Y2*	*Y3*	*Y4*	*Y5*	*Y6*	*Y7*	*Y8*	
		f. Encouraging non-agricultural developments of the type where not much water is required		■	■	■	■	■	■	■	■	MoAC, IARI, Planning Commission, Rural
		g. Enact enabling legislation to regulate ground water use during droughts	Policy	■								CGWB, States
			Proposals	■	■							
			Debate		■							
			Decision		■	■						
(D) Improving Societal sustenance under Climate Change	**(i) Dealing with changing flood and sea level regime**	**1. Estuarine Management**										
		a. Embark on a massive tidal hydraulics data collection programme.	Network planning	■								CWC, CPT, DoOD, Maritime Boards
			Data Collection		■	■	■	■	■	■	■	
		b. Increase modeling capacity about storm surge, tidal hydraulics, salinity and unsteady flow..	R&D		■	■						CWPRS, NIH, CWC, NWA
			Capacity Building		■	■	■	■				
		c. Take up programme for planning tidal embankments to protect against tides with increased flood frequency and increased sea level.	Studies	■	■							CWC, DoOD Maritime Boards States
			Proposals		■	■	■	■				
		d. Implement tidal embankments	Implementing interventions		■	■	■	■	■	■	■	States
		e. Study possibility of using some tidal channels for fresh water storage.	Action Research	■	■							WALMIs, States, CWC
		f. Implement the above with user participation.	Action Research		■	■	■	■	■	■	■	WALMIs, States, NGOs
		g. Study effect of sea level rise on ground water salinity, and mitigative measures like induced recharge.	Study		■	■	■					CGWB, CWC, States
			Proposals				■	■	■	■		

Objective	*Strategy/*	*Sub-Strategy*	*Action Points*	*XI Plan*			*XII Plan*					*Actor*
				Y1	*Y2*	*Y3*	*Y4*	*Y5*	*Y6*	*Y7*	*Y8*	
	(ii) Adjusting to changing flood regime	**1. Floods to be used for ensuring dam safety in climate change situation**										
		a. New acceptability criteria need to be evolved. Suggestions included.	Proposal	■								CWC, Planning Commission, States BIS
			Debate	■	■							
			Decision		■							
		2. Floods to be used in planning flood control works										
		a. New acceptability criteria need to be evolved. Suggestions included.	Proposal	■								CWC, Planning Commission, States BIS
			Debate	■	■							
			Decision		■							
		b. Improved capacities for unsteady flow models to be used as routines	Capacity Building	■	■	■	■					NWA, NIH, CWPRS, CWC,
			Use		■	■	■	■	■	■	■	
		c. Linking the digital elevation models for low lying areas with hydraulic models to understand flood situations under different floods	Model development	■	■	■						NWA, NIH, CWPRS, CWC
			Use		■	■	■	■	■	■	■	
		d. Build capability of linking storm surge models, tidal hydraulic models and flood flow models		■	■	■	■					NWA, IMD, NIH, CWC, CWPRS
		3. Urban storm water drainage improvements	New Criteria	■								MoUD, Municipal Bodies, Cantonment Boards, States, CWC, IMD
			Guidelines		■	■						
			Modeling Capability			■	■	■				
			Implementation				■	■	■	■	■	

Objective	*Strategy/*	*Sub-Strategy*	*Action Points*	*XI Plan*			*XII Plan*					*Actor*
				Y1	*Y2*	*Y3*	*Y4*	*Y5*	*Y6*	*Y7*	*Y8*	
	(iii) Adjusting to increasing erosion and sedimentation	**1. Reservoir Sedimentation, Erosion control and River Management under climate change**										
		a. Use changed acceptability criteria and practice regarding planning. (Suggestions included).	Proposal	■								CWC, Planning Commission, States, BIS
			Debate		■							
			Decision			■						
		b. Use more liberal acceptability criteria. (Suggestions included).	Proposal	■								CWC, Planning Commission, States, BIS
			Debate		■							
			Decision			■						
		c. Prepare sediment budgets and accounts for each basin	Studies	■	■	■						CWC, ICAR
		d. Build a universal soil loss model depicting erosion and sediment transport etc. Prove the modal based on sediment flow and reservoir sedimentation data.	Model development		■	■	■					NIH, ICAR, CWC
		e. Actuate the above model for changed rainfall regime and changed management practices	Studies		■	■	■	■	■	■	■	NIH, CWC,
		f. Develop, through R&D effort, a combined unsteady flow hydraulics-cum-sediment transport model capable of depicting river erosion in each flood event. Use the model to test river management works	R&D	■	■							NIH, CWPRS, IITs, GFCC
			Model development		■	■	■					
			Use			■	■	■	■	■	■	
	(iv) Disaster	**1. Disaster Management**										

Objective	Strategy/	Sub-Strategy	Action Points	XI Plan			XII Plan					Actor
				Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	
	Management	a. Dam break or Embankment break studies done routinely. A management plan needs to be prepared.	Policy									CWC, NIH, CWPRS
			Implementation									
		b. Improve analytic capacities in regard to two dimensional unsteady flow hydraulic models.	Capacity Building									CWC, NIH, CWPRS, NWA
		c. Setup, through legislations, State and Central Dam Safety Services	Proposal									MoWR, States
			Debate									
			Legislation									
(E) Improved Water Quality Management	**(i) Improved Water Quality Management**	**1. Water Quality Management**										
		a. Programme of data collection on Surface and ground water quality	Data Collection									CPCB, SPCB, CWC, CGWB
		b. Setting up water quality models for each major river and aquifer	Modeling									CPCB, SPCB, CWC, CGWB
		c. Enhance the capacity of the institutional and legal mechanism to take action	Policy									CPCB, SPCB, State Governments , MoEF
			Legal									
		d. Allow attractive financial packages combined with penalties to users/defaulters to build and operate modern effluent treatment plants and re-circulation arrangements in order to reduce penalties										MoEF, Urban Affairs
		e. Encourage direct use of partially	Policy									MoEF,

Objective	*Strategy/*	*Sub-Strategy*	*Action Points*	*XI Plan*			*XII Plan*					*Actor*
				Y1	*Y2*	*Y3*	*Y4*	*Y5*	*Y6*	*Y7*	*Y8*	
		treated domestic effluents in irrigating non food crops	Implementation									MoWR, States
		f. Encourage public bodies/ industrial States to construct common effluent treatment plants through soft loans/ subsidies and technical support	Policy									MoEF, Ministry of Industries, States
			Implementation									
		g. Disallow the use of comparatively good waters for diluting pollution loads. Insist on treatment	Policy									MoEF, MoWR, States
			Implementation of policy									
			Installation of effluent treatment plants in critical areas									
		h. Disallow proposals for establishing, enhancing, or improving piped domestic water supply, unless these include effluent treatment	Policy									MoEF, MoWR, Planning Commission, States
			Implementation									
(F) Managing water relate conflicts	**(i) Strategies- Within Indian Basins**											
		a. Setting up of empowered basin Authorities	Proposal									MoWR, GoI, States
			Debate									
			Legislation									
		b. Setting of sub-basin or area authorities	Proposal									MoWR, GoI, States
			Debate									
			Legislation									
		c. Setting up of a permanent Water Tribunal	Proposal									MoWR, GoI, States
			Debate									
			Legislation									

Objective	*Strategy/*	*Sub-Strategy*	*Action Points*	*XI Plan*			*XII Plan*					*Actor*
				Y1	*Y2*	*Y3*	*Y4*	*Y5*	*Y6*	*Y7*	*Y8*	
		d. Encouraging mediation and voluntary arbitration	Proposal Debate Legislation									MoWR, GoI, States
	(ii) Strategies-Indian Inter-basin Transfers											
		a. Set up authority empowered to decide surpluses	Proposal Debate Legislation									MoWR, GoI, States
		b. Set up mechanism to appeal and settle decisions	Proposal Legislation									MoWR, GoI, States
		c. Decide policies about implementation, ownership, etc.	Proposal Debate Legislation									MoWR, GoI, States
		d. Encourage negotiated solutions, after such empowerment	Policy Implementation									MoWR, GoI, States
	(iii) International Conflicts and Discords											
		a. In short run, continue as usual.										MoWR, MEA
		b. Set up, comprehensive flood forecasting and flood wave transport models with other countries, for Indus, Ganga, Teesta and Meghana.	R&D Modeling Use									MoWR, MEA
		c. In long run, discuss more optimized Indus development possibilities, with Pakistan	Proposals Discussions Decision									MoWR, MEA
		d. Review interpretation of regime maintenance for Ganga, after climate change	Study									MoWR, MEA

6.2 A Preliminary Cost Estimate

Costs and Financial implications of the programme to mitigate effects of Climate change:

An Action Plan for measures to mitigate the effect of climate change in India has been worked out. Now, we try to give very crude estimate of the financial requirements of this programme. In this connection, following important points are brought out:

1. The costs mentioned cover the residual Eleventh Five Year Plan Period (three years) and the full period of Twelfth Five Year Plan Period (five years).

2. The costs mentioned are the additional costs require to be spent for mitigating the effects of the climate change, in addition to the normal water sector programmes of various Ministries, Departments of the State Governments, etc.

3. The costs, as mentioned, are the aggregate of the costs in the Central Sector and the State Sector. The subsidies from the Centre to the State, subsidies from the Central funds to the water users, etc. are also, therefore, included in this costs.

4. The costs to be incurred by private enterprise or by various water users, on their own, to maintain their facilities and services are not included.

5. The costs are distributed by the objectives, strategies and programmes to the extent possible. The costs are also segregated as "data collection costs" "software costs" and the "hard costs". The data collection costs would include both the soft costs, such as, costs involved in planning the data collection network, costs of instruments and setting up works, and operational costs. For other items, the software costs will include items such as studies, assessments, appraisals, preparation of guidelines, debates and discussions, research including action research, etc. The hard costs would include pilot implementation and potato implementation of physical measures and facilities necessary for mitigating the climate change costs.

6. The Preliminary crude estimate presumes that within this period of eight years, the targets in regard to the physical works would include modernization of irrigation over 2 Mha, increasing storage capacities in large dams by 10 km^3, increasing storage capacities of minor dams by 10 km^3, drainage of water logged areas for 2 Mha and additional industrial and domestic effluent treatment plants capable of treating 0.5 km^3/year and 2 km^3/year of effluents respectively.

Table – 13 Preliminary Estimate of costs of National Programme for Mitigating Effects of Climate Change on Surface Water Management

#	Objective	Item	Estimated Cost (Rs. Crore)			
			Data collection	Software	Hard items	Total
1.	**Better understanding of water resources, etc.**	Data collection - Esturian	200			200
		Data collection – Low rainfall areas	50			50
		Data collection – Himalayan – Permanent snow	100			100
		Data collection – Himalayan – seasonal snow	100			100
		Data collection – strengthening evaporation data	50			50
		Data collection – strengthening automatic rain gauge data	50			50
		Reassessment of water situation		200		200
		Basin classification		20		20
		Research support to GCM and RCM		100		100
		Research – Water and Climate related		100		100
	Sub-Total (A)		**550**	**420**	**0**	**970**
2.	**Increasing food and water security**	Minimizing inadvertent evaporation		50	2000	2050
		Increasing use of ground water storage		20	100	120
		Repeated use of surface storage		50	100	150
		Increasing storages – large projects		100	1500	1600
		Minor tanks		100	700	800
		Water bodies		50	500	550
		Increasing water use efficiency		100	500	600

#	Objective	Item	Estimated Cost (Rs. Crore)			
			Data collection	Software	Hard items	Total
		Modernisation of distribution		100	1500	1600
		Encouraging water transfers		100		100
		Flood flow transfers for GW recharge		50	300	350
	Sub-Total (B)		**0**	**720**	**7200**	**7920**
3.	**Improving Intra-national equity in useable water.**	Drought Management		100		100
	Sub-Total (C)			**100**		**100**
4.	**Improving social sustenance under climate change**	Esturian Management under changing flood and sea level regime.		100	500	600
		Adjusting to changing flood regime		100		100
		Urban storm water improvement		50	300	350
		Adjusting to increasing erosion and sedimentation.		100		100
		Disaster management – Dam Break		100		100
	Sub-Total (D)		**0**	**550**	**800**	**1350**
5.	**Improved quality water management**	Reusing domestic effluents in agriculture	50	100		150
		Subsidies for industrial treatment and recovery plants		20	100	120
		Subsidies to public bodies for domestic sewage treatment			5000	5000
		Encouraging common effluent treatment		200	3000	3200
		Discouraging dilution and encouraging treatment		20	200	220
	Sub-Total (E)		**50**	**340**	**8300**	**8690**

#	Objective	Item	Estimated Cost (Rs. Crore)			
			Data collection	Software	Hard items	Total
6.	**Managing water related conflicts**	Indian Basins – Basin authorities		200		200
		Inter-basin transfers – empowerment		100		100
		International		50		50
	Sub-Total (F)		**0**	**350**	**0**	**350**
GRAND TOTAL (A)+(B)+(C)+(D)+(E)+(F)			**600**	**2480**	**16300**	**19380**

This cost of around Rs.20000 crore would be spread over 8 years ie. the residual three years of the XI plan and the full five years for the XII plan. While the annual break-up has not been worked out, the costs would be around Rs.5000 crore in the XI plan and Rs.15000 crore in the XII plan.

The costs, as mentioned, are the aggregate of the costs in the Central Sector and the State Sector. The subsidies from the Centre to the State, subsidies from the Central funds to the water users, etc. are also, therefore, included in this costs. While these have not been separately estimated, most of the implementation costs would be on account of the States. A significant part of this may have to be met from Central subsidies. We are not making any firm recommendation about the extent of the subsidies since, various administrative and fiscal considerations would be involved in deciding the subsidies. However, as a preliminary guess the Central sector expenditure, including the subsidies could be around 1/3rd of the total costs.

7 POLICY MODIFICATIONS IN VIEW OF CLIMATE CHANGE CONCERNS

7.1 Background

India's water policy was documented in 1986, and was revised in 2002. The main purpose of revision was to incorporate the growing environmental concerns, larger need for information and growing complexity of the projects which increase the need for integrated water resource management.

In future, demands for water would increase considerably both on account of rising population and their rising food and domestic water needs, as also on account of larger industrialization and changing standards of living. Even without climate change, many areas and basins would become water stress and water would start operating as a major constraint on development. Changes in NWP which stress on new strategies of water management and on meticulous accounting of water situation would be necessary.

The likely climate change, and the concerns caused by the change shall further increase the stress and can make the future more uncertain. Also, a large programme of data collection, planning and implementation of mitigative measures would have to be taken up. All of these have been discussed already. To meet this situation, following changes in the NWP are suggested:

7.2 The Concept of Available Water

1. Currently, the water available in Indian rivers and aquifers alone is being considered as the water resource of India. Instead it needs to be recognized that the precipitation over India and the water being received from upper riparian countries through rivers and aquifers constitute the water resource of India.

2. As a corollary, the management of rain water and the management of the evaporation would be additional broad strategies available, apart from the current strategies of managing the rivers and aquifers.

7.3 Water Balance as a Tool to Understand the Unified Resource

a) The current policy already mentions that water is a unified resource. The total water balance of the country, its basins, sub-basins, areas etc. depicting the quantified hydraulic cycle should become the main tool for understanding the water situation. Water balances, water budgeting, water accounting, water audits etc. should be based on this hydraulic cycle and inter-action between rain water, surface water, ground water, evaporation etc.

b) The acceptability criteria in regard to new water developments need to be re-worked in view of the likely climate changes. In regard to the reliability of the project outputs, the main criteria would not be based on climate change. However, alternate likely climate change scenario would have to be used in the 'sensitivity testing' mode and in this mode a relaxed acceptability criteria would have to be satisfied. In regard to environmental acceptability, the hydro-ecological parameters and the likely changes in these parameters under the climate change scenario would have to be considered.

c) The acceptability criteria in regard to the existing developments would have to be similar to those of the new developments. However, considering the impracticability in changing the salient features of the projects in a short run, a long phased programme for making the necessary changes would have to be evolved.

d) In view of the increasing stress on available water due to various reasons including the likely effects of Climate Change, evaporation management would be a major strategy. This and the various possible methods for achieving this need to be spelt out in the policy.

e) Similarly, the increasing complexities of water management would make it necessary to manage the waters with the river basin as a unit in a holistic way and also to plan for inter-basin transfers of water. Although both these aspects and the related aspect of river basin management have been mentioned in the current policy, the larger stress would have to be laid on these aspects.

7.4 Covering Data Gaps

a) There is a large data gap in regard to the estuarine region. In this region, water levels change depending upon the river discharge and the tides in the sea. The flow direction also changes. Due to rise in sea water level, attributable to the climate change, and also to increased frequency of floods, again attributable to climate change, better data and its analysis would be required for planning mitigative measures. Hydrometric and salinity data would have to be collected for all important estuaries, i.e. estuaries of larger rivers as also estuaries of rivers where much industrial development is taking place. (Details in this regard are covered elsewhere).

b) The low rainfall areas as also the catchments of high altitude mountains streams are likely to be the areas which are going to be largely affected by climate change. Similarly, data about the parameters of the water balance and regime changes regarding high altitude lakes is insufficient. A large data collection programme about the hydraulic parameters and water use parameters would have to be launched in these regions.

c) The hydrometric net-work in high altitude mountainous areas is very sparse, when compared with the WMO norms. These areas are likely to be affected due to changes in the regime of glaciers, snow falls, and snow melts. A large programme of data collection is necessary.

d) The net-work for collecting data about evaporation and transpiration is insufficient. The climate change and the rise of temperature would largely affect the evapo-transpiration needs of the crops. Rainfed crops would use more water leading to less deep percolation and surface run-off. Irrigated areas would demand more water. For better water management a large supplementation of the evaporation data network including modern instruments for monitoring moisture flux would have to be mounted.

e) The data about short duration storm rainfall, collected through automatic rain-gauges is already not sufficient. With increased frequency of intense storms, attributable to climate change, additional data would be required.

f) Another gap in the basic water related data is about the morphology of the rivers. The river channels continuously undergo changes in their geometry due to erosion, deposition, changes in the meandering pattern etc. Anthropogenic changes also take place due to construction of reservoirs, sand mining etc. Accurate morphologic data is necessary for planning river management, erosion control and flood control. All these problems will become acute if strong frequencies and sediment load change. It is necessary to monitor the morphology through setting up of permanent river cross-sections and of surveying these at intervals like five years. Remote sensing studies can indicate shifts of the river and this can be checked after each monsoon.

g) While the water related data is available at many places, and while, under the new information sharing regime, much of it would become available to the citizens, tracking the data & information becomes a difficult task. A meta-data about the availability of data at different centre should be prepared and made easily available both by the Central and State Governments. Also, much of the abstracted data should become readily available in electronic media and there should be less need for applying for the data.

7.5 Water Allocation and Water Rights

a) At present, water allocation of an Inter-State River Basin, within States, is decided either by a mutual agreement or through a process of adjudication. The process of settlement through agreement needs to be preferred.

b) Inter-State agreements need to be recognized and approved by the Union Government, utilizing legislative powers through legislation. While doing so, the Union may ensure that all affected or concerned States are a party to the agreement and that the concerns of the Union such as environment related concerns are not affected. Through this approval, the agreement would be converted in an enforceable document.

c) Guidelines for allocation of water amongst basin States may be finalized as an aid to reaching agreements or to adjudicated solutions.

d) Water needs to be recognized as a negative community in which usufruct rights can operate.

e) States need to be encouraged to lay down a policy for distribution of the water allocations to different regions of the States.

f) The water allocations of the States need to be converted in to legally recognized water rights of the users. These water rights need not be fully linked to ownership of the land; but need not also be tradable. The water allocations could be subject to periodic reviews.

g) For faster settlement of adjudicated disputes, and for encouraging specialization, a standing water dispute tribunal may be considered.

7.6 Priorities amongst Uses

The first priority needs to be towards the core needs for essential water requirements for human health and hygiene. This could be of the order of 50 lpcd.

The priorities amongst other uses, such as the residual, non-core domestic water, irrigation, industrial water, ecologic and environmental requirements, navigational requirements, requirements for commercial fishery, recreation and tourism, etc., will change from situation to situation, depending upon socio-economic conditions, market forces and established rights.

The priorities for the domestic water could be interpreted as the quantitative priority where demands exceed supplies, most dependable source amongst alternative sources and/or a source with the best quality of raw water, amongst alternate sources.

7.7 Increasing Analytic Capacities

The Analytic Capacities of the Indian Water Resource Personnel would have to be improved, through a large scale quality improvement programme. Where necessary, international expertise as also commercially available international software would have to be obtained. For some important items, software development to suit the Indian conditions would have be made by using agencies like CWC, NIH, CWPRS, etc. Again the international expertise could also be used. However, where possible, the developments should be open format so that users can fully understand and make some modifications in the software. A large programme for training the water personnel in the various public and private agencies in India, including personnel of Indian Consultants, would have to be launched. Assistance and subsidies from Government of India should become available for this quality improvement programme. The areas where such quality improvement is essential are listed below:

a) Routine use of one dimensional non-uniforms steady flow computations by water resources professionals.

b) Routine use of one dimensional unsteady flow computations by water resource professionals.

c) Use of two dimensional unsteady flow computations for dam break, embankment break, etc. at least by the design offices and research institutes of all States and academic institutes.

d) Capacities for basin and sub-basin water assessments using models of hydrologic cycle based on water balance concepts. The models should be capable of depicting the different hydrologic behaviour as per soil, land use, type of crop, etc. The models should preferably be distributed models. Either, commercially available software is to be adopted or new software has to be developed as a national programme. Scenario development and testing its effect on the basin hydrology, in an iterative way, is to be a part of the water assessment exercise.

e) Capabilities in linking the unsteady flow hydraulic model for rivers with the storm surge model in the open seas and tidal hydraulic models in the estuaries have to be built up for enabling better forecasts and better planning of tidal embankments, etc. These capabilities should be available in the reading research institutes. If possible, the salinity transport models also need to be linked to these.

f) Capabilities in regard to linking a universal soil loss type model with sediment transport and sediment trapping in reservoirs need to be built up. The model would have to be "proved", for each basin, to reproduce the observed sediment load in the rivers and the observed sediment deposition in the reservoirs. Thus, the model would yield a sediment budget. This model can be actuated with changed rainfall regime, crops, management practices, etc., to predict sediment budget for different climate change scenarios.

g) Capabilities in modeling the water balance of glaciers and of modeling the snowmelt regimes, both for permanent areas and seasonal snow areas would have be built up.

h) For effective flood management, it is necessary to enhance the capacity of linking the digital elevation models of low lying areas with steady or unsteady flood flow models. Various proposals for flood control, and their effect on both the hydrology of the basin, and the hydraulics of the channels including the extent of flooded area can then be studied on such models.

i) The capability of combining the hydraulic models for flood wave propagation with the sediment transport models is generally not available anywhere. Much work is being done on the subject. Such models would be particularly useful for the Indian alluvial planes in the climate change scenario, since the additional sediment load and additional flood frequencies can cause severe erosion and conversion of meandering reaches into braded reaches. As a national programme, reading institutes should take this as a challenge. Such models, undeveloped, can predict the changes in the river morphology.

7.8 Stakeholder Managed Basin Authorities to reduce Conflicts

Legally empowered basin authorities need to be set up. All stakeholders including Governments and Departments of the Government, water users and consumers of different types surrogates for environmental ecological interests, etc., need to be represented in the authority. The authority would have wide powers in regard to approving development and management plans, directing changes in emergencies, etc. The basin authority and the smaller area authorities would have powers in resolving smaller conflicts and imposing penalties for misuse, etc

7.9 Improving Water Use Efficiencies in Irrigation

a) The efficiencies of individual water systems need to be improved to ensure that the water withdrawn from the natural system, after considerable use of resources, is used in an optimum way. The control and minimization of inadvertent evaporation of the withdrawn water would be the main strategy.

b) Anthropogenic water logging in irrigation commands needs to the loss of productive land to agriculture and also the large in advertent water evaporation/evapo-transpiration of the swampy areas. A well planned drainage system would make the area available for productive use and would allow the re-use of the drained water. Schemes for drainage and management of water logged areas need to be planned and executed urgently to avoid increased water stress and to improve efficiencies.

c) Lining of water conveyance systems in selected reaches, where large seepages leading to water logging would be occurring, is necessary.

d) In general, in closed basins, seepages are likely to be an important source for sustaining the larger ground water use conjunctively with the surface water. Such conjunctive use should be encouraged since it adds additional ground water fluctuation storage to the water system.

e) Participatory management of irrigation systems by public agencies, farmers and other stakeholders, and the eventual transfer of the treasury systems to the stakeholders will increase equity and reliability and would reduce losses due to over irrigation, etc. A time bound programme for such participation and eventual withdrawal of the Government from day to day management of the lower systems should be planned.

f) As stated, return flows are an important resource if re-use is possible. However, if the returns are to "sinks", such as saline aquifers, low coastal areas, etc., re-use may not be possible. Returns, unless required for other purposes, need to be mopped up before reaching the scene.

g) For each large irrigation system, bench marking and performance evaluation studies for each water year should be done and the results publicized. The complete water budget and efficiency related data should be included in this study.

h) The "basin efficiency", is a concept which is much more relevant to optimum water use than the "system efficiency". The basin efficiency or sub-basin efficiency needs to be estimated through a rigorous exercise, using models similar to the water assessment models.

i) For closed basins, the basin efficiency needs to exceed 80%.

j) Irrigation efficiencies can be improved by managing in such a way that no over irrigation takes place and small doses and larger number of waterings are provided. For this purpose, piped irrigation, use of sprinklers and drips, construction of storages at the users end for storing irrigation water between rotations, etc., need to be encouraged. Subsidies could be made available for these.

k) Minimisation of controls on canals, which could be misused, is an important strategy. Proportionate distribution and removal of small cross regulators could be encouraged if participatory management has become possible.

l) Automation, computer controlled decision support systems, on demand irrigation through creation of level pools in canals, using real time soil moisture data to decide irrigation doses, etc. are important means of improving efficiency. In water scare and highly productive areas, these need to be implemented on a pilot basis. Subsidies would encourage this initially.

7.10 Increasing Useable Water

a) Increasing the useable water, without importing water from other areas/basins is possible only in "open" basins. In basins which are "closed" or are likely to become closed, no increase in useable water is possible except through reduction of inadvertent evaporation or return to sinks. The situation needs to be assessed for each basin.

b) For closed basins, increase in useable water in one area may lead to decrease elsewhere. Such changes in the pattern of use may be socially desirable, and can be made after the externalities are studies and discussed.

c) Water harvesting is an important method of increasing useable water and needs to be encouraged.

d) Larger storage and larger carry over storage becomes essential to increased water use. Where surface storage possibilities are low, ground water storages can be used in conjunction. Such possibilities include:

- Anthropogenically enhanced ground water fluctuations, caused by pre-monsoon pumping and additional river bed recharge in monsoon, or through the concept of Kharif channels are possible strategies which need to be encouraged. Pilots for ground water depletion need to be implemented, with subsidized financing and studied closely.

- Conjunctively using unreliable surface water with more reliable ground water to enhance the total use. In this strategy, additional ground water withdrawal capacity is made available, but is activated only in years where surface water is not available.

e) If more water is used in the wet season and less is used in other seasons, water use can increase for the same storage availability. Such strategies, which need to be encouraged include:

- Use of dug out farm ponds which get filled up repeatedly in each rain spell, and the water used in between the spells.

- Planning storages with irrigated khariff as the reliable main crop, and resorting to unreliable Rabi irrigation depending on the storage position at the end of the wet season.

f) Increasing storages in existing dams would be possible if the dam is spilling very frequently. In view of the larger water stress attributable to climate change and increased demands, a programme for such increases in the capacities needs to be taken up (see discussions in the report)

g) For minor, ungated, tanks which spill frequently, installing low gates would allow increased storage without much cost in raising of the dam (see discussions in the report). A programme for locating, studying and implementing such proposals needs to be taken up.

h) The existing programme of restoration of tanks and water bodies needs to be reviewed with a changed focus and implemented (see discussions in the report)

i) Inducing ground water seepage through seepage tanks is very effective in the rocky areas of the peninsula, where the geology is favorable. This needs to encouraged and subsidized. Since the conveyance is through the geologic formations and use through the private dug wells/bores, stakeholders participation is ensured.

j) Hydro-fracturing is another method of increasing local utilisable water, and needs encouragement.

7.11 Inter-basin Transfers

a) Inter-basin transfers are an effective way of achieving better equity. If the transfer is from an open basin to a closed basin, increased water use is achieved. Such transfers need to be encouraged.

b) Inter-basin transfers of flood waters and the use of these waters to re-charge depleting ground waters in water stressed areas have been proposed. These need a more detailed study, preparation of a few feasibility reports and their appraisal.

c) Inter-basin transfers are not merely for increasing production. They also are an important means of reducing absolute poverty and increasing the economic carrying capacity of water scarce over populated region, without recourse to distress migration. This aspect needs to be highlighted and studied.

d) Inter-basin transfers raise new issues about ownership, financing models, implementing responsibilities and revenue collection. Policies in this regard need to be evolved.

e) Enabling legal measures (see details in the report) which empower an agency to study and detail the proposals for execution after calculating the available surplus, a procedure for appeals in this regard and a procedure for implementation are essential.

f) Negotiated solutions between the surplus and the deficit States involved in the transfer need to be encouraged and the agency be empowered to execute the transfers.

7.12 Drought Management

Apart from water harvesting, in basin developments and inter-basin transfers, integrated farming systems, and non-agricultural developments also need to be considered.

The nexus amongst the resources of land and water, on the outputs in terms of food, livelihood, energy and ecologic services has to be recognized in resource planning. Where livelihood support and poverty alleviation is a major problem, irrigated agriculture, with in-basin or inter-basin development may be necessary. Energy plantations in low rainfall area may consume rainwater and affect food and livelihood.

7.13 Environmental Impacts

a) In view of the additional stress which climate change may cause to both hydrology and to the ecology of the affected area, maintaining aquatic ecology, through environmental flow requirements as decided after considering the needs of various uses, and the trade-offs, will become even more important. Much work needs to be done for deciding an acceptable methodology.

b) Improved management of wet lands has to be a part of the NWP. The management of anthropogenic wet lands needs to be different from that of natural wet lands. Amongst the natural wet lands, the coastal wet lands, estuarine wet lands away from the coast, wet lands in middle reaches and the embanked flood planes need to be treated separately.

c) Anthropogenic wet lands (water-logged areas) need to be drained. The supply needs to be reduced and the returning water needs to be re-used.

d) Coastal wet lands and mangroves need to be conserved.

e) Embanked flood plains need to be maintained and the agriculture needs continued protection. New proposals for embanking urbanized and industrial areas may have to be implemented, but new proposals for embanking agricultural lands need careful balancing between the interests of agriculture and aquatic ecology.

f) Natural wet lands like jheels, beels, charlands need to be managed by balancing the interest of agriculture, ecologic conservation and commercial fishery.

7.14 Flood Management Strategies

Utilising the model development capacities, and the morphological data, the hydraulics of each major river needs to be modeled. Inundation maps, for historical floods, as observed, would be matched with the model. Using this model, likely Inundated area for floods of different frequencies needs to be prepared.

7.15 Multipurpose Projects

In view of the increased water stress and shortage of storage sites, multipurpose developments become very important. The present trends towards single purpose development are perhaps due to institutional constraints, and this needs to be overcome. The tendency of the farmer irrigation departments to protect the historic dominance of irrigation needs to be changed. The compatibility amongst uses for irrigation, hydro power, domestic and industrial supplies, etc. can be enhanced through innovative planning.

7.16 Disaster Management

a) Utilizing the capacity in unsteady flow hydraulic models, dam break studies should become a routine exercise for all dams, and especially for the unsafe dams. Emergency preparedness plans should be prepared and publicized.

b) Legally empowered dam safety services need to be set up in the States as well as in Centre. Dam Safety would be a concern of the State, but for nationally important dams, and for dams having significant trans-boundary hazard potential, the Central Dam Safety Service needs to be responsible.

c) Utilizing the capabilities in hydraulic and hydrologic modeling, basin-wise flood propagation models should be built and used for flood warning and flood forecasting with longer lead times. In regard to international basins, international cooperation needs to be extended and ensured.

7.17 Conflict Management – International basins

In the situation of larger stress on limited resources, increasing demands and growing complexities, under Climate Change, managing International conflicts would become more important. The policies in this regard need to balance, on one hand, the protection of national interests and the need for pragmatism, and on the other hand, the need for larger cooperation for mutual benefit towards a brighter shared future.

a) For the Indus Basin, without disturbing the present arrangements, international cooperation towards a more optimum use of the basin, under increased stress due to reducing resources, growing demands, and impaired ecology, needs to be promoted.

b) In regard to the Ganga, the regime changes due to climate change, which was not foreseen earlier, need to be well documented.

7.18 Changed Acceptability Criteria

The Planning and Designing of water projects is so done that these plans fulfill the various acceptability criteria. These have been generally codified as standards or guidelines by the BIS, or through the various Circulars of the Government and the Planning Commission. In the changed circumstances, attributable to Climate Change and increasing demands, these guidelines need to be reviewed changed. While preliminary proposals in this regard are worked out already, these need to be quickly debated in the concerned fora, and accepted. These criteria would be in regard to:

1. Reliability of success in regard to water availability.

2. Planning reservoirs for accommodating sediment.

3. Deciding floods for designing dams.

4. Deciding design floods for flood control and erosion control works.

5. Economic viability.

Acknowledgements
(Would be completed later)

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Report of Sub-Committee

on

Ground Water Management

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CHAPTER I: BACKGROUND

Climate change may alter the distribution and quality of India's natural resources and adversely affect the livelihood of its people. Since India's economy is closely coupled with its natural resource base and climate-sensitive sectors such as agriculture, water and forestry, the country may face a major threat because of the projected changes in climate. To meet the challenges of impact of climate change the Hon'ble Prime Minister released the National Action Plan on Climate Change on 30th June 2008 laying down the principles and the approach to be adopted. The National Water Mission is one of the eight National Missions identified and was mounted to ensure integrated water resource management helping to conserve water, minimize wastage and ensure more equitable distribution both across and within states. The Terms of Reference of the Mission are as follows-

- Increasing the efficiency of water use
- Exploring options to augment water supply in critical areas
- Ensuring more effective management of water resources
- Need for new regulatory structures with appropriate entitlements and pricing and incentives to adopt water-neutral or water positive technologies
- Integrated water policies to cope with variability in rainfall and river flows at the basin level

The High Level Steering Committee for National Water Mission, in its first meeting held under the Chairmanship of Secretary to Government of India, Ministry of Water Resources on 7th August 2008, constituted six sub- committees on various aspects of impact of climate change on water resources to prepare a comprehensive mission document in a time bound manner. One of the sub committee is on Ground Water Management including quality of Ground Water under the Chairmanship of the Chairman, Central Ground Water Board. The constitution of the sub-committee is enclosed as **Annexure I.**

The functions and the important activities identified for this Sub-Committee are :-

- To examine all related issues in respect of specific issues about ground water management including quality of ground water.
- To make assessment of the present status, quantification of the impact of climate change on related issues,
- Identification of most appropriate measures for mitigation and adaptation for specific issues
- Proper coordination among all concerned Ministries.

The Technical Document' annexed with the "National Action Plan on Climate Change" has identified key elements related to various studies / strategies needed for successful implementation of the National Water Mission. Specific Studies/ Strategies identified for Management and Regulation of Ground Water Resources are :-

- Mandating water harvesting and artificial recharge in relevant urban areas

- Enhancing recharge of the sources and recharge zones of deeper groundwater aquifers
- Mandatory water assessments and audits; ensuring proper industrial waste disposal
- Regulation of power tariffs for irrigation
- The Mission to take into account the provisions of the National Water Policy and develop a framework to optimize water use by increasing water efficiency by 20 %.
- Incentives structures will be designed to promote recharging of underground water source
- Restoration of old water tanks.

1.1 GLOBAL WARMING AND CLIMATE CHANGE

Intergovernmental Panel on Climate Change (IPCC)[1] in its recent released report has reconfirmed that the global atmospheric concentration of carbon dioxide (CO_2) and greenhouse gases (GHGs) have increased markedly as a result of human activities since 1750. The global increase in CO_2 concentration is primarily due to fossil fuel use and land use change. These increase in GHGs have resulted in warming of the climate system by 0.74^0C between 1906 and 2005. The rate of warming has been much higher in recent decades. This has, in turn, resulted in increased average temperature of the global ocean, sea level rise, decline in glaciers and snow cover. There is also a global trend for increased frequency of droughts, as well as heavy precipitation events over most land areas and extreme events.

1.1.1 OBSERVED CLIMATE CHANGE IN INDIA

There have been observed changes in surface temperature, rainfall, evaporation and extreme events since the beginning of the 20th century. India's Initial National Communication, 2004 (NATCOM 1)[2] to UNFCCC has consolidated some of these. Some highlights from NATCOM I and others are as under :

SURFACE TEMPERATURE

At the national level, increase of 0.4° C has been observed in surface air temperatures over the past century. A warming trend has been observed along the west coast, in central India, the interior peninsula, and north-eastern India. However, cooling trends have been observed in north-west India and parts of south India

RAINFALL

While the observed monsoon rainfall at the all-India level does not show any significant trend, regional monsoon variations have been recorded. A trend of increasing monsoon seasonal rainfall has been found along the west coast, northern Andhra Pradesh, and north-western India (+10% to +12% of the normal over the last 100 years) while a trend of decreasing monsoon seasonal rainfall has been observed over eastern Madhya Pradesh, north-eastern India, and some parts of Gujarat and Kerala (-6% to -8% of the normal over the last 100 years).

EXTREME WEATHER EVENTS

Instrument records over the past 130 years do not indicate any marked long-term trend in the frequencies of large-scale droughts and floods. Trends are however observed in multi-decadal periods of more frequent droughts, followed by less severe droughts. There has been an overall increasing trend in severe storm incidence along the coast at the rate of 0.011 events per year. While the states of West Bengal and Gujarat have reported increasing trends, a decline has been observed in Orissa. Goswami[3] et al , by analysing a daily rainfall data set, have shown (i) a rising trend in the frequency of heavy rain events and (ii) a significant decrease in the frequency of moderate events over central India from 1951 to 2000.

RISE IN SEA LEVEL

Using the records of coastal tide gauges in the north Indian Ocean for more than 40 years, Unnikrishnan and Shankar[4] have estimated, that sea level rise was between 1.06-1.75 mm per year. These rates are consistent with 1-2 mm per year global sea level rise estimates of IPCC

IMPACTS ON HIMALAYAN GLACIERS

The Himalayas possess one of the largest resources of snow and ice and its glaciers form a source of water for the perennial rivers such as the Indus, the Ganga, and the Brahmaputra. Glacial melt may impact their long-term lean-season flows, with adverse impacts on the economy in terms of water availability and hydropower generation.

The available monitoring data on Himalayan glaciers indicates that while recession of some glaciers has occurred in some Himalayan regions in recent years, the trend is not consistent across the entire mountain chain. It is accordingly, too early to establish long-term trends, or their causation, in respect of which there are several hypotheses

1.1.2 PROJECTED CLIMATE CHANGE

Some modeling and other studies have projected the following changes due to increase in atmospheric GHG concentrations arising from increased global anthropogenic emissions:

Annual mean surface temperature rise by the end of century, ranging from 3 to 5° C under A2 scenario and 2.5 to 4° C under B2 scenario of IPCC, with warming more pronounced in the northern parts of India, from simulations by Indian Institute of Tropical Meteorology (IITM), Pune.

Indian summer monsoon (ISM) is a manifestation of complex interactions between land, ocean and atmosphere. The simulation of ISM's mean pattern as well as variability on inter-annual and intra-seasonal scales has been a challenging ongoing problem. Some simulations by IITM, Pune, have indicated that summer monsoon intensity may increase beginning from 2040 and by 10% by 2100 under A2 scenario of IPCC.

1.1.3 CLIMATE CHANGE AND WATER RESOURCES

The importance of climate change impacts on water resources has been well brought in the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2000a) , which says " Climate change will lead to an intensification of the global hydrological cycle and can have major impacts on regional water resources, affecting both ground and surface water supply . Rising global temperatures are expected to raise sea level and change precipitation and other local climate conditions. Changing regional climate could affect forests, crop yields, and water supplies. It could also threaten human health, and harm living beings and the ecosystem.

Changing climate is expected to influence both evaporation and precipitation in most of the areas. In those areas where evaporation increases more than precipitation, soil will become drier, water level in lakes will drop and rivers will carry less water. Lower river flows and lower lake levels could impair navigation, hydroelectric power generation, water quality and reduce the supplies of water availability for agricultural, domestic and industrial uses. Melting snow provides much of the summer water supply; warms temperatures could cause the snow to melt earlier and this reduce summer supplied even if rainfall increased ruing the spring. Various studies carried out in India in different basins to assess the impact of Green House Gases(GHG) and global warming including development of simulation models (SWAT) revealed that under GHG scenario the conditions may deteriorate in terms of severity of droughts in some basins and enhanced intensity of flood in other basins of the country. However, there is a general overall reduction in the quantity of the available runoff. This may have considerable implications on Indian agriculture and hence on our food security and farmers livelihood. The strategies may range from change in land use, cropping pattern, to water conservation, flood warning system.

1.2 EXISTING POLICY FRAMEWORK IN CONTEXT OF GROUND WATER

1.2.1 NATIONAL WATER POLICY

- The Ministry of Water Resources, Government of India (“Ministry”) is responsible for laying down policy guidelines and programmes for the development and regulation of country’s water resources. Amongst others the Ministry has been allocated the function of “overall planning for the development of ground water resources, establishment of utilisable resources and formulation of policies of exploitation, overseeing of and support to State level activities in ground water development.”
- There should be a periodical reassessment of the ground water potential on a scientific basis, taking into consideration the quality of the water available and economic viability of its extraction.
- Exploitation of ground water resources should be so regulated as not to exceed the recharging possibilities, as also to ensure social equity. The detrimental environmental consequences of overexploitation of ground water need to be effectively prevented by the Central and State Governments. Ground water recharge projects should be developed and implemented for improving both the quality and availability of ground water resource.
- Integrated and coordinated development of surface water and ground water resources and their conjunctive use, should be envisaged right from the project planning stage and should form an integral part of the project implementation.
- Over exploitation of ground water should be avoided especially near the coast to prevent ingress of seawater into sweet water aquifers.

- Drought-prone areas should be made less vulnerable to drought-associated problems through soil moisture conservation measures, water harvesting practices, minimization of evaporation losses, development of the ground water potential including recharging and the transfer of surface water from surplus areas where feasible and appropriate. Pastures, forestry or other modes of development which are relatively less water demanding should be encouraged. In planning water resource development projects, the needs of drought-prone areas should be given priority.

1.2.2 NATIONAL ENVIRONMENT POLICY

As per the constitutional status the Center's power to legislate on groundwater is based on Environment Policy which suggests the following action points in relation to ground water :

- Take explicit account of impacts on groundwater tables on electricity tariffs and pricing of diesel.
- Promote efficient water use techniques, such as sprinkler or drip irrigation, among farmers. Provide necessary pricing, inputs, and extension support to feasible and remunerative alternative crops from efficient water use.
- Support practices of contour bunding and revival of traditional methods for enhancing groundwater recharge.
- Mandate water harvesting in all new constructions in relevant urban areas, as well as design techniques for road surfaces and infrastructure to enhance groundwater recharge.
- Support R&D in cost effective techniques suitable for rural drinking water projects for removal of arsenic and mainstream their adoption in rural drinking water schemes in relevant areas.

CHAPTER II GROUND WATER SCENARIO

Ground water is one of the most precious natural resource and has played a significant role in maintenance of India's economy, environment and standard of living. Besides being the primary source of water supply for domestic and many industrial uses, it is the single largest and most productive source of irrigation water. India is a vast country having diversified geological, climatological and topographic set-up, giving rise to divergent groundwater situation in different parts of the country. The prevalent rock formations, ranging in age from Achaean to Recent, which control occurrence and movement of groundwater, are widely varied in composition and structure. Broadly two groups of water bearing rock formations have been identified i.e.

(i) **Porous rock formations** which can be further classified into unconsolidated and semi consolidated formations having primary porosity; and (ii) **Fissured rock formations** which mostly have secondary or derived porosity.

Similarly, not too insignificant are the variations of landforms from the rugged mountainous terrains of the Himalayas, Eastern and Western Ghats to the flat alluvial plains of the river valleys and coastal tracts, and the aeolian deserts of Rajasthan. The rainfall patterns too show similar region-wise variations. The topography and rainfall virtually control run-off and groundwater recharge. The entire country has been broadly divided into following five distinct ground water regions considering the characteristic physiographic features as well as occurrence and distribution of ground water:-

Mountainous Terrain and Hilly areas: This region is occupied by varied rock types including granite, slate, sandstone and limestone. The yield potential of aquifers ranges from 1 to 40 litres per second (lps). However, because of high conductivity and hydraulic gradient , it offers very little scope for ground water storage. The valley fills in mountains function as underflow conduits and act as the major source of recharge. Springs are main source of water supply.

Indo-Gangetic-Brahmaputra Alluvial Plains: Indo-Gangetic- Brahmaputra alluvial plains, occupy the States of Punjab, Haryana, Uttar Pradesh, Bihar, Assam and West Bengal. The plain is underlain by thick pile of sediments. Thickness of the sediments increases from north to south. At places, the thickness of the alluvium exceeds 1000m. The thick alluvial fill constitutes the most productive ground water reservoir in the country. In the present scenario the ground water development in this region is at low level except the western parts in the States of Haryana and Punjab. The deeper aquifers in these areas offer good scope for further exploitation of ground water. In Indo-Gangetic- Brahmaputra plain, the deep wells yield in the range of 25-50 lps.

Peninsular Shield Area: The area is located south of Indo-Gangetic plain and consists mostly of consolidated sedimentary rocks, Deccan basalts and crystalline rocks in the states of Karnataka, Maharashtra, and Tamil Nadu. Occurrence and movement of ground water in these rich formations are restricted to weathered material and interconnected fractures at deeper levels. These have limited ground water potential. Ground water occurs within depth 50m, occasionally down to 150m, and rarely beyond 200m depth. Ground water development is largely through dug wells and borewells. The yield of borewells tapping deep fractured zones in hard rocks varies from 2-15 lps.

Coastal Area: Coastal areas have a thick cover of alluvial deposits and form potential multi-aquifer systems covering states of Gujarat, Kerala, Tamil Nadu, Andhra Pradesh and Orissa. However, inherent quality problems and the risk of seawater ingress impose severe constrains in the development of these aquifers. In addition, the ground water development in these areas is highly vulnerable to up-coning of saline water. The yield of tubewells varies from 20-25 lps.

Central Alluvial Areas: This region has been grouped separately owing to its peculiarity in terms of presence of three discrete fault basins, the Narmada, the Purna and Tapti, all of which contain extensive valley-fill deposits. The alluvial deposit ranges in thickness from about 50 to 150 m. Ground water occurrence in the area is restricted to deep aquifer systems tapping fossil water. For example, in parts of Purna valley the ground water is extensively saline and unfit for various purposes. The yield potential of tubewells varies from 1-10 lps.

The Hydrogeological map of India is depicted in **Plate 1** showing ground water potentials of the broad groups of water bearing formations.

2.1 PRESENT STATUS OF GROUND WATER RESOURCE AVAILABILITY

Rainfall is the major source of ground water recharge, which is supplemented by other sources such as recharge from canals, irrigated fields and surface water bodies. The rainfall is unevenly distributed. The average rainfall in country is around 117 cm. It is below 75 cm in the northwestern part covering parts of the states of Rajasthan, Gujarat, Haryana and the southern part, covering the states of Karnataka and Tamil Nadu. The amount of ground water withdrawal and situation of low rainfall are the factors which decides the overall stress on ground water and accordingly the assessment units are being categorized as over-exploited & critical blocks.

Large development of ground water resources in the country takes place from the upper unconfined shallow aquifers, which hold replenishable ground water resource. Central Ground Water Board has assessed the replenishable ground water resource in the country in association with the concerned State Government authorities. As per the latest estimates, the annual replenishable ground water resource has been estimated as 433 billion cubic meters (bcm), out of which 399 bcm is considered to be available for development for various uses. A quantum of 34 bcm is set aside for natural discharge during non-monsoon period for maintaining flows in springs, rivers and streams. Ground water Draft as on March 2004 for all uses is estimated as 231 bcm per year. The overall stage of Ground Water Development in the country is 58%. The state-wise availability of ground water resources is given in **Annexure II**.

In addition to annually replenishable ground water, extensive ground water resources occur in the confined aquifers in the Ganga-Brahmaputra alluvial plains and coastal - deltaic areas. These aquifers have their recharge zones in the upper reaches of the basins. The resources in these deep-seated aquifers are termed as 'In-storage ground water resources'. In alluvial areas, these resources are normally renewable over long periods of time, except in case of sedimentary rock aquifers in Rajasthan, which comprise essentially non-renewable fossil water. Tentative estimates put the quantum of in-storage ground water resources in the country at 10,800 BCM

2.1.1 GROUND WATER DEVELOPMENT SCENARIOS

The past six decades have witnessed phenomenal increase in growth of ground water abstraction structures due to implementation of technically viable schemes backed by liberal funding and availability of power and diesel, good quality seeds, fertilizers, govt. subsidies etc As per the third Census of Minor Irrigation Schemes, during the period 1951-2001, the number of dug wells increased from 3.86 million to 9.62 million, shallow tube wells from 3000 to 8.36 million and public bore/ tube wells from negligible to 0.53 milion. There has been steady increase in area irrigated by ground water from 6.5 M.ha in 1951 to 57.83 M.ha in (Report of 3rd Census of Minor Irrigation Schemes)

The development of ground water in different areas of the country has not been uniform. Highly intensive development of ground water in certain areas in the country has resulted in over - exploitation leading to decline in ground water levels and sea water intrusion in coastal areas. As per the latest assessment of ground water resources, the assessment units are categorized as 'Over-exploited', 'Critical' and 'Semi-critical' based on the stage of ground water development and long term water level declining trend during the past decade (1995-2004). Out of 5723 assessment units (Blocks/ Mandals/ Talukas) in the country, 839 units in various States have been categorized as 'Over-exploited' in which the annual ground water extraction exceeds the annual availability of ground water resource and significant decline in long term ground water level trend is observed either in pre- monsoon or post- monsoon or both. In addition 226 units are 'Critical' i.e. the stage of ground water development is between 90 % and 100% and significant decline is observed in the long term water level trend in both pre-monsoon and post-monsoon periods. There are 550 semi-critical units, where the stage of ground water development is between 70% and 100% and significant decline in long term water level trend has been recorded in either Pre-monsoon or Post-monsoon. Categorisation of Ground Water assessment units (over-exploited, critical, semi-critical and safe) have been shown in **Plate II** and the state-wise details are given in **Annexure III.**

2.1.2 FUTURE GROUND WATER REQUIREMENTS

The National Commission for integrated Water Resource Development, 1999 had worked the gross water requirement for the future. It has been estimated that 843 BCM water will be required in the year 2025 in a high demand scenario from all the sources. Out of total requirement of 843 BCM, 35.3% i.e. 298 BCM is estimated to be the contribution from Ground Water source while the rest is estimated to be met from surface water source. The areas where Ground Water is expected to contribute mainly will be irrigation, Domestic & Municipal water supplies, Industries and Power Sector. The detailed break-up of various uses is given in the following table.

Ground Water Requirement in the year 2025 (High Demand Scenario)

S.No.	Uses	Water Requirement for the year 2025 (in BCM)	Percentage Requirement of different uses
1.	Irrigation	245	82.2%

2.	Domestic & Municipal	26	8.7%
3	Industries	20	6.7%
4.	Power	7	2.4%
	Total	298	100.0%

2.2 PREVAILING GROUND WATER MANAGEMENT STRATEGIES

Concerns of overdraft and a broad array of other management needs are emerging in many areas. There is need for planned development and management of ground water resources. Further, ground water being a common pool resource and its development is mainly through private entrepreneurship , the management of ground water needs to be tackled in two framework that is adoption of suitable supply side and demand side management measures. Various management measures under supply side and demand side are described as follows:-

2.2.1 SUPPLY SIDE MANAGEMENT - SCIENTIFIC DEVELOPMENT OF GROUND WATER

In view of the diminishing fresh water resource and increase in its demand, it has become essential to promote development of ground water in areas with prolific aquifers and low stage of ground water development and conservation of fresh ground water resources through development of ground water in water logged areas. Use of saline/ brackish ground water in water deficit area also needs to be promoted. Strategies for ground water development for increasing the irrigation potential will vary considerably depending on the hydrological/hydrogeological settings of the area. There is a need to formulate area-specific ground water development and management plans to help State Governments and other stakeholders to reorient their strategies for sustained development and management of ground water resources.

The following thrust areas have been identified for ground water development:-

DEVELOPMENT OF GROUND WATER IN AREAS WITH LOW STAGE OF GROUND WATER DEVELOPMENT:

The eastern and north eastern parts of the country mainly in the states of Arunachal Pradesh, Assam, Bihar, Chhattisgarh, Jharkhand, Manipur, Meghalaya, Mizoram, Nagaland, Orissa, Tripura and West Bengal, have huge ground water resources both in unconfined and confined aquifers. The annual replenishable resources of 137 bcm have been assessed in these States. The ground water draft is only ~ 36 bcm and stage of ground water development is ~ 28 %.

GROUND WATER DEVELOPMENT IN COASTAL AREAS:

Many parts of coastal areas of India have thick deposits of alluvial sediments in which multi-aquifer systems of good ground water potential exist. There is considerable scope for development of ground water from such aquifer systems. However, development of ground water from such aquifers needs to be done with caution and care should be taken to ensure that over-exploitation of resources does not lead to seawater intrusion.

Large diameter dug wells; filter point wells and shallow tube wells are best suited for such aquifers. Radial wells and infiltration galleries can also be constructed in areas where the requirement of water is large.

GROUND WATER DEVELOPMENT IN HARD ROCK AREA

The hard rock areas are characterized by considerable heterogeneity and the aquifers are normally discontinuous and have limited ground water potential. These aquifers play an important role in meeting the drinking, agricultural and industrial needs in the peninsular shield areas of the country. Modern technologies in the fields of Remote Sensing, Geophysical and Geographical Information Systems (GIS), coupled with conventional hydrological and hydrogeological surveys are in use for demarcating areas suitable for further ground water development. There is however a need to restrict the development from such aquifers within their recharging capabilities to ensure their long-term sustainability.

DEVELOPMENT OF GROUND WATER IN FLOOD PLAIN AREAS

The flood plains in the vicinity of rivers are good repositories of groundwater. A planned management of groundwater in the flood plain aquifers offers an excellent scope of its development to meet the additional requirements of water. The development of ground water in Yamuna flood plain area in Delhi is an example of scientific management of water resources. During rainy season, the flood water spreads over the plains to recharge flood-plain aquifers. More than 100 tube wells has been constructed in the Palla Sector which is part of Yamuna flood plain in the depth range of 38-50 m , these tube wells have augmented Delhi's water supply by 35 MGD. The studies so far indicated that flood plain aquifers holds good ground water potential and offers better prospect of ground water development , at the same time it also instigates induced recharge from the adjoining rivers during flood season. Hence, detailed work need to be taken up in different flood plain areas of the country which can be used as alternative source of ground water in the climate change scenario as well.

GROUND WATER DEVELOPMENT IN WATERLOGGED AREAS:

Water logging and soil salinity problems resulting from gradual rise of ground water levels, are observed in many canal command areas due to the implementation of surface water irrigation schemes. As per the assessment made by the Working Group on Problem Identification with Suggested Remedial Measures (1991), about 2.46 million hectare of land under surface water irrigation projects in the country is either water-logged or under threat of it. Such areas offer good scope for further ground water development as the shallow water table in such areas can be lowered down to six meters or more without any undesirable environmental consequences. The problems related to inferior quality of water in such areas can be solved by mixing them with the canal waters. Judicious development through integrated use of surface and ground water can greatly reduce the menace of water-logging and salinity in canal irrigated areas. Central Ground Water Board has completed 13 feasibility studies for conjunctive use of surface water and ground water in canal commands of Indira Gandhi Nahar Pariyojana Stage I & II (Rajasthan); Sarada Sahayak (Uttar Pradesh); Mahi – Kadana (Gujarat) Hirakud and Rushikulya (Orissa), Tungabhadra, Nagarjunasagar & Sriramsagar (Andhra Pradesh), Ghatprabha (Karnataka), Gandak and Kosi (Bihar), and Western Yamuna (Haryana). These studies have established the need for conjunctive utilization of ground water and surface water in a judicious proportion to address the existing and emergent problems of water logging and salinity in canal command areas. Based on these studies, sector wise planning for conjunctive use has been devised including techno-economic feasibility of implementing these schemes by the State agencies in coordination with the Command Area Development Authorities (CADA).

DEVELOPMENT OF DEEPER AQUIFERS:

Studies by CGWB in the Indo-Gangetic basin in Punjab, Haryana, Uttar Pradesh, Bihar and West Bengal have revealed the existence of deep aquifers having voluminous quantity of ground water in storage. Fresh ground water has been reported down to a depth of about 700 m in Uttar Pradesh. Studies carried out by ONGC in the Gangetic alluvial plain has indicated the existence of fresh ground water at more than 1000 m depth. Free flow of ground water due to artesian conditions exists in Tarai and sub-Tarai belt of Uttar Pradesh, Bihar and J&K. As no energy is required for extraction of ground water from such aquifers, development of ground water from these auto-flow zones is both economically viable and eco-friendly.

DEVELOPMENT OF SALINE/ BRACKISH AQUIFERS:

Many areas in the country are underlain by saline water aquifers. Yields of many crops, vegetables and fruit plants e.g. barley, dates and pomegranate, when irrigated with saline or brackish water are not significantly affected. Saline/ brackish water can be successfully used to irrigate such plants and fresh or good quality water can be saved for use by other sensitive crops or for other uses.

2.2.2 DEMAND SIDE MANAGEMENT STRATEGIES - TO TACKLE DECLINE OF WATER LEVELS

In the demand side management, socio-economic aspects play an important role to arrest decline in ground water levels. The measures for demand side management can be successfully implemented only with people's participation. It is, therefore, essential to educate the masses on need and ways for regulation, conservation and augmentation of ground water resources.

REGULATION OF GROUND WATER DEVELOPMENT

Regulation of over-exploitation of ground water through legal means can be effective under extreme situations if implemented with caution. As water is a basic need and thereby an important social issue, the regulatory mechanism needs to be transparent and people-friendly. National and international experiences indicate that enforcement of legislative measures for ground water regulation and management would be meaningful only when stakeholders are motivated through local self governing bodies and directly involved in the decision-making and enforcement process.

Ground water regulatory measures in India are implemented both at Central and State level. The central Ground Water Authority, constituted under Environment (Protection) Act of 1986 is playing a key role in regulation and control of ground water development in the country. As water is a State subject, the management of ground water resources is a prerogative of the concerned State Government. In an effort to control and regulate the development of ground water, the Ministry of Water resources has prepared and circulated a Model Bill to all States and Union Territories.

2.3 GROUND WATER QUALITY

In general, ground water in shallow aquifers is suitable for use for different purposes. The quality of ground water in deeper aquifers shows wide variations. Ground waters have been found not suitable for various uses in some parts of the country due to quality problems of geogenic and/or anthropogenic nature. Some of the major ground water quality problems in India include:

Salinity: Inland salinity in ground water is prevalent mainly in arid and semi arid regions of Rajasthan, Haryana, Punjab, and Gujarat and to a lesser extent in the states of Uttar Pradesh, Delhi, Karnataka, Maharashtra, Madhya Pradesh and Tamil Nadu. Electrical conductivity of ground water in these areas exceeds 4000 micro siemens/ cm. Inland salinity of ground water is caused due to waterlogging in canal command and other shallow water table areas.

The country has a dynamic coast line of about 7500 km length. Problem of salinity ingress has been noticed in Mangrol – Chorwad- Porbander belt along the Saurashtra coast, parts of Subarnrekha, Salandi, Brahamani outfall regions in Orissa, parts of U.T of Pondicherry, Minjur area in Tamil Nadu, and parts of Andhra Pradesh, Kerala, Maharashtra and Karnataka coast.

Fluoride: High concentration of fluoride in ground water beyond permissible limit of 1.5 milligram/litre is a major health problem in the country. Fluoride in excess of permissible limit has been reported from isolated pockets in the States of Andhra Pradesh, Assam, Bihar, Chhattisgarh, Delhi, Gujarat, Haryana, Jharkhand, Jammu & Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamilnadu, Uttar Pradesh and West Bengal.

Arsenic: The occurrence of Arsenic in ground water was first reported in 1980 in West Bengal, where 79 blocks in 8 districts have Arsenic beyond permissible limit of 0.01 milligram/litre. About 16 million people are in risk zone. The most areas are in the eastern side of Bhagirathi river in districts of Malda, Murshidabad, Nadia, North 24 Parganas and South 24 Parganas and western side of the districts of Howrah, Hugli and Bardhman. The occurrence of Arsenic in ground water is mainly in the intermediate aquifer in the depth range of 20-100m. The deeper aquifers are free from Arsenic contamination. In Bihar, 12 districts viz. Patna, Bhojpur, Begusarai, Khagaria, Samstipur, Bhagalpur, Saran, Munger, Katihar, Buxar, Vaishali and Darbhanga are arsenic affected. Arsenic contamination has also been reported in Dhemaji District of Assam. In Uttar Pradesh, arsenic contamination in ground water has been reported from parts of Gonda, Ballia, Balrampur, Lakhimpur Kheri and Siddharthnagar districts. Localised occurrence of arsenic in ground water has been reported from parts of Rajnandgaon district of Chhattisgarh.

Iron: High concentration of iron in ground water has been observed in more than 1.1 lakh habitations in the country. Ground water contaminated by iron has been reported from Assam, Tripura, West Bengal, Orissa, Chhatisgarh, and Karnataka. Localized pockets are observed in the states of Bihar, Uttar Pradesh, Punjab, Rajasthan, Maharashtra, Madhya Pradesh, Jharkhand, Tamil Nadu, Kerala and North Eastern States.

Nitrate: Nitrate is a very common constituent in ground water, especially in shallow aquifers. Anthropogenic activities are the major source of nitrate in ground water. High concentration of nitrate has been found in many States, the highest being 3080 milligram/litre found in Bikaner in Rajasthan.

In addition to the quality problems mentioned above, pollution of ground water resources due to industrial effluents contributing to the presence of hazardous chemicals including heavy metals in ground water and urban sewerage resulting in bacteriological contamination are serious concerns in many areas in the country.

CHAPTER III: POSSIBLE IMPACT OF CLIMATE CHANGE ON GROUND WATER RESOURCES

3.1 GROUND WATER RECHARGE & AVAILABILITY

How climate change can influence moisture content of the atmosphere, and its sources and sinks is shown in **Figure 1 (**Trenberth[5]). A warmer climate will accelerate the hydrologic cycle, altering rainfall, magnitude and timing of run-off. Warm air holds more moisture and increase evaporation of surface moisture. With more moisture in the atmosphere, rainfall and snowfall events tend to be more intense, increasing the potential for floods.

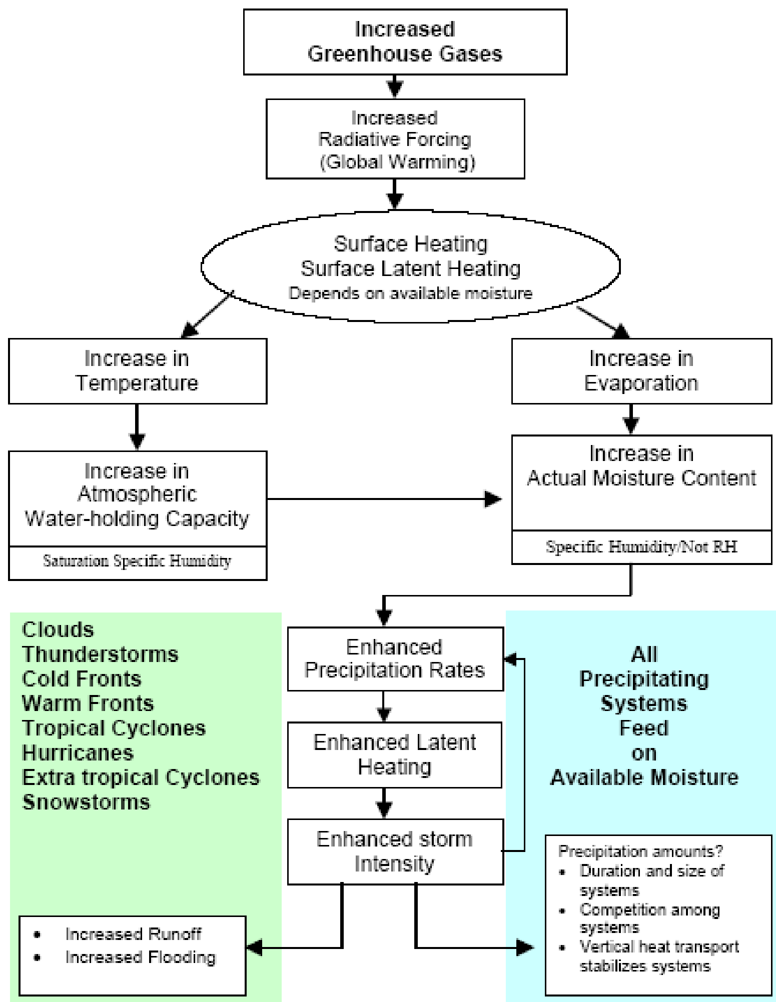


Figure 1. Conceptual model of the effect of greenhouse gases and global warming on the hydrologic cycle and phenomena associated with many climate extremes (source: Trenberth[18]).

However, if there is little or no moisture in the soil to evaporate, the incident solar radiation goes into raising the temperature, which could contribute to longer and more severe droughts. Therefore, change in climate will affect the soil moisture, groundwater recharge and frequency of flood or drought episodes and finally groundwater availability in different areas.

Studies by several workers in the Indian sub continent show that there is increasing trend in surface temperature, no significant trend in rainfall on all-India basis, but decreasing/increasing trends in rainfall at some parts. According to highlights from NATCOM-I and others the observed monsoon rainfall at the all-India level does not show any significant trend but the regional monsoon variations have been recorded. A trend of increasing monsoon seasonal rainfall has been found along the **West coast, Northern Andhra Pradesh, and North-western India** (+10% to +12% of the normal over the last 100 years) while a trend of decreasing monsoon seasonal rainfall has been observed over **eastern Madhya Pradesh, north-eastern India, and some parts of Gujarat and Kerala** (-6% to -8% of the normal over the last 100 years).

The study by Gosain and Rao[5] projected (for the period 2041-2060) that the quantity of surface run-off due to climate change would vary across the river basins as well as sub-basins in India. However, there is general reduction in the quantity of the available run-off (Figure 2).

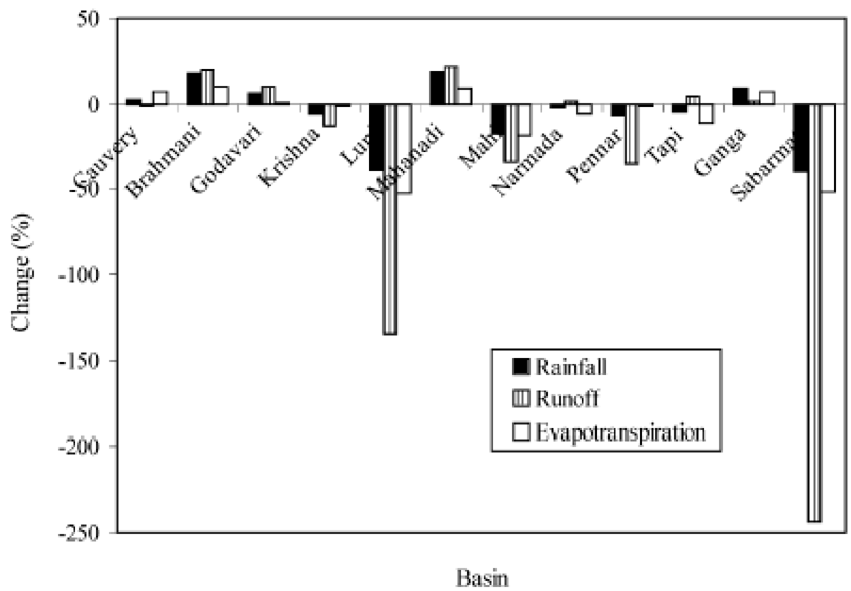
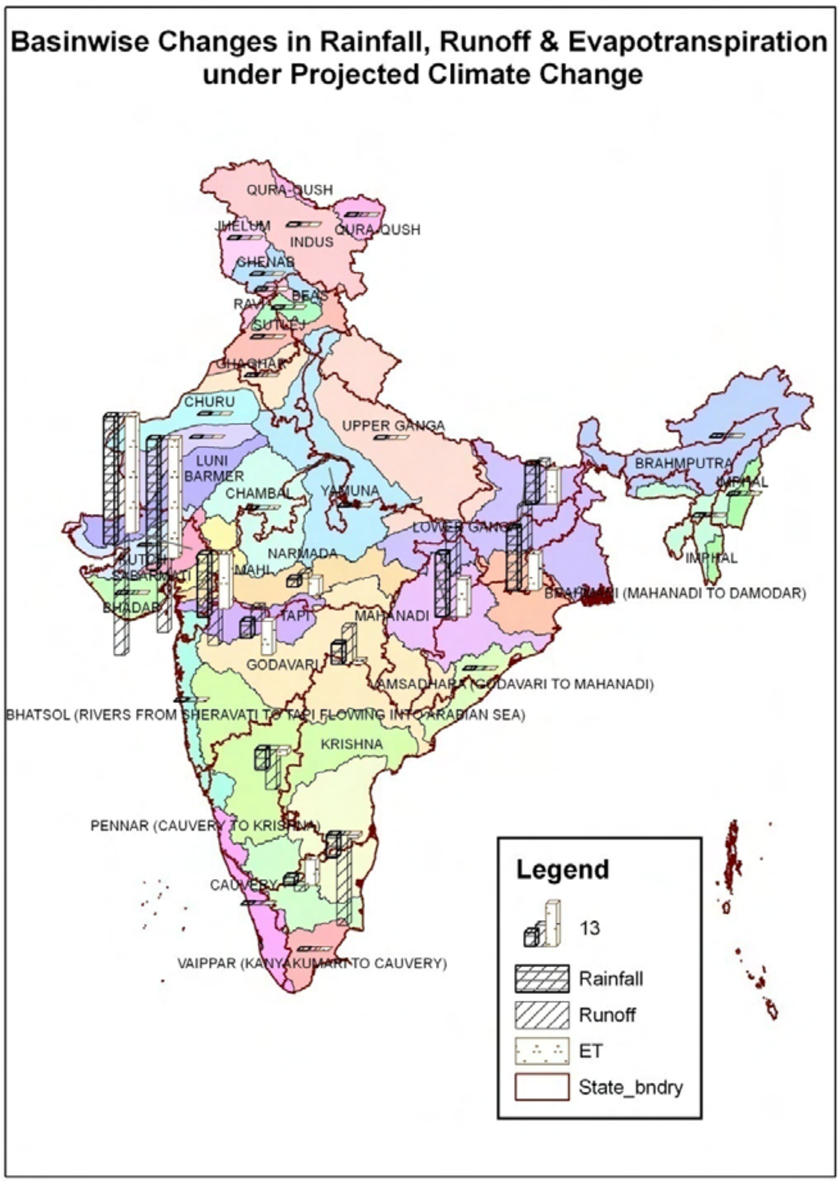


Figure 2. Changes in Rainfall, Run-off and Evapo-transpiration due to projected climate change

An increase in precipitation in the Mahanadi, Brahimani, Ganga, Godavari and Cauvery is projected under climate change scenario; however, the corresponding total run-off for all these basins does not increase. This may be due to increase in ET on account of increased temperature or variation in the distribution of rainfall. In the remaining basins, a decrease in precipitation was noticed. Sabarmati and Luni basins show drastic decrease in precipitation and consequent decrease of total run-off to the tune of two-thirds of the prevailing run-off. This may lead to severe drought conditions in future. The analysis has revealed that climate change scenario may deteriorate the condition in terms of severity of droughts and intensity of floods in various parts of the country.

The basin wise changes in rainfall pattern, runoff and evapotranspiration under projected climate change are pictorially represented in Fig. 3.

Fig: 3



Perusal of the map indicates that in general there is conflicting scenario of increase and decrease in rainfall, runoff etc. in different parts of the country. In case of cauvery river basin an increase of 2.7% of rainfall has been observed but the runoff has in fact reduced by about 2%. On the contrary reduction in rainfall in Narmada has resulted in increase in runoff , which is contrary to usual expectations. Hence , the studies indicates that the increase in rainfall due to climate change is not resulting always in an increase in the surface runoff as may be generally predicted.

Utility of precipitation primarily depends upon its spatial as well as temporal distribution. Uniform precipitation over a larger area is more useful than its occurrence over a smaller region. Also, precipitation occurring over a larger time period would be more effectively utilized rather than when it occurs within a short time-span. Secondly, intense rain occurring over fewer days, besides causing increased frequency of floods during the monsoon season, will also mean that much of the monsoon rain would be lost as direct run-off resulting in reduced groundwater recharging potential.

NORTHERN ANDHRA PRADESH, AND NORTH-WESTERN INDIA

Depending upon the spatial as well as temporal distribution of monsoon seasonal rainfall with increasing trend (+10% to +12% of the normal) in parts of **northern Andhra Pradesh, and north-western India** may possibly enhance the quantum of ground water recharge. Seeing as these areas have very high percentages of over exploited / critical blocks, this may be advantageous from recharge and resource availability point of view,.

EASTERN MADHYA PRADESH, NORTH-EASTERN INDIA, AND SOME PARTS OF GUJARAT AND KERALA

Increase in temperature and decline in rainfall (-6% to -8% of the normal) in parts of e**astern Madhya Pradesh, north-eastern India, and parts of Gujarat and Kerala** may reduce net recharge and affect groundwater resource availability.

3.2 SEA WATER INGRESS IN COASTAL AQUIFERS

Indian coastline stretches about 5700 kms on the mainland and exhibits most of the known geomorphological features of coastal zones. The impact of global warming-induced sea level rise due to thermal expansion of near surface ocean water has great significance to India due to its extensive low-lying densely populated coastal zone. Sea level rise is likely to result in loss of land due to submergence of coastal areas, inland extension of saline intrusion and ground water contamination and may have wide economic, cultural and ecological repercussions. Using the records of coastal tide gauges in the north Indian Ocean for more than 40 years, Unnikrishnan and Shankar[6] have estimated, that sea level rise was between 1.06-1.75 mm per year. These rates are consistent with 1-2 mm per year global sea level rise estimates of IPCC. Observations suggest (Aggarwal[7]) that a mean sea level rise of between 15 and 38 cm is projected by the mid- 21st century along India's coast. However, these regions face many hydrological problems like flooding due to cyclones and wave surge, and drinking fresh water scarcity due to problem of saltwater intrusion. Features, which affect coastal aquifers, are summarized in **Figure 4.**

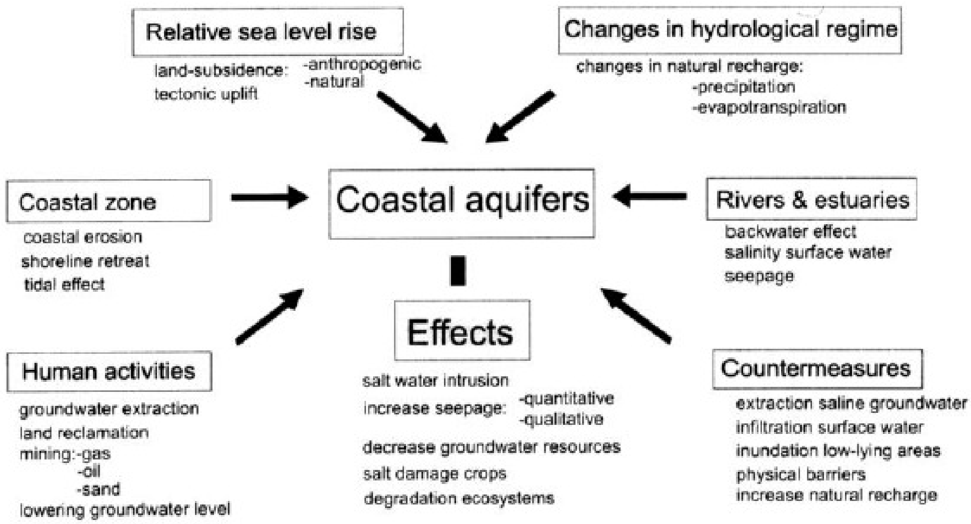


Figure 4: Features Affecting the Coastal Aquifers

LAND INUNDATION AND POPULATION AFFECTED

Recent studies on the potential impact of one meter sea level rise along Indian coast provide an idea about the land which could be inundated and the population that would be affected provided no protective measures are taken. It has been suggested that the total area of 5763 km2 along the Coastal States of India i.e., 0.41% could be inundated and almost 7.1 million i.e., 4.6 % of coastal population could be directly affected (TERI[8], 1996). The most vulnerable areas along the Indian coastline are the Kutch region of Gujarat, Mumbai and South Kerala. Deltas of rivers Ganges (West Bengal), Cauvery (Tamil Nadu), Krishna and Godawari (Andhra Pradesh), Mahanadi (Orissa) and also the islands of Lakshadweep Archipelago would be totally lost. Vulnerability of the region can be assessed not only in terms of physical exposure to sea level rise but also in terms of the level of socio-economic development of that region like population density, land uses, level of infrastructure and other investments.

SALT WATER INTRUSION AND FRESH WATER RESOURCES AND AGRICULTURE

In the coastal regions of Tamil Nadu, salinity of groundwater due to the intrusion of seawater into the subsurface aquifer is a major problem (Subramanian8, 2000). Due to excess withdrawal of groundwater, the water table has fallen too far below thereby allowing seawater to percolate. Similarly, in Gujarat due to uncontrolled withdrawal of groundwater, the ground water is becoming highly saline apart from the fact that depth of the water table reaching at places beyond 200 meters (Subramanian[9], 2000). Coastal aquifer system will be more contaminated with salinity bringing greater complicacy to the problem of tapping usable groundwater (Mohanty[10], 1990). In coastal regions of West Bengal and Orissa, the problem of fresh water is fairly acute because of the depth of water table and high cost of lifting the same from the depth of 700-1000 meters. Tidal ingress and pushing up of saline waters inland may extend by 35-50 kms beyond the present limit (Mohanty & Ray[11], 1987) and during storm conditions, the spread of salinity in the low-lying agricultural lands may ruin the prospect of crops. The potential impacts of one meter sea level rise on the land uses affected in the Coastal States in terms of the share of total land affected are shown in Table (TERI, 1996). The cultivated land would be worst affected by both inundation and intrusion due to rising sea level.

Table : Fraction of land likely to be affected in case of one meter sea level rise along coasts of various Indian States

State	Cultivated	Cultivable Land	Forest Land	Land not Available for Agriculture
Gujarat	0.03	0.08	0.00	0.89
Maharashtra	0.39	0.21	0.09	0.31
Goa	0.65	0.03	0.00	0.31
Karnataka	0.51	0.13	0.13	0.23
Tamil Nadu	0.39	0.39	0.00	0.21
Orissa	0.68	0.15	0.05	0.12
West Bengal	0.74	0.04	0.00	0.22

Source: State Sea Level Rise Report

3.3 GROUND WATER QUALITY CHANGE

Freshwater bodies have a limited capacity to process the pollutant charges of the effluents from expanding urban, industrial and agricultural uses. Water quality degradation can be a major cause of water scarcity. Although the IPCC projects that global warming of several degrees will lead to an increase in average global precipitation over the course of the 21st century, this amount does not necessarily relate to an increase in the amount of potable water available. One reason is a decline in water quality from an increase in runoff and precipitation that carries with it higher levels of nutrients, pathogens and pollutants. These contaminants were originally stored in the groundwater reserves but the increase in precipitation flushes them out in the discharged water. Similarly, when drought conditions persist, and easily recoverable groundwater reserves are depleted, the residual water that remains is often of inferior quality due in part to the leakage of saline or contaminated water from the land surface, confining layers, or adjacent waters that have highly concentrated quantities of the depleting element(s). This occurs because decreased precipitation and runoff results in a concentration of effluent in the water, which leads to an increased microbial load in waterways and drinking-water reservoirs.

One of the most significant sources of water degradation results from an increase in water temperature. The increase in water temperatures can lead to a bloom in concentration of inorganic constituents in water as well as microbial populations, which among other things can have a negative impact on human health. Additionally, the rise in water temperature can adversely affect different inhabitants of the ecosystem due to a species' sensitivity to temperature. The health of a body of water, such as a river, is dependent upon its ability to effectively self purify through biodegradation, which is hindered when there is a reduced amount of dissolved oxygen. This occurs when water warms and its ability to hold oxygen decreases (IPCC). Consequently, when precipitation events do occur, the contaminants are flushed into waterways and drinking reservoirs which has significant health implications.

Climate change will give rise to the rise and fall in sea level and in turn it may contaminate groundwater. Salt water may contaminate the water that coastal cities depend upon. An increase in sea levels would mean that the ocean would make its way inland because the soil is drying up, allowing salt water to invade the dropped levels of rivers and streams. This has an impact on the drinking water systems, especially those along the coasts. When contaminants invade our drinking water, we need to do what we can to make sure they do not stay there. There are plenty of options to make sure we get good quality water which include, artificial recharge, water filters, reverse osmosis systems, etc.

The states that have coastlines along the Bay of Bengal and Indian Oceans and also Thar desert would suffer the most if global warming came into full effect. Malnutrition and diaorrhea are the most significant health issues in poor section of the society. These issues would increase because they are highly sensitive to climate. Not only are regions with high temperatures in danger, but those regions that rely on mountains for their water would be most affected as well. The regions which falls in the flood plain are likely to have dilution of chemicals due to increased flow in the river.

CHAPTER IV PROPOSED MITIGATION MEASURES AND ACTION PLAN

In view of the clear evidences of change in global surface temperature, rainfall pattern, evapotranspiration and extreme events and its possible impact on the hydrological cycle, it is pertinent to reassess the availability of water resources. It is critical for formulating relevant national and regional long-term development strategies in a holistic way. The various mitigation measures within the constraints imposed by the possible climate change and hydrologic regimes and future research needs are discussed in following paragraphs.

4.1 RAINWATER HARVESTING AND ARTIFICIAL RECHARGE:

Extreme climate events such as aridity, drought, flood, cyclone and stormy rainfall are expected to leave an impact on human society. They are also expected to generate widespread response to adapt and mitigate the sufferings associated with these extremes. Societal and cultural responses to prolonged drought include population dislocation, cultural separation, habitation abandonment, and societal collapse. A typical response to local aridity is the human migration to safer and productive areas. However, climate and culture can interact in numerous ways. We hypothesize that people may resort to modify dwelling environments by adapting new strategies to optimize the utility of available water by harvesting rain rather than migrating to newer areas. When we review recent palaeo climatological evidence for climate change during the Holocene, and match those data with archaeological and historical records to test our 'climate change-rainwater harvest' hypothesis. We find correlation between heightened historical human efforts for construction of rainwater harvesting structures across regions in response to abrupt climate fluctuations, like aridity and drought. Historical societal adaptations to climate fluctuations may provide insights on potential responses of modern societies to future climate change that has a bearing on water resources, food production and management of natural systems. Decentralized rainwater harvesting from roof catchments in cities has the potential to supplement centralised water supply strategies to create an overall more resilient urban water supply. This result highlights the importance of implementing a diverse range of water sources and conservation for urban water management. The efficiency of translation of rainfall into runoff is highly dependent on strategy and location.

The immediate priority for augmentation of ground water are the areas already overexploited resulting into severe decline in ground water level, coastal areas affected by sea water ingress due to haphazard and unscientific development of ground water and the areas infested with pollution due to various reasons. While prioritizing the areas, the possible impact of climate change needs to be dovetailed. As a long term measure an attempt has been made to provide a conceptual framework for utilization of surplus monsoon runoff for artificial recharge of ground water and consequently a " National perspective plan for recharge to ground water by utilizing surplus monsoon runoff" has been prepared. The report provides availability of non-committed surplus monsoon runoff in 20 river basins of the country vis-a vis the subsurface available space under different hydrogeological situations for saturating the vadose zone to 3 m below ground level. It was estimated that it is possible to store 21.4 Mham in the ground water reservoir through out the country out of which 16.05 Mham can be utilized. In the present context, in view of the possible impact of climate change on the overall runoff generation there is a need to re estimate the availability for any future planning.

Assuming the importance of artificial recharge and rain water harvesting, the Model Bill on Ground water prepared and circulated by Ministry of Water Resources has been amended in 2006 to accommodated the this important aspect and all the state Governments has been asked to formulate their own rule and law for better governance of ground water adopting suitable augmentation measures where ever required or else impose regulatory measure to ensure sustainability of this vital resource.

An increase in precipitation in the basins of Mahanadi, Brahimani, Ganga, Godavari and Cauvery is projected under climate change scenario. Unless remedial measure are implemented to control the runoff , frequency of floods in these areas are unavoidable. During and after the floods , ground water plays a significant role as alternative source of drinking water. The construction of " Sanctuary wells " in such areas at suitable locations or near the shelters houses may provide a solution for solving the drinking water crisis during the flood times. Preferably the Sanctuary wells may be constructed tapping the deeper aquifers which are less vulnerable to contamination because of inundation.

4.2 CONJUNCTIVE MANAGEMENT

Conjunctive management will play crucial role as a mitigatory measure since climate change will lead to extreme situation of water level rise in some areas and water level decline in other areas. In such event Conjunctive management need to be adopted so as

- To evolve a suitable plan for controlling the problem of rising water levels by adopting the technique of conjunctive use of surface and ground water, and proper drainage.
- To prepare sector/ block-wise plans for development of ground water resource in conjunction with surface water based on mathematical model results.
- To test the sustainability of the present irrigation pattern with respect to conjunctive use of water resources and suggest improvement for future.
- To evaluate the economic aspect of groundwater development plan with respect to Cost benefits ratio, internal rate of return and pay back period etc.

Further, there is an urgent need to adopt participatory Irrigation management ensuring participation of stakeholders since inception of the conjunctive use projects. As already discussed in previous chapters regarding variations in rainfall and runoff in different basins of the country, it is expected that imbalances in availability of surface and ground water may aggravate the conditions of water logging at one end and scarcity at other end. The major irrigation command areas are more vulnerable to such extreme events and hence there is an urgent need to implement conjunctive use practices in field conditions so as to control water rising water level scenario, water logging and even water shortages in tail end areas. Several studies carried out in this context by different agencies and their findings may provide sufficient feedback to prepare the road map for planning simultaneous utilization of surface and ground water in an optimal manner. The findings of the feasibility studies for conjunctive utilization of surface and ground water in some of the major irrigation commands is provided in **Annexure- IV.**

In alluvial aquifer areas, conjunctive management of rain, surface water, and groundwater is the big hitherto underexploited opportunity for supply-side management. Massive investments being planned for rehabilitating, modernizing, and extending gravity-flow irrigation from large and small reservoirs need a major rethink in India. In view of the threat of Climate Change, indeed, we need to rethink our storage technology itself. Over the past 40 years, the South Asian landmass has been turned into a huge underground reservoir, more productive, efficient, and valuable to farmers than surface reservoirs. For millennia, it could capture and store little rainwater because in its predevelopment phase it had little unused storage. The pump irrigation revolution has created 285 to 300 km^3 of new, more efficient storage in the subcontinent. Like surface reservoirs, this is good in some places and not so good in others. To the farmer, this reservoir is more valuable than surface reservoirs because he has direct access to it and can scavenge water on demand. Therefore, he is far more likely to collaborate in managing this reservoir if it responds to his recharge pull. Indeed, he would engage in participatory management of a canal if it served his recharge pull. This is best illustrated by the emergence of strong canal water user associations of grape growers in the Vaghad system in Nasik district of Maharashtra. Vineyards under drip irrigation in this region need to be watered some 80 to 100 times a year, but canals are useless: they release water for a maximum of just 7 times. Yet grape growers have formed some of the finest water user associations in the region for proactive canal management here mostly because they value canals as the prime source of recharging the groundwater that sustains their high-value orchards (Bassi 2006, pers. comm.).

In mainstream irrigation thinking, groundwater recharge is viewed as a byproduct of flow irrigation, but in South Asia today, this equation needs to be stood on its head. Increasingly, the region's 450-odd km^3 of surface storage makes economic sense only for sustaining water-scavenging irrigation in extended command areas. A cubic meter of recharged well water, scavengeable on demand, is valued many times more than a cubic meter of water in surface storage. Farmers' newfound interest in local waterbodies throughout semiarid South Asia reflects the value of groundwater recharge. This is evident in South Indian tank communities that are converting irrigation tanks into percolation tanks, and in Saurashtra and Kutch, where a new norm intended to maximize groundwater recharge forbids irrigation from check dams.

Already, many canal irrigation systems create value not through flow irrigation but by supporting well irrigation. In the Mahi Right Bank system in Gujarat, with a command area of about 250,000 ha, it is the more than 30,000 private tube wells—each complete with heavy-duty motors and buried pipe networks to service 30 to 50 ha—that really irrigate crops; the canals merely recharge the aquifers. An elaborate study by India's Central Groundwater Board (1995) lauded the Mahi irrigation system as a "model conjunctive use project" in which 65 percent of water was delivered by canals and 35 percent was contributed by groundwater wells. However, what conjunctive use was occurring was more by default than by design.

4.3 INSTITUTIONAL AND REGULATORY MEASURES

One of the most important mitigation measure is strengthening of institutional as well as regulatory framework of the country in relation to ground water. In spite of the fact that water is a state subject and it need to be regulated at the state level, there are several states in which there is no independent department or set up to look after the ground water governance. Hence, there is an urgent need of institutional strengthening at appropriate level and adoption of regulatory measures in strict sense.

In this connection the implementing agencies for regulatory measure may be decided by the Central and State government. The implementation may be through the State Ground Water Department/PHED or local development board or authority. The implementation should be entrusted to one single department in the state and not to a number of departments with a view to better implementation, monitoring of the progress etc. If the programme has to be implemented in more than one department in the state due to unavoidable and certain special consideration, one of the departments should be designated as Nodal Department for coordinating the all the activities related mitigatory measure related climate change and ground water and sending consolidated progress to the Central Government. The Panchayati Raj Institution should also be involved in the implementation of the schemes, particularly in selecting the location of standpost spot sources, operation and maintenance. Planning Commission in its report of the Expert Group on " Ground Water Management and Ownership - Sep'2007 " has discussed the requirement of certain institutional changes and suggested that the mandate of Central Ground Water Board to be shifted to a facilitator rather than a regulator to assist better implementation of management options.

For effective implementation of ground water management plan it is proposed to formulate a three tier institutional arrangements involving Central, State and Districts level agencies. The role of different level of Organizations is discussed below.

CENTRAL LEVEL:

National apex Organisation may be identified to take up the role of rendering all technical assistance in respect of exploration, monitoring, management and regulation of country's ground water resources, to the concerned State Ground Water (Nodal) Department in planning and implementation of all mitigation plans / schemes. These nodal departments may also assist in preparing technical manuals, establishing capacity building arrangements, etc. required for the implementation. Ministry of Water Resources may have the role of facilitating allocation of the necessary budgetary outlay for such mitigation schemes among the States.

STATE LEVEL:

The concerned State Government may select a Nodal Department (preferably State Ground Water Department), which in turn may prepare District wise mitigation plans/ schemes, identify district level implementing agencies and periodical monitoring of progress of work.

The concerned State Government may also constitute a State Level Steering Committee(SLSC) under the chairmanship of Secretary, Water Resources which would be responsible for overall implementation of the schemes including laying guidelines for planning, implementation, monitoring, appraisal and approval of the District wise mitigation plans/ schemes.

DISTRICT LEVEL:

To ensure effective implementation of the mitigation plan/ schemes at gross root level, State Government may also constitute a district level implementation and monitoring committee (DLIMC) under the Chairmanship of District Collector. DLIMC would monitor the physical and financial progress of the mitigation scheme and may report to SLSC on all matters for implementation.

The district level authority should be empowered to identify the implementing agencies involving Gram Panchayats / Gram Sabhas and equivalent local bodies. Various stakeholders namely Water User Associations (WUA) , Pani Panchyats and registered NGO's .

4.4 INCREASING GROUND WATER USE EFFICIENCY

Water use efficiency programs, which include both water conservation and water recycling, reduce demands on existing water supplies and delay or eliminate the need for new water supplies for an expanding population. These effects are cumulative and increasing. Water conservation savings have increased each year due to expansion of and greater participation in these water conservation programs. Water recycling, or the use of treated wastewater for non-potable applications, is used in a variety of ways, including for irrigation and industrial processes. This in turn will provide environmental benefits as well as significant aesthetic and human health benefits. A reduction in water-related energy demand due to water conservation and water recycling reduces the air pollutants and allows to respond to the water supply challenges posed by global climate change. Water conservation and water recycling programs clearly save energy and reduce air pollutant emissions.

Broadening the limits of the quality of water used in agriculture can help manage the available water better in areas where scarcity of water is due to salinity of the available ground water resources. Cultivation of salt tolerant crops in arid/semi-arid lands, dual water supply system in urban settlements - fresh treated water for drinking water supply and brackish ground water for other domestic uses are some such examples. Recycling of water after proper treatment for secondary and tertiary uses is another alternative that could be popularized to meet requirements of water in face of the scarcity of resource in the cities. It has been estimated that parts of Haryana, Punjab, Delhi Rajasthan, Gujarat, Uttar Pradesh, Karnataka and Tamil Nadu have inland saline ground water of the order of about 1164 BCM. Yields of many crops, vegetables and fruit plants e.g. barley, dates and pomegranate, when irrigated with saline or brackish water are not significantly affected. Saline/ brackish water can be successfully used to irrigate such plants and fresh or good quality water can be saved for use by other sensitive crops or for other uses. Brackish water can also be utilized for pisciculture / aquaculture. Therefore, additional resource of 1164 BCM of saline/brackish ground water resource would be available for use. Studies are required to be undertaken on use and disposal of brackish / saline ground water

Studies have shown that that substantial quantity of water could be saved by the introduction of micro irrigation techniques in agriculture. Micro irrigation sprinklers and drip systems can be adopted for meeting the water requirement of crops on any irrigable soils except in very windy and hot climates. These water conservation techniques would provide uniform wetting and efficient water use.

Changes in cropping pattern aimed at higher return of investment may lead to increased exploitation of ground water, as the experiences in Punjab and Haryana have shown. Suitable scientific innovations may be necessary to solve this issue. Less water intensive crops having higher market value, scientific on-farm management, sharing of water and rotational operation of tube wells to minimize well interference and similar alternatives can provide viable solutions for balancing agro-economics with environmental equilibrium.

In order to increase the ground water use efficiency suitable incentives for community management of new wells, for construction of recharge structures, for energy saving devices like installation of capacitors and frictionless foot valves and for adoption of micro irrigation can be offered to the users in water stressed areas (Over exploited and Critical blocks) instead of putting ban for further exploitation of ground water.

GROUND WATER AND ENERGY NEXUS

As of now, managing the energy-irrigation nexus with sensitivity and intelligence is the region's principal tool for groundwater demand management. The current challenge is twofold. First, diesel-based groundwater economies of the Indo-Gangetic basin are in the throes of an energy squeeze; some recent studies (Shah 2007b; Ul Hassan et al. 2007) show that, with further rise in diesel prices, will undermine the potential benefits of conjunctive use of ground and surface waters in water abundant areas of Ganga basin. Electrification of the groundwater economy of these regions combined with a sensible scheme of farm power rationing may be the most feasible way of stemming distress out migration of the agrarian poor. In the electricity-dependent groundwater economy of western and peninsular India, the challenge is to transform the current degenerate electricity-groundwater nexus into a rational one. Tariff has proved a political challenge in many of these states; but other 'hybrid' solutions need to be invented. Gujarat's experience under the Jyotirgram scheme illustrates a 'hybrid' approach based on intelligent rationing of power supply. But other states in the region too are moving in the direction of demand management by rationing power. Punjab has effectively used stringent power rationing in summer to encourage farmers to delay rice transplantation by a month and in the process significantly reduced groundwater depletion.[1] Andhra Pradesh gives farmers free power but has now imposed a seven-hour ration. Our surmise is that power rationing can be a simple and effective instrument for groundwater demand management.

In hard-rock India, together with intelligent management of the energy-irrigation nexus, mass-based decentralized groundwater recharge offers a major short-run supply-side opportunity. Public agencies are likely to attract maximum farmer participation in any programs that augment "scavengable" water around farming areas. Experience also shows that engaging in groundwater recharge is often the first step for communities to evolve norms for local, community-based demand management. Surface system management is clearly in dire need of reinvention.

ADOPTING PIPED WATER SYSTEM :

There is a new groundswell of enthusiasm for pipes rather than open channels to transport water. South Asia's irrigation boom, based on the triad of mechanical pumps, boreholes, and rubber pipes, is quintessentially the smallholders' response to the age-old hydraulic constraints imposed by gravity and open channel flow. But the use of pipes for water transport is also valued for at least two other benefits: first, saving scarce farmland otherwise used for watercourses and field channels, and second, microirrigation. In the

Sardar Sarovar Project, the major reason water user associations refused to build water distribution systems was land scarcity. In an agrarian economy with already high population pressure on farmland, flexible pipes for water distribution make more sense than surface channels, and buried pipes are even better. Pipes also support micro-irrigation technologies. This is what explains a boom in the use of plastics in many parts of Indian agriculture. And if China's experience is any guide, this boom will continue to generate water as well as energy savings.

Promoting piped water conveyance aggressively can be a win-win strategy in India's pump irrigation economy. Recent discussion has cast doubts on whether microirrigation offers real water savings at the basin level or not. Regardless, the appeal of microirrigation to farmers derives not from water savings but from reduced cultivation costs, higher yields, and better product quality.[2] To the extent that microirrigation improves smallholders' livelihoods from available land and water, it deserves aggressive promotion, with energy savings thrown in as a bonus. The primary reason microirrigation technology is not spreading as fast as it could is, paradoxically, the government subsidy intended to promote it. Drip irrigation companies can manipulate the subsidy scheme to make money without having to promote the technology to farmers, as they would have done in a subsidy-free market. Microirrigation markets can grow in India if subsidies are abolished all together, and it can boom if subsidies are redesigned so that instead of shrinking the market for these technologies, as they now do, they begin growing it.

It could also reduce the redundancy of separate water delivery systems—surface canals for irrigation and pipes for domestic water supply—common in India. The value of the productive land released, improved water availability, energy savings, and carbon credits earned may pay for much of the retrofitting costs. Why, one might ask, has such a system not been tried more extensively elsewhere in the world? The answer comes in two parts: first, it is indeed being tried in many developed countries simply for the water savings and pressurized irrigation that piped systems offer; second, nowhere do we find a boom in groundwater irrigation within canal commands as we find in India. From society's viewpoint, there is little justification for investing in expensive surface canal systems if farmers are going to predominantly use them for groundwater recharge.

4.5 ADOPTING THE CONCEPT VIRTUAL WATER

Virtual water is defined as water embedded in commodities. It is said that the largest exported commodity in the world is 'Water', which is in terms of virtual water contained in the food grains. As a thumb of rule, a grain crop transpires about 1 cubic meter of water in order to produce 1 kilogram of grain. Thus exporting or importing 1 kilogram of grain is approximately equivalent to exporting 1 cubic meter of water. The best example of virtual water in Indian context can be thought in terms of producing fodder in the water surplus areas of Indo Gangetic plains and transported to the water stressed areas of Gujarat, Rajasthan, Punjab etc. this way water used for fodder production in these states can be reduced and water saved can be fruitfully utilized for other priority sectors. Thus the concept of Virtual Water can help in combating the impact of climate change on ground water by planning the suitable cropping pattern depending upon the availability of ground water .

2

4.6 COASTAL AQUIFER MANAGEMENT

Recent studies on the likely impact of sea level rise to the tune of one meter along Indian coast provide an idea about the land which could be inundated and the population that would be affected provided no protective measures are taken. The ingress of salinity in the coastal aquifers with respect to sea level rise and ground water abstraction is most likely in the event of climate change. Most vulnerable areas along the Indian coastline are the Kutch region of Gujarat, Mumbai and South Kerala. Deltas of rivers Ganges (West Bengal), Cauvery (Tamil Nadu), Krishna and Godawari (Andhra Pradesh) and Mahanadi (Orissa).

The future studies should be focused on developing efficient monitoring mechanism, Filling the data gap through ground water exploration, hydrochemical and modeling studies**.**

MONITORING SYSTEM :

The most important future study should be on a monitoring mechanism which can alert in the event of a sea water intrusion. There should be tube wells/ piezometrs (Pz) all along the coast and across the coast to monitor the water level / peizometric surface of individual aquifers. These wells / piezometer (Pz) should be fitted with automatic recorders for recording the water level and quality. These should be fitted with pump (provision) for taking samples for chemical analysis to confirm the recording. These piezometers are to be constructed across the coast in a row/ line at periodic intervals along the coast, so that they will help in studying the advancement of the fresh water sea water interface.

Since the coastal areas are prone to natural calamities like Tsunami, Cyclones, Earth Quakes etc. which necessitates a permanent provision for disaster management. With minor modifications the above monitoring wells can also act as a source of domestic water during exigency. Once the situation normalizes again the well/Pz will be kept only for monitoring. As soon as a well or Pz becomes defunct it should be replaced with a new one. Such wells/piezometers with dual purpose can be termed as **"SANCTUARY WELLS**". The wells / Pz are to be fitted with pump for collecting samples. If the well can be protected with sufficient protection inside a room, it can help in disaster management. The pump shall be operated periodically to flush out the stagnant water and also to keep the pump in working condition.

EXPLORATION

The exploration in the coastal area are mostly limited to the maximum of 600 m, however, it is required to further explore the area up to 1000/ 1500 m so as to decipher the deeper aquifers. These deeper aquifers seldom get affected by natural calamities and hence can act as a strategic source during natural calamities.

HYDROCHEMICAL STUDIES:

Detailed hydro chemical studies of the formation water may be carried out. This will not only help in identifying the type of water, its reaction with the aquifer material and the hydro chemical equilibrium but also will strengthen the hydro geological findings. Apart from studying the routine major ions the analysis of Bromide, Boron, Strontium, and Iodide are to be carried out. This will help in establishing the sea water intrusion if any.

Modeling Studies

Modeling studies may be taken up in a few select areas (Saurastra coast, Chennai – Minjur Pondicherry area, Alleppey area, Puri – Balasore area, Haldia – Kolkatta area and Krishna Godavari delta) where the sea water intrusion has already been noticed to establish the ground water dynamics including movement of the fresh water saline water interface wherever encountered and the threat of the sea water intrusion wherever it is likely to take place in future.

4.7 WATER QUALITY MITIGATION MEASURES

Various mitigation measure related to tackling ground water quality related problems are basically linked with the type and sources of contamination. Generally the ground water contamination is an irreversible process , that is once the ground water aquifers get contaminated it is very difficult if not impossible to claen the aquifer. However, limited world wide examples are available for in situ Aquifer remediation, which is a very complex issue. Hence , pre requisite for any remediation measure would essentially require a detailed study regarding dynamics of contaminant transport be it geogenic or man made . Many negative externalities associated with the pump irrigation boom are impossible to internalize fully anytime soon and are best coped with. A good example is arsenic in the eastern Ganga basin and fluoride in western and peninsular India. These contaminants of drinking water are geogenic, and their links with irrigation development seem neither clear nor straightforward. Even if the link is strong, restoring aquifers to their predevelopment stage by banishing groundwater irrigation would be an unrealistic response. A more practical approach is to enhance social capacity to cope with and adapt to these contaminants. Doing this is as much a socioeconomic issue as a scientific and technological one. Notably, the society is quicker and more savvy in responding to these threats than the state is, as the small-scale reverse osmosis industry in North Gujarat would suggest. NGOs in Saurashtra, too, have noted that one spillover benefit of the decentralized recharge movement is a reduction in fluoride concentration in groundwater. Although there is no systematic supporting evidence, it stands to reason that fluoride concentrations might be greater when water is pumped from greater depths in hard-rock aquifers than from closer to the surface. In the arsenic affected areas of West Bengal, the immediate remedial action was to identify the arsenic free deeper aquifers where ever possible or to resort to arsenic removal plants. Hence, the mitigation measures for ground water quality need to be formulated on scientific basis within the socio economic framework.

4.8 R & D NEEDS

Increasing thrust on ground water resources in the event of climate change may require efficient groundwater management practices supported by Research and Development studies. The broad objectives of the R & D should be targeted to improve the well-being, hygiene, health and quality of life of the populace through supplying dependable, safe, and suitable water supply for multiple uses. In National Water Policy (2002), drinking water (which is mostly sourced from ground water), has been given the highest priority. Given this priority for improved groundwater management, there is a need to develop technologies through applied research and undertake purpose driven studies in frontier areas. Focus to these studies will primarily rest on the various needs of ground water users. The priority areas for taking up studies and research are as follows:

- **Effect of urbanization and industrialization on groundwater quality** with special reference to solid waste Disposal, fly ash disposal, landfills using contaminant transport modeling etc.
- **Recycling and reuse of water**. In urban centers recycling and reuse of water can reduce heavily the stress on ground water system. Studies may be taken up to evolve the mechanism for recycling and reuse of water for specific conditions and areas.
- **Development of ground water basin models for conjunctive use of surface and ground water.** Present approach in conjunctive use planning is by enacting the ground water simulation and optimization models separately, combining with the economic analysis to arrive at the optimal development strategy. There is a need to adopt, the ***Ground Water Hydraulic Management Models (Management models)*** which incorporates a ground water simulation model as constraint in the Management model.
- **Refinement of Methodologies for Assessment of Ground water Resources.** Quantification of groundwater resources is often critical and no single comprehensive technique is yet identified which is capable of accurate ground water assessment. Inaccurate assessment leads to various problems in ground water resource development. With the advent of new techniques for data generation and fast computing facilities there is an urgent need to take up studies to refine the existing methodology (GEC, 1997).
- **Development of Decision Support System (DSS) for planning and management of ground water resources.** In the coming decades there is going to be major shift towards ground water management rather than development. Decision Support Systems (DSS) are most advanced technical tool to support information needs of ground water resources management processes. DSS application may pertain to groundwater resources planning or management depending on the scope of the decisions they intend to support. A typical DSS includes five main components: data acquisition system, user-data model interface, databases, data analysis tools, and a set of inter-linked models.
- **Environment and radioisotope applications in groundwater dating, contaminant transport and groundwater recharge studies.** Environment and radioisotopes are very helpful in precise and accurate quantification of ground water . These studies are also useful for determining the origin and age of different aquifers; determination of recharge and discharge areas and estimation of the velocity of ground water as well as contaminant flow.
- **Application of RS/GIS in Ground Water.** With the help of new tools like remote sensing, delineation of fresh water aquifers within saline areas and location of old buried channels has become possible in water scarcity areas. Such information when integrated in a Geographic Information System (GIS) provides additional tools to policy planners for generating area specific solutions. This helps in prioritization of areas for resources augmentation, conservation and optimal use of water and continuous monitoring of ground water development and its utilization.
- **Mapping of High Altitude Aquifers -** in the high hilly terrains, the major source of drinking water supply is springs. However, with the increase in population and damage to the environment, the discharge of the springs is decreasing. It is the need of the hour to take up research studies to identify areas of recharge, movement pattern of the springs and to revive the spring line.

- **Participatory Research -** There are Research institutions like NIH, IITs and others, which take up research studies in the field of ground water. To amalgamate the lab generated ideas into field applications there is urgent need to take up various ground water research studies in collaboration.
- **Coastal Aquifer Management:** Several agencies are engaged in hydrogeological studies in the coastal areas , however there is an urgent need to bring all the data / information to a common platform so as to build a scientific data base of the coastal aquifer system and their hydrodynamics which will help in planning strategies during calamities. Further, it is also proposed to undertake R & D studies in context of increasing areas under seawater ingress and their relation with overexploitation of ground water to arrive at possible mitigation measures. There is a need to construct medium deep and deep tube wells along the coast vulnerable to cyclones and Tsunamis , these wells may be categorized as "**Sanctuary wells**" and kept in reserve for utilization during natural calamities , rest of the times these wells may be used as monitoring wells. Above all, there should be a planned ground water monitoring system which can give warning on sea water intrusion and other hydrogeological problems well in advance to initiate mitigation measures.

4.9 CAPACITY BUILDING AND TRAINING NEEDS

As per an estimate within the country about 10000 professionals, 20000 sub-professionals and nearly 100000 skilled personnel are employed in the work of ground water investigation, development and management. Many of the sub professionals like drillers etc. have no formal training in ground water which is very essential for getting optimum benefits as its sustainable development. Training and capacity building are integral part of organizational development. In view of the increasing importance of ground water and anticipated climate change there is a need to create exclusive infrastructure to cater the need of training requirements of ground professional in the country. The country had so far not been able to create the requisite training facilities. The professionals being assigned to the work usually possessed a Master's Degree in Geology / Geophysics / Chemistry or Bachelors Degree in Engineering. Though the Universities and Technical institutes are well equipped to carry out academic teaching programmes in the mother disciplines like geology, Geophysics they have limited facilities for training the field professional on specialized aspects of ground water assessment, management application of advanced tools like modeling , GIS etc.

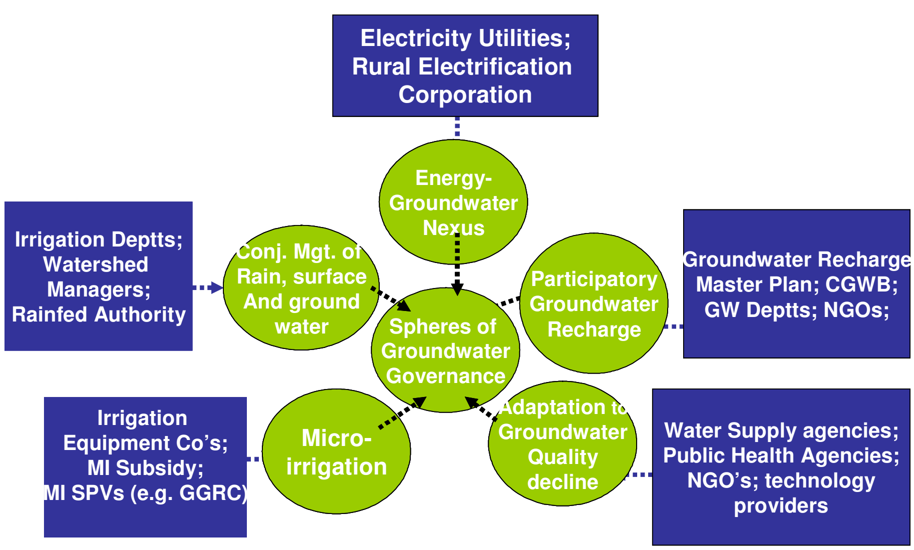
In the context of water resources, training in the form of capacity building is indispensable for (a) strengthening the enabling institutional environment which takes the organizations in the right directions; (b) optimizing the available water resources which is becoming more and more critical with the passage of time; (c) establishing responsibility and accountability at all appropriate levels of hierarchy to usher in the needed efficiency; (d) understanding and appreciating value of water as a social and economic good; (e) developing and encouraging reliable information on policies, programmes, and projects, and systems of sharing this information to bring in transparency; and (f) keep finding innovative solutions to problems, technical or otherwise, facing the sector to manage the resource sustain ably.

CHAPTER V: SYNERGY AMONG VARIOUS STAKEHOLDERS

The mission of sustained development of ground water resources and various mitigation programmes required in the event of possible climate change in the country can be accomplished only with the help and active cooperation of all stakeholders such as the Ministries of Government of India for Water Resources, Environment & Forests, Rural Development, Agriculture, Science & Technology and the institutions working under them; State Governments & their organizations; Associations of Industry, Non-Government Organizations, District Administrations and Panchayati Raj Institutions and the individuals users. To be successful in this mission we also have to create conditions for complete synergy in the activities of all the stakeholders.

A National Ad-hoc Committee on Groundwater, comprising various stakeholders may be formed to develop and promote a national strategy on groundwater across the country. The committee along with the Central and State nodal agencies engaged in ground water development may develop coordination programme in providing technical and scientific inputs for the success of such national mitigation operations. In this regard Ministry of Water Resources has taken a step forward by constituting the " Advisory Council on Artificial Recharge to Ground Water " involving members from all walks of life. However, the stakeholders in grass root levels need to be sensitized to the social relevance of technical decision on mitigation.

Although the groundwater agencies at central and state level are the custodians of our groundwater resource, in reality, multiple agencies in public and private sectors are involved as major players in India's groundwater economy**.** As climate change transforms groundwater into a more critical and yet threatened resource, there is dire need for coordinating mechanisms to bring these agencies under an umbrella framework to synergize their roles and actions. Even as governments evolve groundwater regulations as outlined in the figure below. Synergizing the working of agencies in these offer the best chance to bring a modicum of order and method to the region's water-scavenging irrigation economy (see the figure below).



India’s Groundwater Governance Pentagram

One aspect of the pentagram (Figure above) is the recognition of changing roles and protocols for designing and managing surface waterbodies for maximum impact on groundwater recharge. Surface systems in water-stressed regions of western India are already being remodeled to mimic the on-demand nature of groundwater irrigation. In Rajasthan’s Indira Gandhi Canal, the government is subsidizing farmers to make farm ponds, to be filled by canal once a month and then used to supply water on demand. Gujarat is following suit through a new program of supporting farmers in command areas to build on-farm storage from which they can irrigate on demand. Integrating large canal irrigation projects in the atomistic pump irrigation economy may support the case for rethinking their modernization in ways previously unimagined. Replacing lined canals with buried perforated pipes that connect with irrigation wells or farm and village ponds, creating recharge paths along the way, may be a more efficient way of using surface storage than flow irrigation.

The time is ripe for India’s policymakers to reinvent public irrigation systems. Retrofitting large reservoirs and canals as piped systems delivering water for pressurized irrigation has never received serious consideration because of the high capital cost of piped water transport. But in India today, this idea deserves to be explored for its countless advantages. Four to 7 percent of the land in the command area of a canal irrigation system is used up by the canal network itself. In a land-scarce region like India, land acquisition itself is the major cause of cost and time overruns, not to mention widespread farmer unrest and opposition from civil society groups. Then, pump irrigators in many Indian canal commands expend more energy on their wells and tube wells than the hydropower that reservoirs generate. Using the weight of the water in the reservoir, closed systems of buried pipes below the reservoir[13] could run turbines as well as provide pressurized irrigation service. On a micro scale, this is already practiced by water sellers in Gujarat, who use overhead tanks and buried pipelines to deliver pressurized irrigation to their customers.

By far the most critical response to hydroclimatic change in India’s water sector demands exploring synergies from a variety of players for a nation-wide groundwater recharge program. Evolving a groundwater recharge strategy appropriate to India needs to begin with an appreciation of the variety of actors that can contribute through different kinds of recharge structures as suggested in the following table. Public agencies with strong science and engineering capabilities need to play a major role in constructing and managing large recharge structures. However, in India, an intelligent strategy can also involve millions of farmers and householders—and thousands of their communities--each of whom can contribute small volumes to recharge dynamic groundwater. The following table explores who can play what role to which purpose and in which conditions. When we approach the problem this, new strategic avenues present themselves

Actors and Roles in a Groundwater Recharge Strategy

Proposed Structure	Aquifers affected	Key players	Numbers of actors who can contribute	Recharge Volumes/ structure	Location of structures
Small structures for recharging wells, farm ponds and roof-water harvesting structures	Dynamic groundwater in hard-rock areas	Individual farmers and urban citizens	millions	100-5000 m^3	Private farm lands and homes
Check dams, percolation tanks, Sub-surface dykes, etc	Dynamic groundwater in hard-rock areas	Communities using a common aquifer system	Tens of thousands	100,000-5,000,000 m^3	Common-property or government land
Large structures on government land for recharge to confined aquifers; improved conjunctive management of surface and groundwater	Confined aquifers; large alluvial aquifers especially in arid and semi-arid areas	Public agencies with hydro-geology expertise; canal system managers	few	0.1 to 1 km^3 or more	Government waste lands or forest lands; command areas of canal irrigation systems.

In view of the criticality of groundwater recharge, a Special Purpose Vehicle (SPV) needs to be created for overseeing private and NGO-implemented groundwater recharge programs as well as for executing, operating and maintaining large-scale groundwater recharge program. It can be visualized as a subsidiary of the CGWB; but besides the scientific talent of the CGWB, such a SPV needs to build engineering and management capacity needed for the purposes on hand.

India's water policy has so far tended to focus on what governments and government agencies can do. Now, it needs to target networks of players, each with distinct capabilities and limitations. If groundwater recharge is to be a major response to hydro-climatic change, the country needs to evolve and work with an integrated groundwater recharge strategy with role and space for various players to contribute as outlined in the table below.

Outline of an Integrated Groundwater Recharge Strategy for India

Key actors	**Arid alluvial aquifer areas**	**Hard rock aquifer areas**	**Roles that need to be played by CGWB, Recharge SPV, other public agencies**
Farmers		Dug wells, farm ponds, roof-water harvesting; other private recharge structures	Vigorous IEC[a] campaign to promote recharge to dynamic waters through dug wells & farm ponds
			Technical support in constructing recharge pits, silt-load reduction, periodic desiltation of wells
			Financial incentives and support to recharging farmers
NGOs, local communities	Percolation ponds, check dams, sub-surface dykes; stop dams and delayed-action dams on streams		Technical and financial support to local communities, NGOs for construction and maintenance
			Supportive policy environment and incentive structures
			Support for building local institutions for groundwater recharge
Canal system managers	Conjunctive management of surface and groundwater		Operate surface systems for extensive recharge
			Where appropriate, retrofit irrigation systems for piped conveyance and pressurized irrigation
			Where appropriate, retrofit irrigation systems for use of surplus floodwaters to maximize recharge
			Where appropriate link canals through buried pipelines to dug wells/recharge tubewells for year-round recharge
Groundwater recharge SPV	Recharge canals to capture flood flows for recharge (e.g., Ghed canal in Saurashtra) or transport surplus flood waters for recharge in groundwater-stressed areas (e.g., *Sujalam Sufalam* in North Gujarat)		Create a Special Purpose Vehicle to execute, operate and maintain large-scale recharge structures
			Build and operate large-scale recharge structures in upstream areas of confined aquifers. e.g. at the base of Aravalli's in North Gujarat
	Large recharge structures in recharge zones of confined aquifers		Build and operate large earthen recharge canals along the coasts

[a] Information, Education, Communication campaign

CHAPTER VI: RECOMMENDATIONS AND ACTION PLAN

- There is a need to prepare a Comprehensive, flexible and user friendly framework for planning and policy analysis under climate variability and uncertainty scenarios.
- Develop regional scenarios of expected intra-seasonal, inter-annual climate variability over all the major hydrogeological provinces of the country to assess the likely changes in availability and demand of ground water in space and time.
- Develop and evaluate adaptation strategies in all the major hydrogeological environs to alleviate negative impacts of climate change and variability.
- Develop a variety of options for adaptation strategies to address the trade offs between water allocations from ground water that prioritize the environment and food security under changed climatic and land use conditions.
- Integrated planning and national network for all knowledge –based institutions related to groundwater.
- Water use efficiency programs including water conservation, water recycling, piped water system and rationalizing energy supply need to be adopted.
- Sanctuary wells may be constructed in coastal areas prone to cyclones and vulnerable in view of expected sea level rise and other flood prone areas. These wells may be used as monitoring well during rest of the time.
- Deeper aquifers in the Gangetic plain provide ample opportunity of development of ground water ensuring the quality and sustainability.
- The eastern and north eastern parts of the country have huge ground water development potential both in unconfined and confined aquifers. The present stage of development is at low key in the tune of 28 % and hence offers ample scope for further development. It can also provide opportunity for growing water intensive crops as well as fodders which may be exported to water stressed areas adopting the concept of virtual water.

The Action plan with time frame and financial involvements is given in Annexure - V

Plate - I

Hydrogeological Map of India

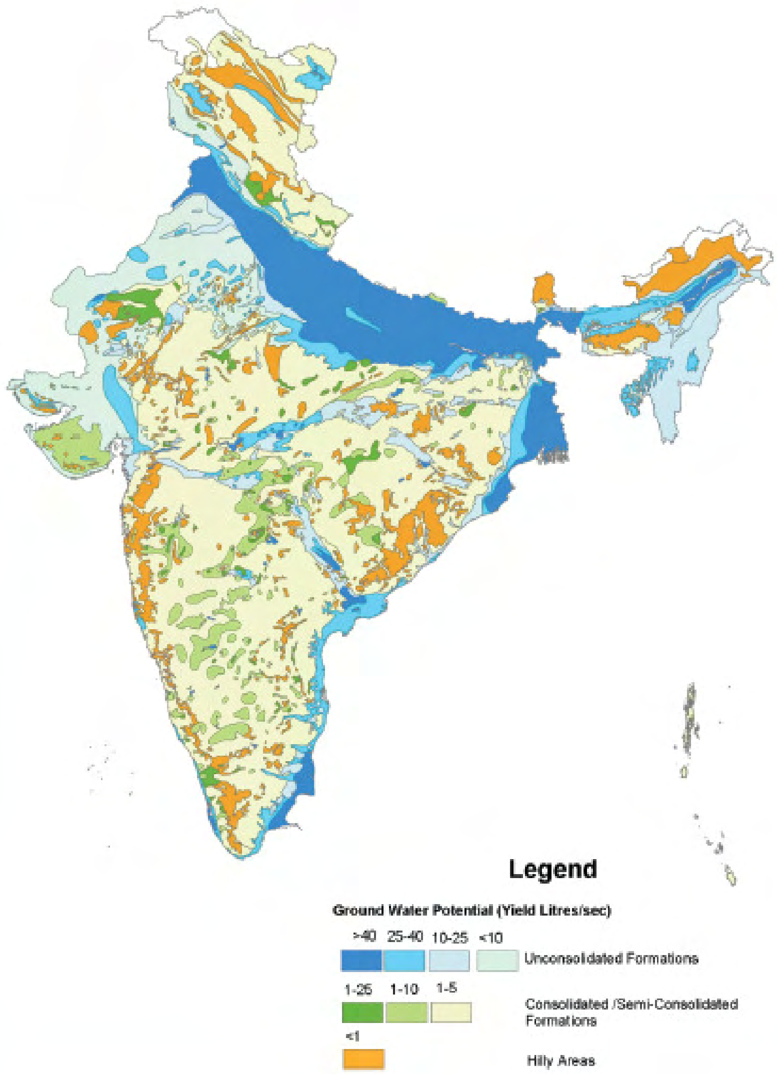
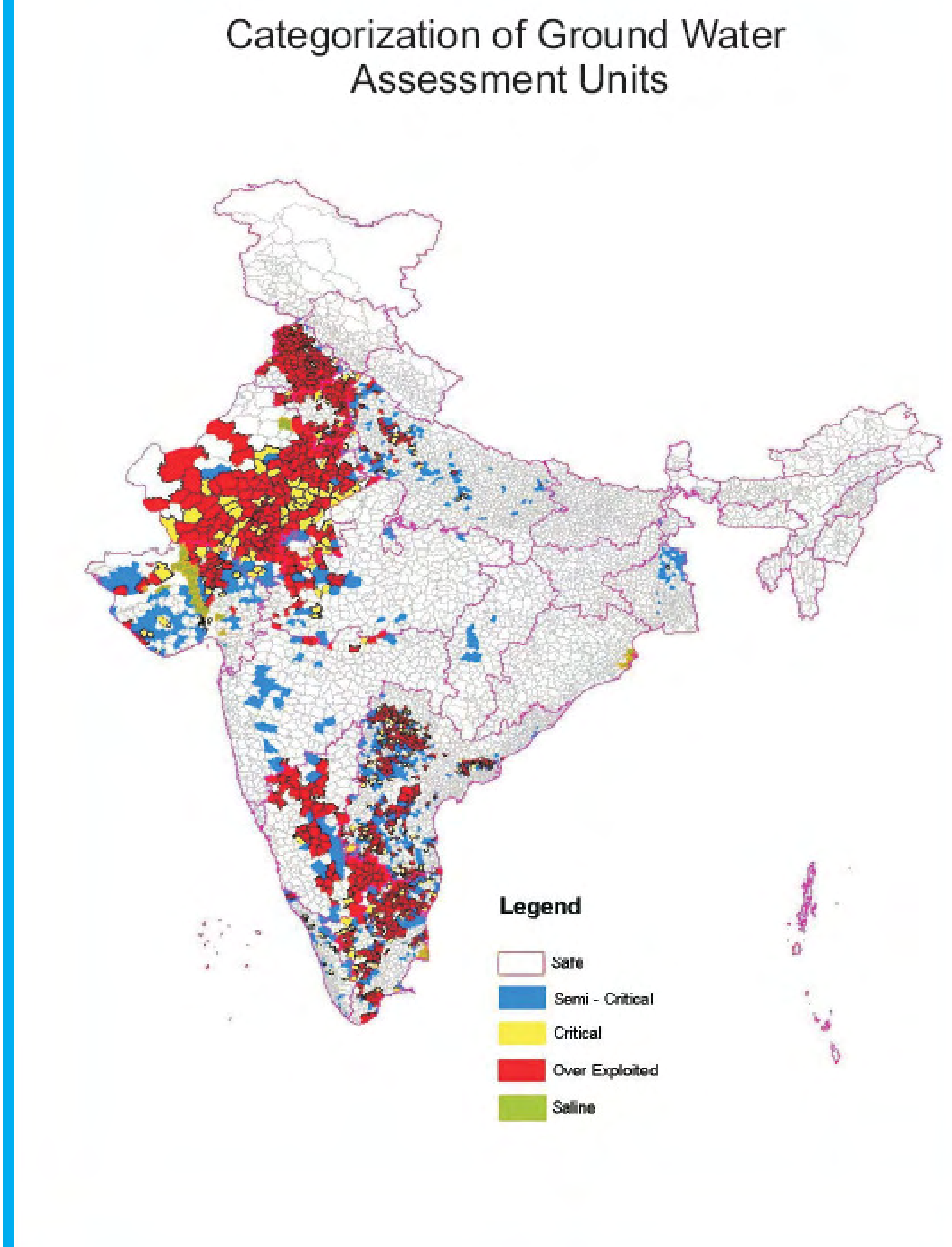


Plate II


Categorization of Ground Water
Assessment Units
Legend
Safe
Semi - Critical
Critical
Over Exploited
Saline

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Annexure 1

Composition of the Sub Committee on Ground Water Management including quality of Ground Water

1.	Chairman, Central Ground Water Board	Chairman
2.	Sh Tushar Shah, Director, International Water Management Institute	Member
3.	Representative of Department of Drinking Water Supply, Ministry of Rural Development	Member
4.	Representative of Ministry of Environment & Forests	Member
5.	Representative of National Environmental Engineering Research Institute	Member
6.	Representative of Central Water Commission	Member
7.	Principal Secretary, Department of Water Resources, Bihar	Member
8.	An officer co-opted by the Chairman of the Sub Committee	Member Secretary

Annexure II

Ground Water Resources of India (Assessment Year 2004)

BCM/yr

S.No.	States/Union Territories	Annual Replenishable Ground Water Resource	Natural Discharge during non-monsoon season	Net Annual Ground Water Availability	Annual Ground Water Draft			Stage of ground water development (%)
					Irrigation	Domestic and industrial uses	Total	
1.	2.	3.	4.	5.	6.	7.	8.	9
	States							
1	Andhra Pradesh	36.50	3.55	32.95	13.88	1.02	14.90	45
2	Arunachal Pradesh	2.56	0.26	2.30	0.0008	0	0.0008	0.04
3	Assam	27.23	2.34	24.89	4.85	0.59	5.44	22
4	Bihar	29.19	1.77	27.42	9.39	1.37	10.77	39
5	Chattisgarh	14.93	1.25	13.68	2.31	0.48	2.80	20
6	Delhi	0.30	0.02	0.28	0.20	0.28	0.48	170
7.	Goa	0.28	0.02	0.27	0.04	0.03	0.07	27
8.	Gujarat	15.81	0.79	15.02	10.49	0.99	11.49	76
9.	Haryana	9.31	0.68	8.63	9.10	0.35	9.45	109
10.	Himachal Pradesh	0.43	0.04	0.39	0.09	0.02	0.12	30
11.	Jammu & Kashmir	2.70	0.27	2.43	0.10	0.24	0.33	14
12.	Jharkhand	5.58	0.33	5.25	0.70	0.38	1.09	21
13.	Karnataka	15.93	0.63	15.30	9.75	0.97	10.71	70
14.	Kerala	6.84	0.61	6.23	1.82	1.10	2.92	47
15.	Madhya Pradesh	37.19	1.86	35.33	16.08	1.04	17.12	48

S.No.	States/Union Territories	Annual Replenishable Ground Water Resource	Natural Discharge during non-monsoon season	Net Annual Ground Water Availability	Annual Ground Water Draft			Stage of ground water development (%)
					Irrigation	Domestic and industrial uses	Total	
16.	Maharashtra	32.96	1.75	31.21	14.24	0.85	15.09	48
17.	Manipur	0.38	0.04	0.34	0.002	0.0005	0.002	0.65
18.	Meghalaya	1.15	0.12	1.04	0.00	0.002	0.002	0.18
19.	Mizoram	0.04	0.004	0.04	0.00	0.0004	0.0004	0.90
20.	Nagaland	0.36	0.04	0.32	0.00	0.009	0.009	3
21.	Orissa	23.09	2.08	21.01	3.01	0.84	3.85	18
22.	Punjab	23.78	2.33	21.44	30.34	0.83	31.16	145
23.	Rajasthan	11.56	1.18	10.38	11.60	1.39	12.99	125
24.	Sikkim	0.08	0.00	0.08	0.00	0.01	0.01	16
25.	Tamil Nadu	23.07	2.31	20.76	16.77	0.88	17.65	85
26.	Tripura	2.19	0.22	1.97	0.08	0.09	0.17	9
27.	Uttar Pradesh	76.35	6.17	70.18	45.36	3.42	48.78	70
28.	Uttaranchal	2.27	0.17	2.10	1.34	0.05	1.39	66
29.	West Bengal	30.36	2.90	27.46	10.84	0.81	11.65	42
	Total States	432.42	33.73	398.70	212.38	18.04	230.44	58
	Union Territories							
1.	Andaman & Nicobar	0.330	0.005	0.320	0.000	0.010	0.010	4
2.	Chandigarh	0.023	0.002	0.020	0.000	0.000	0.000	0

S.No.	States/Union Territories	Annual Replenishable Ground Water Resource	Natural Discharge during non-monsoon season	Net Annual Ground Water Availability	Annual Ground Water Draft			Stage of ground water development (%)
					Irrigation	Domestic and industrial uses	Total	
3.	Dadra & Nagar Haveli	0.063	0.003	0.060	0.001	0.007	0.009	14
4.	Daman & Diu	0.009	0.0004	0.008	0.007	0.002	0.009	107
5.	Lakshadweep	0.012	0.009	0.004	0.000	0.002	0.002	63
6.	Pondicherry	0.160	0.016	0.144	0.121	0.030	0.151	105
	Total UTs	0.597	0.036	0.556	0.129	0.051	0.181	33
	Grand Total	433.02	33.77	399.25	212.51	18.09	230.62	58

Annexure III

CATEGORIZATION OF BLOCKS/ MANDALS/ TALUKAS IN INDIA (Assessment – 2004)

Sl. No.	States / Union Territories	Total No. of Assessed Units	Over-exploited		Critical		Semi-critical	
			Nos.	%	Nos.	%	Nos.	%
1.	Andhra Pradesh	1231	219	18	77	6	175	14
2.	Arunachal Pradesh	13	0	0	0	0	0	0
3.	Assam	23	0	0	0	0	0	0
4.	Bihar	515	0	0	0	0	0	0
5.	Chhattisgarh	146	0	0	0	0	8	5
6.	Delhi	9	7	78	0	0	0	0
7.	Goa	11	0	0	0	0	0	0
8.	Gujarat	223	31	14	12	5	69	31
9.	Haryana	113	55	49	11	10	5	4
10.	Himachal Pradesh	5	0	0	0	0	0	0
11.	Jammu & Kashmir	8	0	0	0	0	0	0
12.	Jharkhand	208	0	0	0	0	0	0
13	Karnataka	175	65	37	3	2	14	8
14.	Kerala	151	5	3	15	10	30	20
15.	Madhya Pradesh	312	24	8	5	2	19	6
16.	Maharashtra	318	7	2	1	0	23	7
17.	Manipur	7	0	0	0	0	0	0
18.	Meghalaya	7	0	0	0	0	0	0
19.	Mizoram	22	0	0	0	0	0	0
20.	Nagaland	7	0	0	0	0	0	0
21.	Orissa	314	0	0	0	0	0	0
22.	Punjab	137	103	75	5	4	4	3
23.	Rajasthan	237	140	59	50	21	14	6
24.	Sikkim	1	0	0	0	0	0	0

25.	Tamil Nadu	385	142	37	33	9	57	15
26.	Tripura	38	0	0	0	0	0	0
27.	Uttar Pradesh	803	37	5	13	2	88	11
28.	Uttaranchal	17	2	12	0	0	3	18
29.	West Bengal	269	0	0	1	0	37	14
	Total States	**5705**	**837**	**15**	**226**	**4**	**546**	**10**
	Union Territories							
1.	Andaman & Nicobar	1	0	0	0	0	0	0
2.	Chandigarh	1	0	0	0	0	0	0
3.	Dadra & Nagar Haveli	1	0	0	0	0	0	0
4.	Daman & Diu	2	1	50	0	0	1	50
5.	Lakshadweep	9	0	0	0	0	3	33
6.	Pondicherry	4	1	25	0	0	0	0
	Total UTs	**18**	**2**	**11**	**0**	**0**	**4**	**22**
	Grand Total	**5723**	**839**	**15**	**226**	**4**	**550**	**10**

CRITERIA FOR CATEGORIZATION:

- Over-Exploited :Stage of Ground water development - >100%, Significant decline in long term water level trend in either pre-monsoon or post-monsoon period or both
- Critical : Stage of Ground Water Development - >90% and <=100%, Significant decline in long term water level trend in both pre-monsoon and post-monsoon period Semi-Critical : Stage of Ground Water Development - > 70% and <=100%, Significant decline in long term water level trend in either pre-monsoon or post-monsoon period

Annexure - IV

FINDINGS OF STUDIES ON CONJUNCTIVE USE OF SURFACE AND GROUND WATER IN MAJOR IRRIGATION COMMAND AREAS

DETAILS	Sardha Sahayak, U.P	MRBC, Gujarat	IGNP stage I, Rajasthan	Ghatprabha, Karnataka	Hirakud, Orissa	Tungbhadra A.P
Year of study	1992-94	1992-94	1992-94	1994-96	1994-96	1994-96
Study area (sq.km.)	8978	3717	4790	10370	1570	6354
Present irrigation intensity	153%	179%	97%	84 %	170 %	61.43 %
Water logging area Pre-monsoon (Sq.Km.)	49	34	375	48	174	1220
Post monsoon	2692	161		670	1494	
Availability of water SW (in MCM)	2177	2259	4215	1114	2856	1611
GW	2603	921	992	956	1272	470
Demand of water Kharif (in MCM)	1434	2221	1028	280		527
Rabi	938	735	1002	305		490
Present utilization of water SW (in MCM)	1481	2221	1989	1055		1027
GW	906	724	41			71
Proposed CU plan Intensity	200 %	185 %	120 %	200 %	200 %	116 %
SW (In MCM)	4627	2221	3995	1068	90 %	1027
GW	2685	792	602	173	10 %	600
Financial Involvement for Implementation of CU plan	93.11 Cr.	7.9 Cr.	3052 Cr.	40.5 Cr.	95.4 Cr.	235 Cr.
B.C ratio	1.56	1.23	1.03	1.25-5.35	1.62	3.45
IRR	9.18%	35.99 %	17.39 %	0.2-7.20 %	55 %	48.12%

Annexure-V

		Sub Committee on Ground Water Management including Water Quality													
		Action Plan with Time Frame and Financial Requirements													
S. No.	**Management Strategy**	**Objective**	**Proposed Action**	**Time Frame**								**Financial Requirements (Rs.in Crores)**		**Total Financial Requirements (Rs.in Crores)**	**Collaborative Agncies**
				XI Plan (Remaining period			**XII Plan**					**XI Plan (Additional)**	**XII Plan**		
				Y-3	**Y-4**	**Y-5**	**Y-1**	**Y-2**	**Y-3**	**Y-4**	**Y-5**				
1	Rain Water Harvesting and Artificial Recharge	Augmentation of ground water	**1 a**. Preparation of state wise ground water bill based on model bill circulated by MoWR including guidelines for RWH & AR 1b. Implementation of ground water bill by the States 2a. **Rural Areas**-Preparation of State wise implementation plan for RWH & AR based on Master Plan 2b. Implementation of RWH & AR in OE Asessment Units 2c. Implementation in Critical and Semi Critical Areas 2d. Impact assessment 3a. **Urban Areas-**Preparation of State wise implementation plan for RWH & AR based on Master Plan 3b. Implementation of RWH & AR 3c. Impact assessment									2b.1400 3b. 740	2b. 1500 2c. 1300 3b. 1860	**6800**	Concerned State Departments

2	Conjunctive Management	To tackle the water logging and rising water level problems in major Irrigation Commands	Feasibilty study and Implementation of schemes on conjunctive use of SW and GW in major command areas having water logging or rising water level problems (a) Feasibility Studies (b) Implementation of Schemes									(a)80	(b) 600	**680**	Concerned State Dept./ CADA/ CGWB
3	Coastal Aquifer Management	To control and regulate the sea water ingress in coastal areas in view of expected sea level rise	(a) Establishment / Strengthening of Ground water Monitoring Network(construction of Purpose built observation wells (b) Construction of Sanctuary Wells (Dual Purpose to be used for Monitoring as well during Natural calamities) (c) Ground water Exploartion to decipher Deeper fresh water Aquifers up to 1000/1500m. (c1)Equipment & Machinery (c2) Exploration (d) Hydro chemical and Solute Transport Modeling in areas vulnerable for Sea water Ingress.									(a)80 (b)50 (c1)105	(c2) 100 (d) 10	**345**	(a) Conerned State Departments. (b)Conerned State Departments. (c) CGWB (d) CGWB , NIH & State GWD
4	Water Quality Mitigation Measures	Protection and remediation of ground water quality	(a) Establishment / Strengthening of Ground water Monitoring and Surveillance System. b) Ground water Exploartion to decipher Deeper fresh water Aquifers (c) Hydro chemical and Solute Transport Modeling in areas vulnerable to quality problems.									(a) 90 (b) 40	(b) 60 (c) 10	**200**	(a) Conerned State Departments. (b) CGWB & State GWD (c)CGWB,IIT,NIH & State GWD

5	Reseach and Development needs	Development of State of Art technologies for sustainable ground water management	(a) Refinemnt of Methodology for Assessment and development potential of Ground water Resources in variuos aquifers systems. (b) Isotope applications in GW dating anf contaminant transport (c) Development of Ground Water Basin Models for Cunjunctive Utilization of SW and GW (d) Development potential of Deeper aquifers. (e) Coastal Aquifer mangement including use of hydraulic barriers for control of sea water ingress (f) Application of RS/GIS in Ground Water Managment									(a) 10 (b)& (d) 2 (c) 10	(b) & (d)3	**25**	CGWB/ NIH/State GWD /IITs/IIS/CWPRS
6	Capacity Building and Training Needs	Providing specialized Training to ground water professionsals and sub professioinal engaged in ground water domain in the coutry.	(a) Setting up well equipped dedicated Institute with advanced facility for library , advanced computing systems and documentation center. (b) To provide training to ground water professional and sub-professional in ground water investigation , development and management techniques.									(a) 30 (b) 11	(b) 14	**55**	CGWB/ NIH/State GWD
											Total	**2588**	**5517**	**8105**	

Report of Sub-Committee

on

Domestic and industrial Water Management

Committee members

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Preface

The availability and quality of freshwater resources in India is being impacted by a combination of factors such as increasing urbanization, agriculture expansion, growing population, rapid industrialization and economic development. This resource is likely to come under further pressure due to climate change. Global warming implies increased evaporation, changing rainfall patterns, reduced snow cover and widespread melting of ice and changes in soil moisture and runoff. Further, water quality is likely to be affected and pollution in terms of increased sediments, nutrients, dissolved organic carbon, pathogens, pesticides and salt is expected to be aggravated. These changes will have an overall negative impact on ecosystems, human health, and water system reliability as well as on food security and increased vulnerability of the poor.

As part of the National Action Plan on Climate Change, the National Water Mission focuses on "*integrated water resource management helping to conserve water, minimize wastage an ensure more equitable distribution*". In the first meeting of the High Level Steering Committee for National Water Mission held on 7th August 2008, under the chairmanship of the Secretary to the Government of India, Ministry of Water Resources (MoWR), six sub-committees were constituted. One of these was the Subcommittee on Domestic and Industrial Water Management. This subcommittee examined (a) Increased water use efficiency in domestic and industrial sector emphasizing recycle and reuse (b) Alternative cost-effective and sustainable water sources viz. reclaimed wastewater, desalinated seawater / brackish water (especially using low grade heat) etc. (c) Water conservation measures viz. source augmentation through rainwater harvesting, artificial recharge etc., reduce wastage through improved instrumentation (leakage monitoring, metering), appropriate tariff, incentives to adopt water neutral or water positive technologies (d) Effective governance and regulation through institutional and policy reforms. The report highlights the key issues and the proposed climate change adaptation action plan for domestic and industrial water management along with the timeline for specific actions.

It is my pleasure to thank all the members of the Committee for providing their valuable inputs and sparing their time towards finalizing this report.

Shri A. K. Mehta　　　　　　　　　　　　　　　　Dated: 19 November 2008

Joint Secretary (UD&A)

Chairman, Sub-committee on Domestic and Industrial Water Management

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1 Introduction

1.1 Water resources and climate change

Water resources in India are vulnerable to climate change as evident from studies in the recent past. Climate change signifies more evaporation of fresh water, changing rainfall patterns, reduced snow cover and widespread melting of ice and changes in soil moisture and runoff. This would have *'wide-ranging consequences on human societies and ecosystems'*. The report also states that *'Over the 20th century precipitation has mostly increased over land in high northern latitudes, while decreases have dominated from 10degreeS to 30degreeN since the 1970s.'* Most of India falls in this range. *'Water supplies stored in glaciers and snow cover are projected to decline in the course of the century, thus reducing water availability - through a seasonal shift in stream flow, an increase in the ratio of winter to annual flows, and reductions in low flows - in regions supplied by melt water from major mountain ranges, where more than one-sixth of the world population currently lives.*

'Higher water temperatures and changes in extremes, including floods and droughts, are projected to affect water quality and exacerbate many forms of water pollution - from sediments, nutrients, dissolved organic carbon, pathogens, pesticides and salt - as well as thermal pollution, with possible negative impacts on ecosystems, human health, and water system reliability and operating costs.' Changes in water quantity and quality due to climate change are expected to affect food availability, stability, access and utilisation. *'This is expected to lead to decreasing food security and increased vulnerability of poor rural farmers, especially in the arid and semi-arid tropics and Asian and African mega-deltas,'* says the report. The mega-deltas include those of the Ganges and the Indus.

Climate change affects the function and operation of existing water infrastructure - including hydropower, structural flood defenses, drainage, and irrigation systems - as well as water management practices. Adverse effects of climate change on freshwater systems aggravate the impacts of other stresses, such as population growth, changing economic activity, land use change and urbanization, the report points out. ***'Current water management practices may not be robust enough to cope with the impacts of climate change on water supply reliability, flood risk, health, agriculture, energy and aquatic ecosystems.'***

Since the supply is projected to be limited and erratic the only way to balance the water demand-supply gap is through management of the resource in an efficient, equitable and sustainable manner. It is essential in this context to assess the status of the available water resource and the key issues that impede the proper utilization of the resource. In so far as the national average of water availability is concerned, India is not a water scarce country. However, due to vagaries of monsoon and inadequate surface water sources in many regions, scarcity conditions are present in several parts of the country; further, equitable distribution of water for different regions of the country requires adequate cooperation among different States to share this common resource.

1.2 Water resources in India and its use

1.2.1 Water requirement, availability and storage

India roughly accounts for about 2.5 per cent of land mass, 4.5 per cent fresh water sources and 16 per cent of the World's Population. According to an assessment made by the Ministry of Water Resources, total water requirement of the country (National Average) would be 694 billion cubic meters (BCM) in the year 2010. Due to regional imbalances and lack of cooperation among the states on sharing of surface water sources, shortage of water will be a fact of life in many regions. As per data compiled by Ministry of Water Resources, the total annual surface water flow is of the order of 1869 BCM. However, utilizable water is 690 BCM from surface sources, 433 BCM from ground water sources, totaling to 1123 BCM. As regards storage, 225 BCM storage capacity has so far been created by way of dams and additional storage capacity of 64 BCM is in the pipeline (Table 1).

Table 1: Water resources and storage

Category	Amount (Billion Cubic Meter or BCM)
Total annual surface water flow	1869
Total utilizable water	1123
Surface sources,	690
Ground water sources	433
Storage capacity	
Existing	225
Under construction	64
Under contemplation	108

Source: MOWR, 2007

The per capita storage availability in India is 207 cubic meters, which is significantly lower than in other countries (Figure 1). Even with the completion of the contemplated projects, storage capacity achieved will remain about 20 per cent of the water resources potential of the country. In the last 50 years, total annual renewable fresh water available per person has reduced from 5177 cubic meters (in 1951) to 1816 cubic meters (in 2001). This is estimated to further reduce to 1341 cubic meters by 2025 to 1140 in 2050, thus approaching a water scarce condition (water availability of less than 1000 cubic meters per year per capita) (MOWR, 2007).

1.2.2 Water requirement by sector

Irrigation would continue to be the major water consumer; however, water requirement for energy and industrial applications is also estimated to increase. Domestic water requirement is estimated to nearly double in the next 40 years (56 BCM in 2010 to 102 BCM in 2050). Correspondingly, industrial requirement is estimated to increase over 5 fold during this period (12 BCM in 2010 to 63 BCM in 2050). (MOWR, 2000)

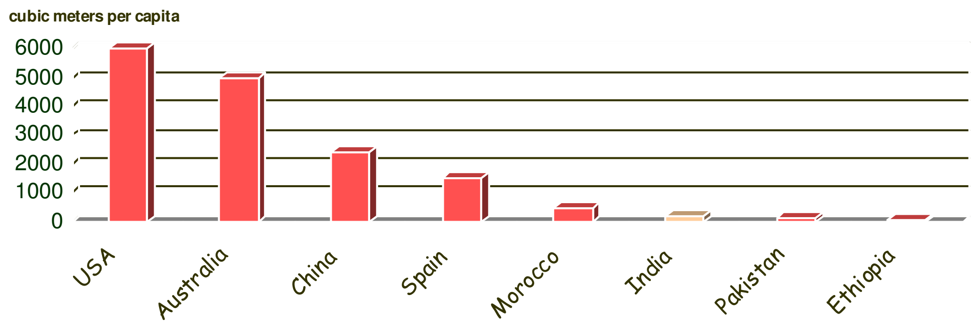


Figure 1: Storage per capita in different semi-arid countries

Source: ICOLD data base

1.3 Investment trends in water sector

Water supply being a State subject, funds for water supply and sanitation projects were provided up to Seventh Five Year Plan (1985 – 90) only in the State sector. Figure 2 indicates plan-wise outlays for this sector. The outlays for water supply and sanitation sector has increased from 1.28 per cent of the total plan outlay in the First Five Year Plan period to 1.23 per cent in the Tenth Five Year Plan period. Though the percentage outlays during the various plan periods have not followed a definite pattern, the actual outlays have been increasing over plan periods.

For the first time, a modest allocation of Rs.68.00 crore was made in the Eighth Five Year Plan under the new scheme known as "Accelerated Urban Water Supply Programme (AUWSP)" as Central assistance in addition to the State Plan funds for covering towns with less than 20000 population as per 1991 Census. In the Ninth Five Year Plan, an allocation of Rs.294.00 crore was made under the scheme, whereas in the Tenth Five Year Plan, this amount has been raised to Rs.900.00 crore.

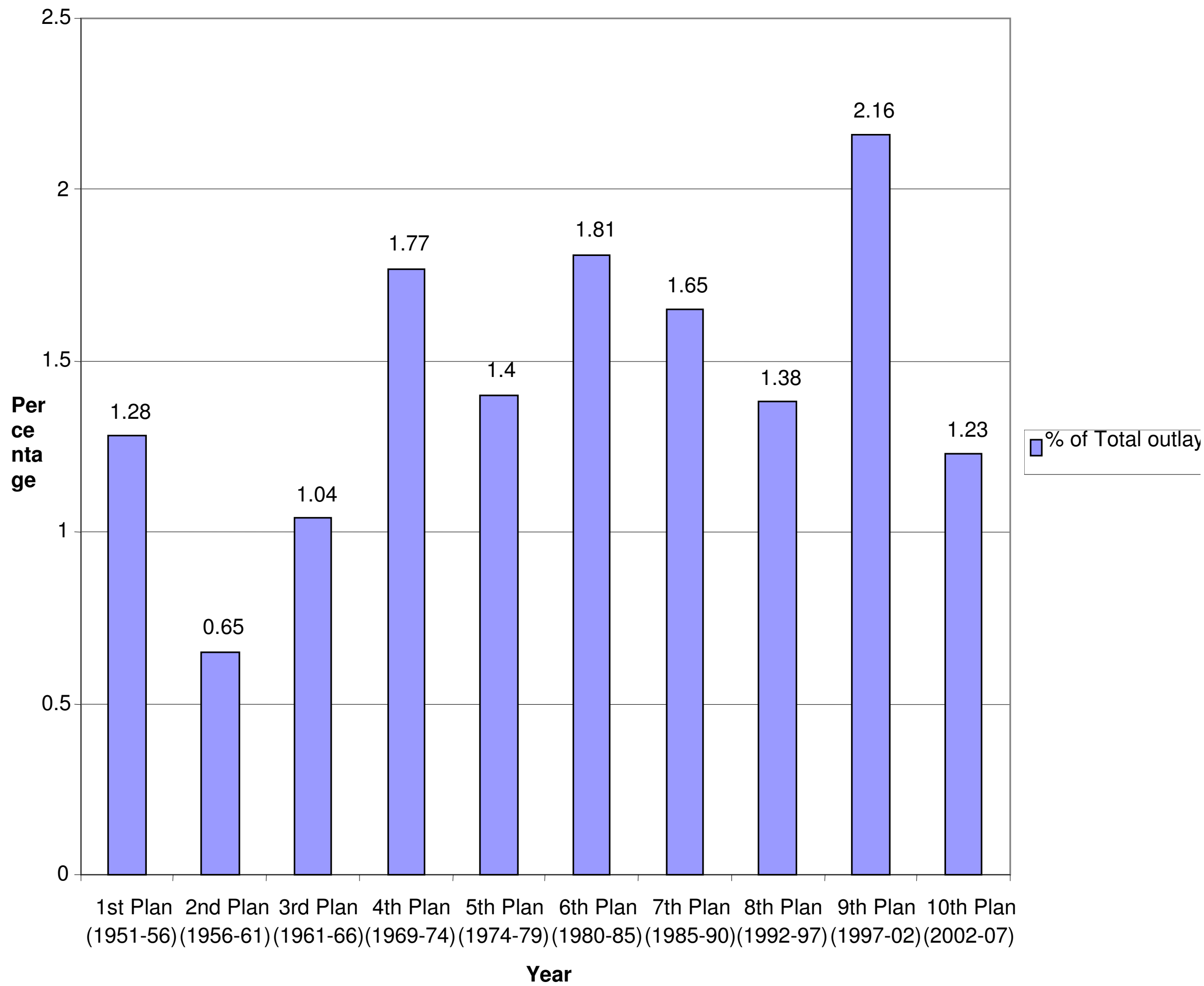


Figure 2 Plan outlays for urban water supply & sanitation sector as a percentage of total public sector outlay

Even with huge investment in the domestic and industrial water supply, the system failed to deliver sustained benefits and performed below the potential expected. This can be attributed to many supply and demand management issues viz., poor conservation, inefficient management, improper operation and maintenance system, lack of revenue generation (poor metering; low tariff), wastage due to leakage and pilferage etc. The key issues under each sector need to be identified for suggesting corrective measures.

1.4 Terms of reference (TOR)

In the first meeting of the High Level Steering Committee for National Water Mission held on 7th August 2008, under the chairmanship of the Secretary to the Government of India, Ministry of Water Resources (MoWR), six sub-committees were constituted. One of these was the Sub-committee on Domestic and Industrial Water Management. The TOR of this Sub-committee is given below.

Terms of reference

1. The mission to take into account the provision of the National Water Policy and develop a framework to optimize water use by increasing water use efficiency by 20 per cent.
2. The mission to seek to ensure that a considerable share of the water needs or urban areas are met through recycling of wastewater and ensuring that the water requirements of coastal cities with inadequate alternative sources of water are met through adoption of new and appropriate technologies such as low temperature desalination technologies that allow for the use of ocean water.
3. Increase in the efficiency of water use in domestic and industrial sector
4. Mandatory water assessments and audits, ensuring proper industrial waste disposal
5. Need for incentives to adopt water neutral or water positive technologies
6. Sea water desalination using Reverse Osmosis and multistage flash distillation to take advantage of low grade heat energy e.g. from power plants located in the coastal region or by using renewable energy such as solar
7. Brackish water desalination
8. Water recycle and reuse
9. Water purification technologies

A meeting of the Sub-Committee was held on 12th September 2008 under the chairmanship of Shri A K Mehta, Joint Secretary (UD&A) and the following points were identified for further action.

1) Action Plan for water audit in the Class I cities of the country – CPHEEO
2) Action Plan for water recycling in Class I cities of the country –CPHEEO
3) Modalities for labeling of water consuming gadgets on the basis of water use efficiency as adopted by Bureau of Energy Efficiency (B.E.E.) for electrical appliances-TERI
4) Rationalization of water tariff to promote efficient use and incentivization – CII
5) Instrumentation in water sector to bring about efficiency – CII
6) Current status of efficient water practices – CPHEEO
7) Inputs regarding possibilities of rainwater harvesting and sub-surface storage potential in India – CGWB
8) Action plan for efficient and cost effective desalination of saline and brackish water – Ministry of Earth Sciences
9) Issues related to National Water Policy – CGWB
10) Action plan for efficient use of water, and to increase water use efficiency by 20 per cent – CPHEEEO
11) Action plan for community participation efficient water management – TERI
12) Inputs regarding future domestic and industrial water demand – CWC
13) Action Plan for efficient use of water in domestic and industrial sector – TERI
14) Proper industrial waste disposal, issues of water neutral and water positive technologies – CII

This report addresses issues and concerns in domestic and industrial water management in India under the framework of the TOR discussed in the foregoing section. For the purpose, three main chapters have been outlined which focus on priority areas viz., understanding the key issues in domestic and industrial water management sector (water use efficiency, wastewater management including recycle and reuse, alternative sources of water like desalination etc), viable water management and conservation measures (discussing the potential strategies to improve the current scenario supported with appropriate case studies) and a section on action plan which classifies the specific implementation strategies, timeline and agencies according to the focal areas of the TOR. The report makes use of published information from various government and non-governmental agencies and has also benefited from discussions with personnel from concerned ministries and subject matter experts in the relevant areas.

2 Key issues in domestic and industrial water management

Though there has been considerable investment in domestic and industrial water sector, over the years (as discussed in the Chapter 1), the performance of the sectors has been dismal owing to a multitude of reasons. This section attempts to assess the current status of sectors and identify the key issues that hamper the performance potential.

2.1 Domestic sector

2.1.1 Urban growth scenario

As per 2001 census, out of total 1.02 billion population in India, the urban population living in 5161 towns was 285.35 million, constituting 27.85per cent of the total population. Of the 5161 urban agglomerations and other towns, 35 metropolitan cities account for about 110 million or 37 per cent of the total urban population. Assuming that the urban population would continue to grow at a rate of 3.1per cent per year, it is expected to increase to an estimated 790 million (nearly 55 per cent of the total population) by 2025 (Figure 3).

Rapid pace of urbanization has put enormous pressure on the urban areas, causing serious problems in urban planning, management and governance, particularly in large cities especially with respect to provision of basic amenities such as drinking water supply and sanitation. Urban and rural populations have different requirements for food and drinking water and therefore their needs are also markedly different. The Table 2 presents a consolidated picture of the total population and its urban and rural segments.

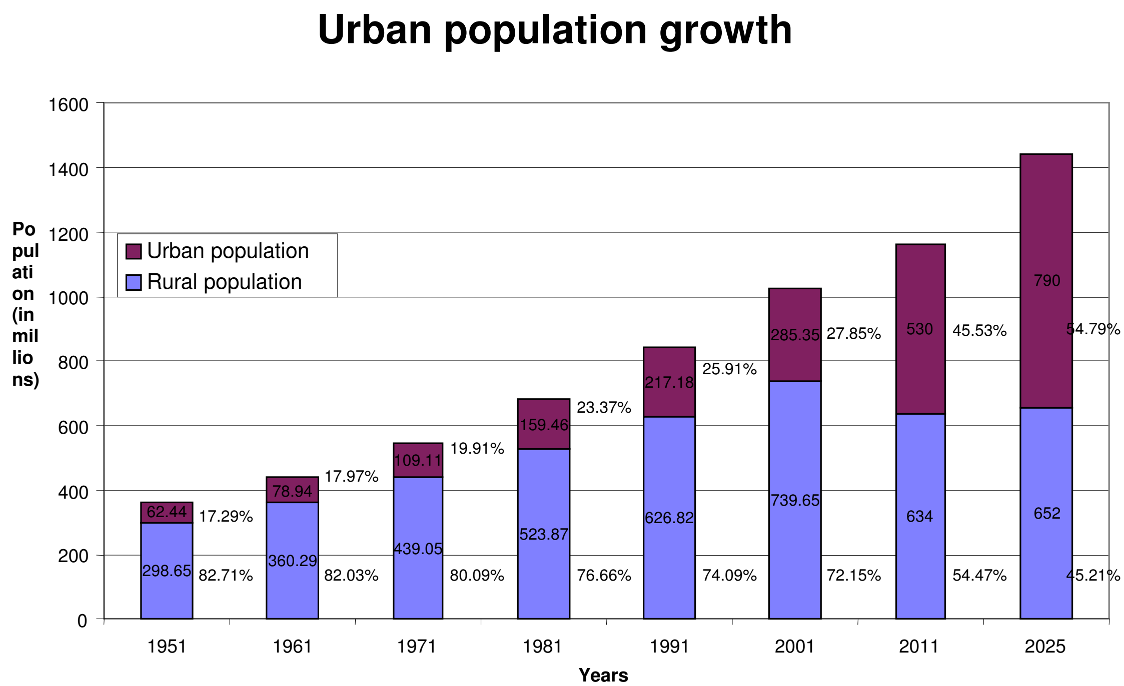


Figure 3: Urban Population growth (Source: Census 2001, Planning Commission)

Table 2 Projected population; urban and rural break up (in million)

Particulars	Population	2010		2025		2050	
		High	Low	High	Low	High	Low
Population		1146	1157	1333	1286	1581	1346
Rural		759	790	730	810	610	700
Urban total		387	367	603	476	971	646
Class I	>100000	258.13	238.55	361.8	261.8	485.5	290.7
Other than Class I							
Class II+III	20000-100000	90.17	88.08	150.75	119.00	242.75	193.8
Class IV-VI	<20000	38.70	4.37	90.45	95.20	242.75	161.5
Total of other than Class I		128.87	128.45	241.20	214.20	485.5	355.3

Source: MoWR (NCIWRDP), 1999

2.1.2 *Water supply*

The total water requirements for domestic use for rural and urban areas are estimated as 90km^3 and 111 km^3 (2050) respectively in two scenarios viz., low and high demand. It is further estimated that 70 per cent of urban and 30 per cent of rural water requirement would be met from surface water sources and balance from ground water sources. The core needs of domestic water use are for drinking, cooking, washing and bathing. Non-core needs are for toilet flushing, sewer flushing, water for lawns, etc. While the core needs have to be met necessarily with adequate and quality supply, the non-core needs can be met with restricted supply and not so good quality water.

2.1.3 *Projected water requirement*

The national water requirement for drinking and municipal uses at different points of time from different sources is presented in Table 3. This is based on the domestic water requirement under two scenarios developed by the National Commission on Integrated Water Resources Development (1999). The two scenarios are 1) High water requirement; where there is high rate of urbanization and 2) Low water requirement; with low rate of urbanization.

Table 3 National water requirements of domestic and municipal use (Quantity in km^3)

Scenario	**2010**	**2025**	**2050**
Low demand-total	**42**	**55**	**90**
Surface water	23	30	48
Ground water	19	25	42
High demand-total	**43**	**62**	**111**
Surface water	24	36	65
Ground water	19	26	46

Source: MoWR, GoI, 1999

2.1.4 *Per capita water supply norms*

As per the Bureau of Indian Standards, IS:1172-1993, minimum water supply of 200 litres per capita per day (lpcd) should be provided for domestic consumption in cities with full flushing systems. IS:1172-1993 also mentions that the amount of water supply may be reduced to 135 lpcd for the LIG and the economically weaker sections (EWS) of the society and in small towns (Modi, 1998; as quoted in Shaban, 2008). The World Health Organization (WHO) also classifies the supply and access to water in four service categories. These categories are, (1) no access (water available below 5 lpcd), (2) basic access (average approximately 20 lpcd), (3) inter-mediate access (average approximately 50 lpcd), and (4) optimal access (average of 100-200 lpcd) (WHO, 2003; Batram, 2003).

As per the then Union Ministry of Works and Housing (Manual on "Water Supply and Treatment"), fixed minimum norms for rural areas is 40 lpcd and for urban areas is 135 lpcd. The present norms suggest 40 lpcd for non desert development program (DDP) blocks and 70 lpcd for DDP blocks (personal communication, MoUD). The minimum norms for water use (as suggested by The National Commission on Urbanization) are given in Table 4. In addition to domestic supply, the commission estimates additional 25 – 30 per cent non-domestic purposes as industrial consumption, fire protection, gardening, etc. Thus, under conditions of minimum supply, a total per capita supply of 90-100 liters per day should suffice for all the city requirements. Since fresh water resources are unevenly distributed, the per capita availability varies widely ranging from 50 to 800 lpcd (Table 5).

Table 4: Norms for use of water for different purposes

Purpose	Absolute minimum (lpcd)	Desirable (lpcd)
Cooking and drinking	10	15
Bathing, flushing etc.	30	40
Washing utensils and clothes	30	35
Total	70	90

Source: Manual on Water Supply Treatment, cited in CPHEEO, 2005

Table 5 Water supply status in select Indian cities (2005-2006)

Sl No.	City	Population	Average daily production (m^3)	Storage (m^3)	Total service connection	Service coverage (per cent)	Per capita consumption (lpcd)
1	Ahmedabad	4491000	623836	650000	556734	74.5	171
2	Amritsar	804455	171005	24000	127786	80.9	105
3	Bangalore	5361500	923090	75655	486850	92.9	74
4	Bhopal	1437000	258000	94000	105012	98.7	72
5	Chandigarh	1150000	381280	236080	139300	100	147
6	Chennai	5320000	623836	355480	344079	44.4	197
7	Coimbatore	994000	228400	125000	113762	91.1	91
8	Indore	2200000	183000	99000	159104	77.3	87
9	Jabalpur	1050000	175115	70000	46260	75.2	139
10	Jamshedpur	488000	370110	45650	38800	74.4	203
11	Kolkata	3998000	971560	474430	262839	79	no data
12	Mathura	238000	38172	45000	24643	70	no data
13	Mumbai	13000000	3200000	997180	309226	100	153
14	Nagpur	2302990	608220	150790	265231	91.5	100
15	Nashik	1350000	310000	98500	127562	92.6	93
16	Rajkot	980000	143836	198000	193879	98.1	101
17	Surat	2954000	554685	34620	310836	77.4	188
18	Varanasi	1489000	270000	79800	114907	77.7	147
19	Vijayawada	675000	131833	58560	78298	70.5	158
20	Visakhapatnam	920000	228451	86420	85668	49.2	124

Source: ADB, 2003

There is a huge gap between the standards prescribed for the per capita water consumption per day for urban users and the actual availability. Figure 4 shows that out of the selected 18 cities (Kolkata and Mathura are excluded due to lack of data), 10 cities do not meet the standard norm of 140 lpcd, while some of the cities' per capita consumption is more than the standard norm (e.g. Ahmedabad, Chennai etc) and percentage difference ranges from 5-45 per cent. For the cities which fall below the standard norm the percentage difference ranges from 1-48 per cent. According to NCIWRD (1999) there is considerable variation in per capita water supply to urban areas; ranging from 9 to 584 lpcd and in rural areas from 5 to 70 lpcd.

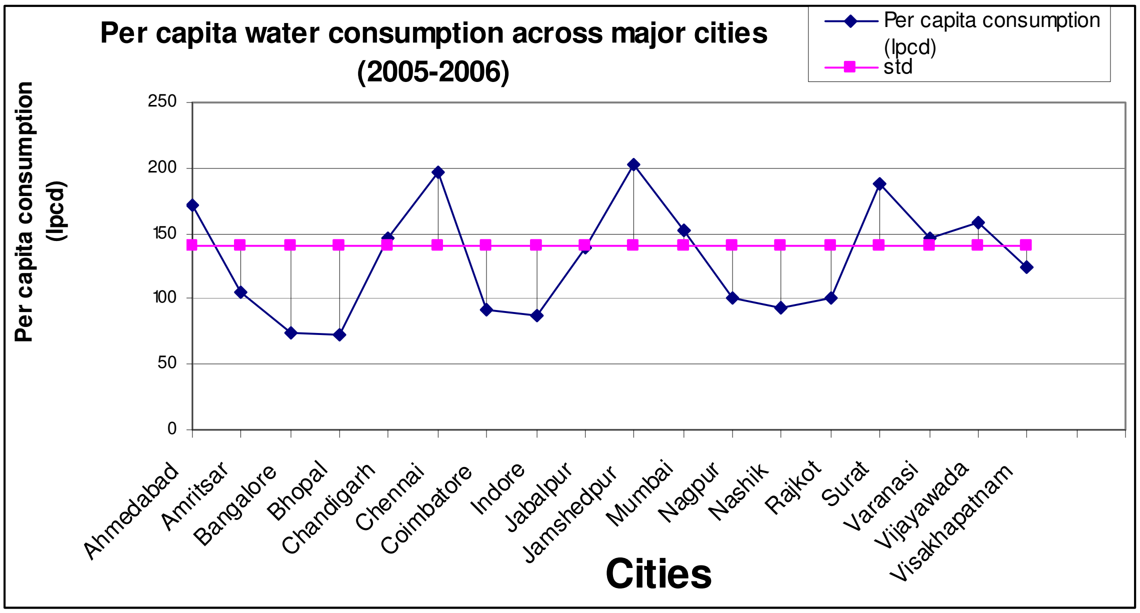


Figure 4: Per capita consumption across cities

2.1.5 Access to water

The World Health Organization (WHO) defines access to water supply services as the availability of at least 20 liters per person per day from an "improved" source within one kilometer of the user's dwelling. Improved sources are those likely to provide safe water such as household connections, public standpipes, protected dug wells, rainwater collection, boreholes, and protected springs. "Not improved" sources include unprotected wells and springs, vendor provided water and tanker truck water (McKenzie & Ray, 2004).

It is estimated that there is a strong positive relationship between state incomes and access to piped water (Zehra, 2002). As a result, access to piped water in urban areas ranges from 18 percent in Kerala, 21 percent in Orissa and 26 percent in Bihar to over 75 percent access in urban areas in New Delhi, Sikkim, Gujarat, Jammu and Rajasthan.

There is a great deal of cross-state variation in use of other methods, with different mechanisms for supply in different states. In urban areas, use of public taps ranges from only two percent in Punjab to 43 percent in Andhra Pradesh; use of private handpumps ranges from less than one percent in Goa to almost 40 percent in Uttar Pradesh; and wells range from less than one percent in several states to 60 percent in Kerala. Rural areas show just as much cross-region variation, with rivers, springs and ponds, which supply drinking water to less than 3 percent of rural households in the nation as a whole, supplying 25 percent or more of households in Jammu, Manipur, Meghalaya, and Nagaland. Access to piped water is therefore seen to be more prevalent in richer states (McKenzie & Ray, 2004).

According to the latest status reports, about 93 per cent (233 million) of the urban population has reportedly got access to water supply. However, the coverage figures indicate only the accessibility. Adequacy, equitable distribution and per-capita supply may not be as per the prescribed norms. Further, even where piped supply is available, it can be intermittent depending upon the availability of raw water, power, water leakage, pilferage losses etc. The piped water supply status in 20 cities across India is summarized in Table 5 above. The water availability ranged from 2-11 hours/day and the per capita consumption was between 72-203 lcd.

The 58th round of NSS nation-wide survey conducted during July 2002 – December 2002 reported on the availability of drinking water, latrine and electricity for lighting in urban areas (Table 6). Residents of around 18 per cent of urban swellings did not have access to any latrine facility. Further, 17 per cent of the notified slums and about 51 per cent of the non-notified slums did not have any latrine facility. About 66 per cent of the notified slums and 35 per cent of the non-notified slums had septic tank / flush latrine. Underground drainage system existed in about 17 per cent of the notified slums and 9 per cent of the non-notified slums. Underground sewerage existed in about 30 per cent of the notified and 15 per cent of the non-notified slums.

Table 6 Availability of drinking water, latrine and electricity for lighting in urban areas

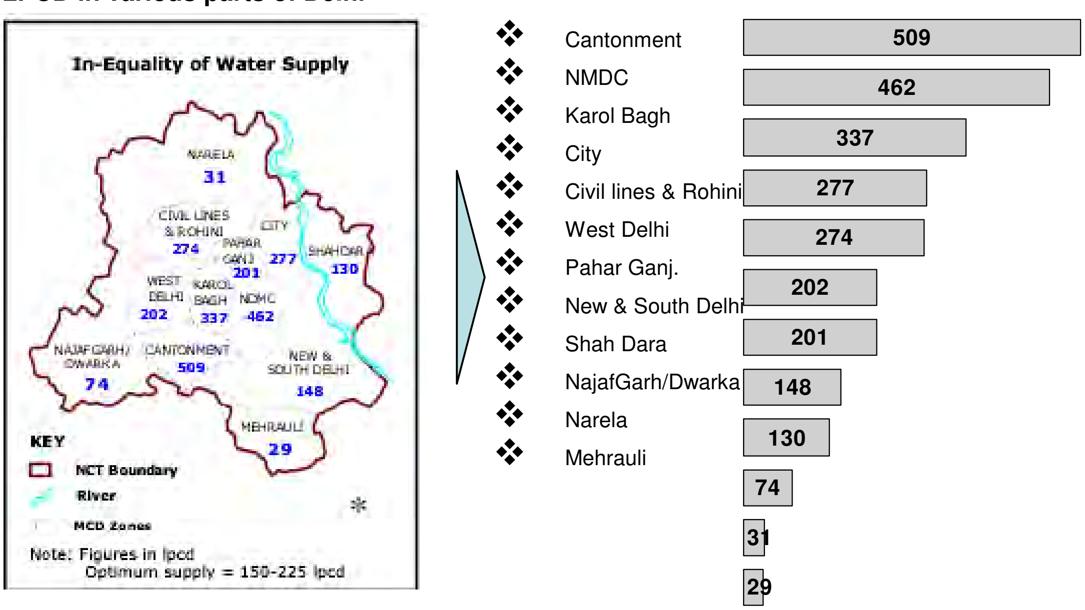
Category	All facilities	No facilities
Urban slums and squatter settlements	15 per cent	11
Dwelling units in other urban areas	63	4

By the end of the Eleventh Five Year Plan i.e. 31.3.2012, 100 percent population coverage is targeted for both (a) urban sewerage and sanitation and (b) drainage. It is proposed that 70 per cent population will be provided with sewerage and sewage treatment and 30 per cent population with low cost sanitation, septic tanks etc.

Access to water supply in Delhi

In a study conducted in Delhi, large inequalities in water distribution in different parts of the city are observed. The per capita supply varies from 509 lpcd in Cantonment area to 29 lpcd in Mehrauli.

LPCD in various parts of Delhi



Source: Ministry of Environment and Forests and GoNCTD, Planning Department

2.1.6 Water source

The source of water is an important consideration in the development of water supply schemes, as the quality, quantity and the cost of development depend on it. Based on studies in four different states viz., Andhra Pradesh, Karnataka, Orissa and Maharashtra, it was found that urban water supply systems are based in 25 per cent of the cases on ground water, 60 per cent on surface water and the rest 15 per cent from both. The surface sources are rivers, canals, reservoirs and lakes and subsurface water is from infiltration galleries, collector wells, bore wells and deep tube wells. In the case of large cities, nearby traditional water sources are now either exhausted or will get exhausted soon. Cities therefore have to reach out for sources that are far away and very expensive to develop and convey. A few examples are presented in Table 7 below.

Table 7: Estimated dependence on far away water resources

City	New source	Distance to new source (km)
Ahmedabad	River Sabarmati Dharoi Dam	150
Bangalore	River Cauvery (K.R.Sagar)	100
Chennai	River Krishna (Telugu Ganga)	400
Delhi	River Bhaigirathi (Tehri Dam)	250
	Renuka Dam (planning stage)	280
	Kishau Dam (Planning stage)	300
Hyderabad	River Krishna (Nagarjunasagar)	160
Mumbai	Bhatsa Dam	54

Source: NCIWRD, 1999

The availability of water from a nearby source tends to go down due to growing competing demands especially in rural areas where the water supply schemes are mostly based on ground water. For instance, the increasing demand from irrigation sector reduces the life of drinking water source leading to water quality issues like brackishness, necessitating the dependence on costly deep tube wells and piped water supply systems, in the place of low cost hand pump systems. In the development of water resources for domestic use, the most important and challenging issue is that of sustainability of source and quality. The re emergence of problem villages/habitations from time to time, despite several schemes and programmmes are due to this unsustainable issue (NCIWRD, 1999).

2.1.7 Pressures on water resources

Depleting ground water table and deteriorating ground water quality are threatening the sustainability of both urban and rural water supply in many parts of India. Groundwater meets nearly 55 per cent of irrigation, 85 per cent of rural and 50 per cent of urban and industrial wastewater needs. Being an open access resource, its use has expanded rapidly, especially for agricultural purposes. As a result, extraction has exceeded the annual recharge and water tables have gone down. Out of the net annual ground water availability of 399 BCM, 231 BCM is being extracted (213 BCM for irrigation and 18 BCM for domestic and industrial use). Further, by 2025, the demand for domestic and industrial use is expected to rise to 29 BCM. Out of the 5723 assessment units assessed jointly by State Ground Water Departments and CGWB in the country, around 71 per cent are in the safe category (Figure 5). Table 8 presents the categorization criteria. Furthermore, the percentage of overexploited blocks that was 4 per cent in 1995 increased to 15 per cent in 2004.

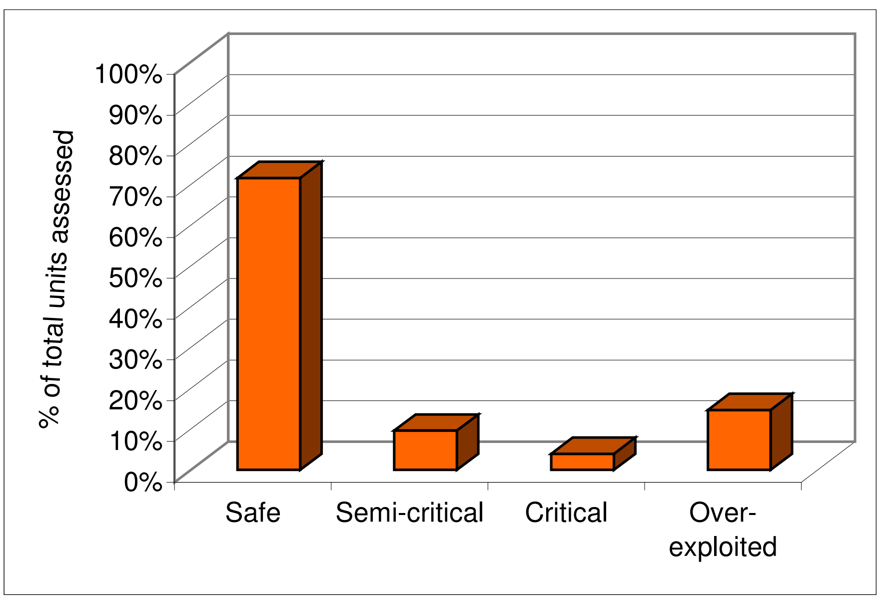


Figure 5 Groundwater status in assessed units

Table 8 Criteria for categorization of assessment units

Stage of ground water use*	Status of decline in water level	Categorization
<=90 per cent	No pre and post monsoon significant long term decline	Safe
>70 per cent and <=100 per cent	Significant long-term decline in either pre or post monsoon	Semi-critical
>90 per cent and <=100 per cent	Significant long-term decline in both pre and post monsoon	Critical
>100 per cent	Significant long-term decline in pre and post monsoon or both	Over-exploited

**This is defined as: Annual ground water draft *100 / net ground water availability*

There is a high degree of variability in annual groundwater draft vis-à-vis net availability across states. Just six states (Gujarat, Haryana, Maharashtra, Punjab, Rajasthan and Tamil Nadu) comprising 1413 assessment units have 762 assessment units that are not safe (54 per cent against the national average of 29 per cent).

The groundwater quality is also deteriorating (increased salinity, contamination by wastewaters etc.). The CGWB is monitoring the ground water levels in the country four times a year (Jan/May/Aug/Nov) through a network of 15640 Ground Water Monitoring Wells. The ground water samples collected during the pre-monsoon monitoring are analyzed (CWC, 2000).

As a consequence of overexploitation, the following problems are encountered.

- Increase in pumping depths, reduction in well / tube well yields and rise in the cost of pumping ground water
- Wide spread and acute scarcity of ground water in summer months for irrigation and drinking uses
- Contamination of ground water due to geogenic factors (because of particular geological formation at deeper levels) resulting in fluoride, arsenic and iron contamination
- Contamination of ground water due to salinity ingress in coastal areas

- Potential reduction in essential base flow to rivers and streams and diminished spring flows.

2.1.8 Wastage of water

The single most important parameter to indicate performance under water resources management is **unaccounted for water (UFW)**. According to ADB (2007) the best performers in terms of low UFW are Jamshedpur (12.8 per cent), Mumbai (13.6 per cent), Jabalpur (14.3 per cent), Visakhapatnam (14.5 per cent), and Chennai (17.0 per cent). The worst performers are Nashik (59.6 per cent), Amritsar (57.4 per cent), Nagpur (51.9 per cent), and Bangalore (45.1 per cent). Metering is a critical component for determining UFW. Only Coimbatore claims to have both production and service connections fully metered. Bangalore and Mumbai have fully production metering but consumption metering are 95.5 per cent and 75.0 per cent, respectively.

The Ministry of Urban Development, with the help of the National Environmental Engineering Institute (NEERI) conducted studies on leaks in water distribution systems across 13 cities, including Delhi, Calcutta, Mumbai and Chennai during 1990's. It was observed that about 17-44 per cent of the total flow in the distribution system was lost on account of water loss through leakages in mains, communication and service pipes and leaking valves. In terms of per capita supply, this worked out to 16-92 lpcd. About 82 per cent of the leakage occurred in house service connections because of corroded pipes, couplings, ferrules and disused connections. The remaining 18 per cent occurred due to leakages in main pipes. The investigations revealed that if water mains were kept clean and repairs to valves were done in time, the carrying capacity of pipes could be increased considerably and wastage could be brought down to 10-12 per cent of the supply (NCIWRD, 1999). A recent study by ADB (2007) across 20 towns and cities corroborated the past studies and showed the water losses due to leakage, pilferage etc, to be of the order of up to 60 per cent (Figure 6). It also highlighted the fact that maximum leakage occurs in the house service connections, i.e., in the tertiary distribution networks. This is a reflection of the inefficiency in the management side which needs immediate attention.

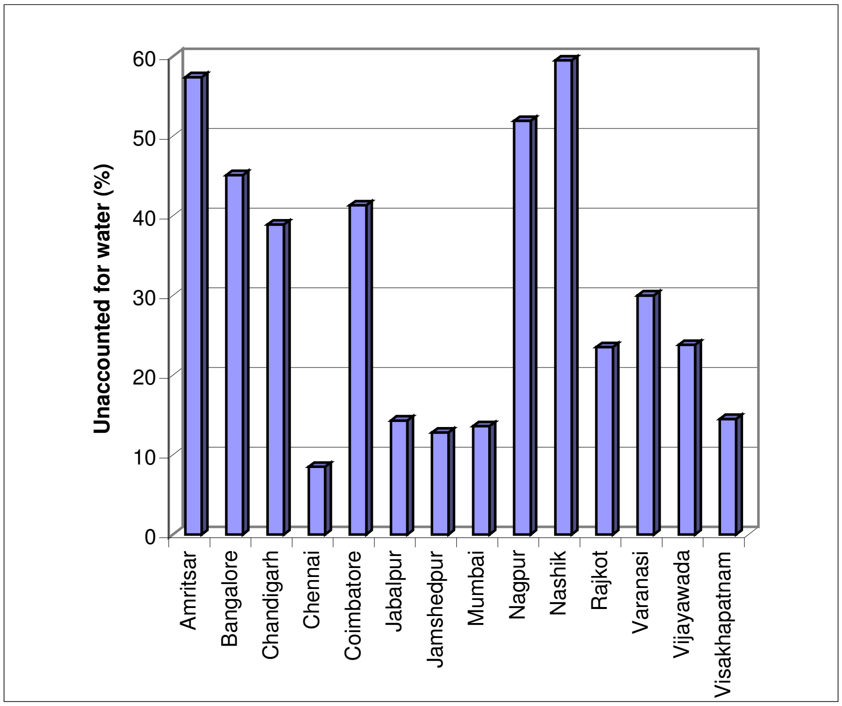


Figure 6 : **Loss in piped water supply in select cities** (Source : ADB, 2007)

Poor maintenance and **intermittent supply** from the mains compels consumers to resort to collection of water in sumps and overhead tanks and some of them living in high rise buildings install booster pumps directly on the mains. Since these are also not properly maintained and cleaned periodically, water quality is affected and in order to make the water potable, filter systems are installed. These again are not maintained properly and add its own contamination after a period of time. Thus, in spite of huge public investment in development, treatment and conveyance and huge private costs in sumps, pumps, boosters, overhead tanks and water filters, the available water do not meet the requirements of the consumer neither in quality nor in quantity. Since water supply is by and large intermittent, during non-supply hours when the system is not under pressure, external pollution quite often gets sucked into the system through the points of leak, causing health hazards. There is evidence that more water is consumed with intermittent supply because people leave their taps open to fill storage, which can often then overflow to waste. The urban poor are the most affected as they cannot afford the cost of dual systems with individual storage and pumping systems in the home. A recent study by Shaban (2008) highlighted that urban poor suffer the most from the lack of water as they have to spend more than 2 per cent of their income on water. Thus, water which should have otherwise been human right, takes precious shares of income of the poor.

A basic need and service like water on tap for 24 hours a day has been unheard of for decades in most Indian towns (ADB, 1993). The recent study by ADB (2007) across 20 cities revealed an alarming situation in the domestic water supply sector. The study reports that **average duration of supply was only 4.3 hours per day**. It is alarming that the longest available supply is only 12 hours a day, Chandigarh, followed by Amritsar (11 hours), Kolkata (8.3 hours), Varanasi (7 hours), and Jamshedpur (6 hours). The shortest supply duration per day belongs to Rajkot (0.33 hour), followed by Indore (0.75 hour), Visakhapatnam (1.0 hour), and Bhopal (1.5 hours) (Table 9). Supplies of less than 24 hours pose not only a risk to health but also affect metering and the ability to reduce UFW levels.

Table 9: Water supply frequency in selected cities (2006-07)

Sl No.	City	Water availability (hours/day)	Per capita consumption (lpcd)
1	Ahmedabad	2	171
2	Amritsar	11	105
3	Bangalore	4-5	74
4	Bhopal	1-2	72
5	Chandigarh	12	147
6	Chennai	3	197
7	Coimbatore	3	91
8	Indore	0.75	87
9	Jabalpur	4	139
10	Jamshedpur	6	203
11	Kolkata	8.3	no data
12	Mathura	1-3	no data
13	Mumbai	4	153
14	Nagpur	5	100
15	Nashik	3-4	93
16	Rajkot	0.33	101
17	Surat	2-3	188
18	Varanasi	7	147
19	Vijayawada	2-4	158

20	Visakhapatnam	0.45	124

2.1.9 Water metering

One of the major issues in mismanagement of the water supply is metering. Metering is necessary to account for water use and to determine the extent of losses. It was reported that none of the cities amongst the selected 20 cities conform to the standards and most of them do not have proper metering facilities. Water metering is the precondition for billing water users on the basis of volume consumed. According to a 2002 study of 300 cities about 62 per cent of urban water customers in metropolitan areas and 50 per cent in smaller cities are metered. Users of standposts receive water free of charge. Only 25 per cent of customers of these utilities were metered. Most other customers paid a flat tariff independent of consumption. Some utilities, such as the one serving Kolkata, actually do not bill residential users at all (ADB, 2007). Those with high levels of consumption metering are Coimbatore (100 per cent), Bangalore (95.5 per cent), Nashik (80 per cent), Chandigarh (79 per cent), and Mumbai (75 per cent). Except for Nagpur (40 per cent), the rest have less than 10 per cent metering, with Bhopal, Jabalpur, Mathura, and Varanasi with no metering at all. On an average only 24.5 per cent of the sample are metered. For Indian water utilities, this is perhaps the single most important area requiring improvement.

2.1.10 Institutional regulatory mechanisms

Previous studies pointed to the underlying problems related to performance of water utilities, such as poor and inadequate investments, poor operation and maintenance (O&M) practices, high nonrevenue water, uneconomic tariff structure and levels, and poor financial management. Poor service delivery is ascribed to inefficient and financially weak utilities that continue to operate without sufficient autonomy, the right incentives, and the necessary accountability to consumers. Concerning operating efficiency, ADB study (2007) showed an average level of non-revenue water (NRW) of 32 per cent. It further states that a significant and sustainable improvement in the performance of water utilities is critical to improving services particularly in the areas of customer satisfaction, water resources management, and financial and human resources management.

A healthy utility should have an operating ratio of about 0.75.The average for an Indian water utility is 1.63, which requires huge subsidies from local governments or urban local bodies. A first step in getting the finances of a utility in order is to ring-fence the water utility operations. This will allow management of finances purely from the water utility's operations. It will require increasing its revenue base, meaning more connections. Tariff level is the most important component of revenues apart from the number of consumers.

2.1.11 Water tariff

The average tariff is a good measure of the financial discipline of a utility and its ability to cover operational costs with revenues from tariffs. The water utilities with high average tariffs are Bangalore (Rs20.55/m^3), Chennai (Rs10.87/m^3), Amritsar (Rs9.34/m^3), Visakhapatnam (Rs8.55/m^3), Nagpur (Rs6.60/m^3), Rajkot (Rs5.07/m^3), and Chandigarh (Rs5.04/m^3). Despite their high average tariffs, Amritsar and Chandigarh could not cover their operational costs because of high UFW. Those who charge the lowest tariffs are Bhopal (Rs0.60/m^3), Mathura (Rs0.62/m^3), Kolkata (Rs1.13/ m^3), Ahmedabad (Rs1.39/ m^3), and Jabalpur (Rs1.50/ m^3). Kolkata is not charging its domestic users, resulting in high operating ratio (as with Bhopal and Mathura) (Table 10, ADB, 2007).

Urban water tariffs are highly affordable, the average being 4.91/ m^3. A family of five living on the poverty line (US$9 per capita per month in 2000) which uses 20 cubic meter of water per month would spend 1.2 per cent of its budget if it has a water meter and 2.0 per cent of its budget if it does not have a water meter on its water bill. This percentage lies well below the widely used affordability threshold of 5 per cent (Water community, 2008)

The distorted water prices may have a subsidized effect on those with higher consumption level in areas where there are no water meters to monitor the water use. The water tariff structure of selected Indian cities lists the different types of metering system adopted (Table 11). In the case of metered consumption and tariffs based on increasing block tariff (IBT) system (that covers about 38 per cent of the urban population), the first lower tariff block is considered the 'lifeline' block (Zerah, 2006). The design of the blocks decides the level of consumption and if it is skewed towards higher level of consumption then in the end large number of consumers will get subsidized. In South Africa, for instance, a national policy has decided to provide free water for all for the first block at 6 cu m per connection (IIR, 2006)

Table 10 Average Tariff in Selected Indian Cities (2007)

City	Average tariff (Rs/m^3)	Unit production cost (Rs/m^3)
Ahmedabad	1.39	1.34
Amritsar	9.34	3.92
Bangalore	20.55	10.13
Bhopal	0.6	3
Chandigarh	5.04	3.93
Chennai	9.85	6.09
Coimbatore	3.66	2.59
Indore	2.79	13.18
Jabalpur	1.5	1.63
Jamshedpur	4.51	2.52
Kolkata	0.53	3.46
Mathura	0.62	2.02
Mumbai	4.6	4.27
Nagpur	6.6	1.91
Nashik	4.32	1.9
Rajkot	5.07	2.83
Surat	1.66	1.82
Varanasi	3.17	2.07
Vijayawada	2.18	2.16
Visakhapatnam	8.55	4.94

Table 11 Water Tariff Structure in Indian Cities

Particulars	Metropolitan cities		Smaller cities and towns	
Metered	Number	Percentage	Number	Percentage
Uniform volumetric tariff	11	52	89	77
Increasing block tariff	8	48	26	23
Total	19	100	115	100
Non metered				
Flat rate charges	10	56	135	72
Ferrule based charges	7	39	37	20
ARV based charges	1	5	10	5
Tap based charges	0	0	6	3
Total	18	100	188	100
Percentage of metered		51.4		37.9

Source: India Infrastructure Report (2006)

2.1.12 Scarcity value of water

Since the water extraction rates far exceed the replenishable rates, water may not always fit into the definition of renewable resource during a period under consideration. The water resource extraction can be regulated by way of introducing water rights and licensing and controlling surface and groundwater extraction (resource regulation). The water resource use can be regulated using economic regulatory measures like tariff structuring, quality assurance, setting standards etc. Since the true opportunity cost of the water is ignored while fixing tariff, higher future costs may be expected, considering the rate of depletion and scarcity levels. This is a reflection of inefficient regulatory mechanisms. The water tariff should include the opportunity cost of the resource so as to arrive at the real value. This would act as an incentive for the consumers to make rational decisions for better management of water resource.

Figures 7 and 8 project the range of water tariff in selected countries in developed and developing nations during the last decade. This reflects the global low water tariff scenario (Annexure I).

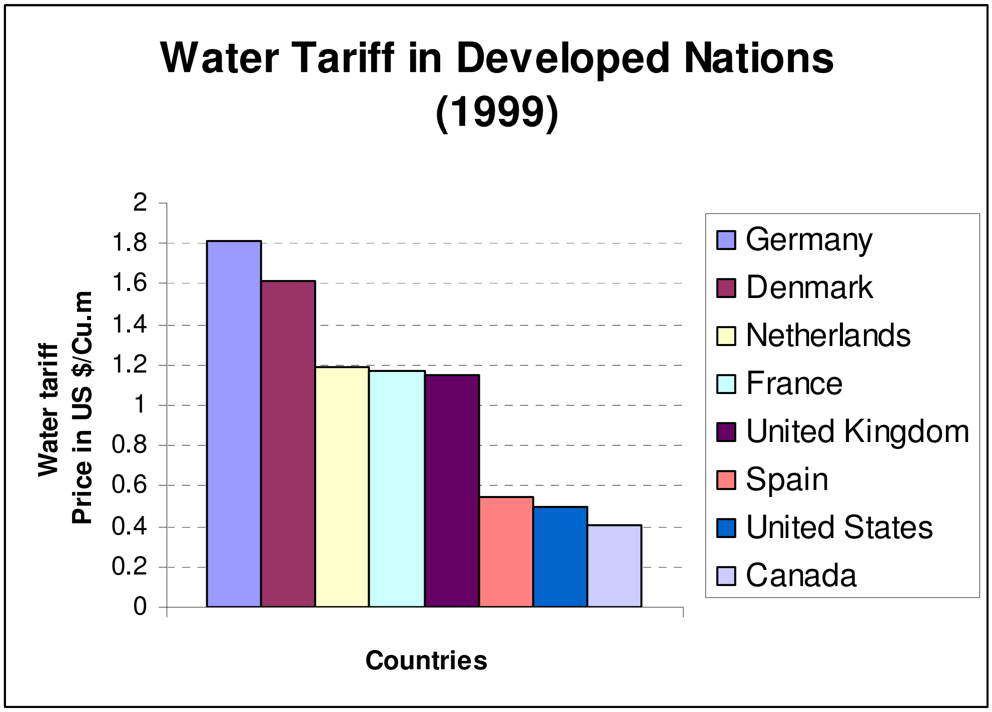


Figure 7 Water tariff in Asian cities (1999) (Source: Berg, 2007)

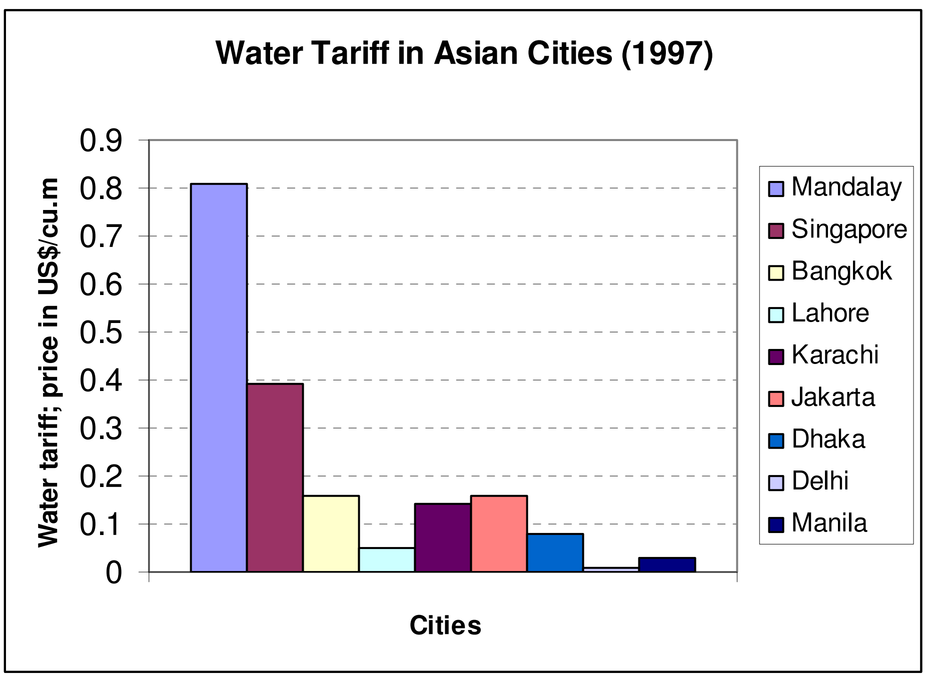


Figure 8 Water tariff in Asian cities (1999) (Source: Berg, 2007)

The water tariff/pricing policy in India is inefficient and there is immense scope for revising the existing policies and pricing structure for fixing a fair price which reflects the opportunity cost of water. Along with the distorted prices, the high cost of connection acts as an entry barrier, as they are often fixed at a high level both for water and a sewerage connection.

2.1.13 Wastewater generation

The wastewater generation, as per assessment made by the Central Pollution Control Board (CPCB) in 921 Class I cities and Class-II towns (housing more than 70 per cent of urban population) is about 26,254 Million Litres Per Day (MLD). The wastewater treatment capacity developed so far is only 7044 MLD targeting around 27 per cent of wastewater generated in these two classes of urban centers (Table 12). Table 13 summarizes the water requirement, supply and wastewater generation in 921 cities and towns.

Table 12: Status of wastewater generation in Class I Cities / Class II towns in 2003-04

Parameters	**Class I Cities**	**Class II Towns**	**Total**
Number (as per 2001 census)	423	498	921
Population(millions)	187	37.5	224.5
Wastewater generated(MLD)	23826	2428	26054
Wastewater generation(lpcd)	127	65	116

Table 13: Summary of the total water requirement, water supplied and wastewater generation per annum (2003-04) in the 921 cities and towns surveyed

Category	Amount (BCM/annum)
Total water requirement (as per 2001 census)– (per capita supply @ 135 lpcd plus 15 per cent system losses and 10 per cent for other uses)	13.94
Water supplied in the year 2003-04	11.98
Wastewater generated in the year 2003-04	9.51

Based on the projected urban population growth that is expected to reach 850 million in 2051, the corresponding gross wastewater generation is estimated to be 83,300 MLD. At present, most of the cities have only primary treatment facilities. Thus, the untreated and partially treated municipal wastewater finds its way into water sources such as rivers, lakes and ground water, causing water pollution. The alternative programme of *Low Cost Sanitation* , which offers an affordable alternative technology, has made very little progress, despite being linked to the social problem of manual scavenging, which is prohibited by law. As of 31.3.2007, about 63 per cent of the urban population has accessibility to sewerage and sanitation facilities (as per information collected by CPHEEO, Ministry of Urban Development). Of this about 30 per cent population has access to sewerage and 33 per cent has got access to low cost sanitation and septic tank facilities.

2.1.14 Wastewater recycle and reuse

Wastewater from both industrial and municipal sources can be (a) recycled i.e. used internally by the original user prior to discharge to a treatment system or other point of disposal (b) reused, when a user other than the discharger withdraws the wastewater. Each recycling may be through a succession of lower quality uses with little or no treatment as part of the cycle or it may include treatment to maintain a certain quality. Annexure II presents the BIS standards for discharge of sewage and industrial effluent in surface water sources and public sewers.

Wastewater reuse and recycling is widely adopted by several countries worldwide. Wastewater reuse is a common practice in developing countries of Asia and Africa and wastewater recycling is common in water scarce regions of the developed countries such as the Australia, Middle East, south west of US, and in regions with severe restrictions on disposal of treated wastewater effluents, such as Florida, coastal or inland areas of France and Italy, and densely populated European countries such as England and Germany (Marsalek et al. 2002). The concept of wastewater recycle and reuse is relatively new to India though it is gradually gaining attention from all concerned. **The wastewater reuse and recycling as a water supply augmentation measure has not been adequately addressed in India and the issue had been sidelined for long. The National Water**

Mission (NWM) 2008 aims to meet a considerable share of the water needs of urban areas through recycling of wastewater.

2.1.15 Multiple uses of reclaimed wastewater

In urban areas, reclaimed wastewater can be used for a variety of applications viz.,

- Non-potable uses (fire fighting, air conditioning, toilet flushing, construction water and flushing of sanitary sewers)
- Potable uses, which would occur by blending in water storage reservoirs or by direct input to water distribution system.
- Ground water recharge
- Development of recreational lakes and urban landscape irrigation / horticulture uses
- Industrial reuse primarily for cooling and process needs.

For municipal wastewater, one of the uses is irrigation. The practice of sewage farming is widespread since nutrients such as nitrogen, phosphorus and potash from domestic and industrial wastewater has been observed to increase crop productivity. Apart from agricultural use, sewage has been reused for fish aquaculture, with the treated effluent being used for cultivation of grain (paddy), ornamental and fodder crops. Wastewaters fed fishponds have been successfully implemented near Kolkata city. Based on this experience, an integrated wetland system (IWS), for wastewater treatment and resource recovery through aquaculture and agriculture has been developed in three municipalities within the Kolkata Metropolitan area.

2.1.16 Technical issues in planning water reuse systems

- Identification and characterization of potential demands for reclaimed water.
- Identification and characterization of existing sources of reclaimed water to determine their potential for reuse.
- Treatment requirements for producing a safe and reliable reclaimed water that is suitable for its intended applications.
- Storage facilities required to balance seasonal fluctuations in supply with fluctuations in demand.

- Supplemental facilities required to operate a water reuse system, such as conveyance and distribution networks, operational storage facilities, alternative supplies and alternative disposal facilities.
- Potential environmental impacts of implementing water reclamation
- Identification of knowledge, skills and abilities necessary to operate and maintain the proposed system
- Constituents in reclaimed water relating to scaling, corrosion, biological growth and fouling (especially for industrial reuse applications).

2.1.17 Promotion of treated wastewater for non potable uses

Creation of incentive mechanisms like tariff structures would enable industries to cover a major part of their operating and maintenance costs. So far there has not been any conscious attempt in India to create a market for the wastewater through regulatory mechanisms like tariff. **The market for adoption of advanced technologies for wastewater use arising from industries and municipal corporations accounts for the largest percentage of the total environmental market in India** (Winrock International India, 2007). Wastewater market is one area which has great potential in developing and improving the water use efficiency through voluntary efforts.

2.1.18 Investment trends

Though the urban water supply and sanitation sector had remained as an important area of concern, but allocation of funds made right from the First Five Year Plan onwards has remained almost of the order of 1.00 to 1.5 per cent of the total public sector outlay. The outlay for Urban Water Supply & Sanitation (UWSS), which was Rs.43 Crore (1.28 per cent of the total public sector outlay) in the first Five Year Plan, gradually, increased to Rs.550 Crore (1.40 per cent) by the Fifth Plan. Despite a rapid increase in the urban population, there has been a gradual shift in priority from urban to rural sector from the Sixth Plan onwards. The percentage share of urban sector, out of the total public sector outlay, showed only a marginal increase from 1.28 per cent to 1.38 per cent between the First Plan and the Eighth Plan. In the Ninth Plan, this, however, could step up to 2.17 per cent. The 10th Plan outlay for urban water supply & sanitation sector was Rs.18749.20 crore, which was only 1.3 per cent of total public sector outlay.

The development of domestic water supply has been almost entirely government funded, either directly from the budget or with the help of institutional finance from public financing bodies like Life Insurance Corporation (LIC) and HUDCO or with foreign assistance from bilateral and international sources. All the funds put together are not adequate to achieve the objective in a time bound manner. The private sector is reluctant to enter the field because of the very low water rates and the ingrained resistance to increase rates. Efforts by government alone will not solve the problem considering the huge financial burden coupled with low recovery of cost. The supply oriented water management should be replaced with a demand side management programme through relevant initiatives viz., participatory management programmes, regulatory incentives, awareness and empowerment etc.

Since the beginning of the Sixth Five Year Plan (1980-85) and the launch of the International Drinking Water Supply and Sanitation Decade (1981-90), India has increased its commitment to the water supply and sanitation sector. Sector investments have increased and presently constitute a significant proportion of the national budget (about 3 percent of which 50 percent is allocated to rural areas and the rest to urban areas). Government of India formulates policies, sets standards and provides technical as well as substantial financial assistance to the States. Central Government funding constitutes about 40 percent of the total investment in the sector. The remainder is provided by the States. About 5 percent of the sector investment comes from External Support Agencies. Since independence, Central and State Governments have collectively spent more than Rs.360 billion (US$ 7.5 billion) for rural drinking water sector (GOI, 2002; Paper presented during Water Forum, 2002). In December 2005, the Government of India (GOI) launched the Jawaharlal Nehru National Urban Renewal Mission (JNNURM), which formally envisages central government investment of potentially up to US$11 billion on basic urban infrastructure and services (water supply, waste management, public transportation, etc.) in 63 identified cities over the next 7 years.

2.1.19 Fund Requirement

To improve the infrastructure related to water supply and sanitation in the urban centers, GoI has been assisting the ULBs / State Government through various schemes / special Central assistance from time to time. However, in order to expedite creation of infrastructure and to improve the urban environment, Government of India has launched the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) and Urban Infrastructure Development Scheme for Small and Medium Towns (UIDSSMT) with Central out lay of Rs. 1,00,000 crore to be invested during 2005-2012 over a period of 7 years.

In order to improve the overall urban environment, it is envisaged to create and to rehabilitate urban water supply and sanitation and other components eligible under the Programme. However, water supply and sanitation has been accorded highest priority among the eligible components and it is expected that 40 per cent of the outlay would be spent on water supply and sanitation sector. As such, the tentative outlay available for the sector under JNNURM & UIDSSMT up to 2012 may be taken as Rs. 40,000 crores.

It has been estimated that by the end of Year 2012 AD, the urban population of the country will be around 365.36 million. On the basis of the information received from the States and Union Territories, it has been assessed that 280.37 million (91 per cent) urban population would be covered with water supply facilities leaving a balance of 27.11 million uncovered population as on 31.3.2004. For achieving 100 per cent population coverage with water supply facilities by the end of 11th Five Year Plan i.e. 31.3.2012 and taking into account the urban population already covered with water supply facilities, the requirement of funds (tentative) has been assessed as detailed below.

(i)	Additional population to be provided with water supply facilities (181.80 million population x Rs. 2500),	:	Rs.4,54,500 million
(ii)	Augmentation/rehabilitation facilities for covered population (82.16 million x Rs. 1000)	:	Rs.82,160 million
			---------------
Total funds required for urban water supply		:	Rs.5,36,660 million
			---------------
			Rs. 53,666 crores

To bring the infrastructure to a level, to meet the requirements as per norms, there exists a gap of Rs. 89,237 crore (1,29,237-40,000) . However, if we compare the gross outlay of Rs. 20,079 crore provided during the 10th Five Year Plan in State as well as Central sector, a huge outlay is needed for the sector. **This necessitates the possibility of exploring additional funding the water supply and sanitation sector from some sources other than the Government.**

2.1.20 Subsidies

There are no accurate recent estimates of the level of subsidies for water and sanitation in India. It has been estimated that transfers to the water sector in India amounted to 5.470.8 crore (US$ 1.1 billion) per year in the mid-1990s, accounting for 4 per cent of all government subsidies in India. About 98 per cent of this subsidy is said to come from State rather than Central budgets. This figure may only cover recurrent cost subsidies and not investment subsidies, which are even higher . Given the low level of cost recovery the actual level of recurrent subsidies may be even higher than the estimate above. There is little targeting of subsidies in Indian water tariffs given that all consumers pay less than full costs. According to the World Bank, 70 per cent of those benefiting from subsidies channeled towards private connections are not poor, while 40 per cent of the poor who do not use any public water services are excluded altogether (Water Community, 2008).

2.1.21 Institutions and policies

Quite often, multiplicity of agencies and overlapping responsibilities are the reasons for ineffective and poor performance of operation and maintenance. In the light of 74th Amendment of the Constitution, the role and responsibility of the Urban Local Bodies (ULBs) have increased significantly in providing these basic facilities to the community on sustainable basis. The new Amendment has enabled ULBs to become financially and technically sound to provide these basic civic amenities to the community. As per the Constitution (74th Amendment Act), 1992, the ULBs have been delegated with sets of responsibilities and functions. But they are not supplemented with adequate financial resources. As a result, they are not able to perform their assigned functions in an efficient and effective manner. They are also not able to fix the rates of user charges and are heavily dependant for grants upon the higher levels of Governments.

Keeping this in view, Ministry of Urban Development has initiated the urban reform agenda. This agenda has been supplemented with the formulation of the *Model Municipal Law*, which intends to assist urban local bodies in the areas of accounting reforms, resource mobilization, levy of user charges and entry of private sector participation. Ward Committees have to be constituted and they have to be consulted / involved in the decision making process with regard to provision of basic amenities (11th plan review, GOI).

On the management side, in urban area municipalities the ULB are in charge of operation and maintenance of the water and wastewater for the concerned city. Some of the metros have a separate entity; for e.g. Hyderabad Metropolitan Water Supply & Sewerage board (HMWSSB) in Hyderabad that manages the water and wastewater in the city. The responsibility of operation, maintenance and revenue collection is generally vested with the elected ULB, while the specialized bodies are not able to raise the water tariff without the approval of the provincial Governments. The local bodies generally receive grant assistance ranging from 10 per cent to 60 per cent for capital works on water supply and sanitation from the State Government. Usually, they do not receive any grant assistance for operation and maintenance (O&M) of water supply and sewerage. Municipal bodies in many parts of the country suffer from inadequate resources. Much is to be done on this important aspect.

Water management issues are more critical than the development programmes. Considerable benefits can be obtained from the present system if managed efficiently. But this is not an easy task and it has often been observed that the costly structures constructed for water distribution are mismanaged and ill maintained leading to a situation where the stakeholders have to incur high private costs and have to resort to alternate means or supplementary sources.

2.2 Industrial sector

Most of the common problems viz., tariff, metering, UFW, storage, source etc have already been dealt with under the domestic sector issues which are not reproduced here, but to be considered relevant and applicable to industrial sector also.

The water requirement for industrial purposes is anticipated to increase significantly in the future. Industrial freshwater supply comes from both surface and ground water sources. Table 14 presents the projected requirements for key industrial sectors.

In order to regulate the ground water development by the industries, a list of over exploited/critical areas have been circulated to Statutory organizations like State Pollution Control Boards, Ministry of Environment and Forests etc which refers new industries/ projects to CGWA for permissions prior to setting up of industries/projects . The proposals received are evaluated on case to case basis, based on site specific recommendations of Central Ground Water Board and are accorded ground water clearance.

2.2.1 Wastewater recycle and reuse

Owing to more stringent environmental norms as well as shortage of quality water supply, medium and large industries are implementing initiatives for wastewater reclamation. Table 15 summarizes the amount of wastewater generated in various industries and the percentage of effluent that can be potentially recycled.

Table 14 Projected water requirements of various sectors of Indian industries

S.N.	Category of industry	Water requirement per unit (m^3)	Year 2000		Year 2010		Year 2025		Year 2050	
			Production 1000 tonnes	Water req. Mm^3/year	Production 1000 tonnes	Water req. Mm^3/year	Production 1000 tonnes	Water req. Mm^3/year	Production 1000 tonnes	Water req. Mm^3/year
1	2	3	6	7	8	9	10	11	12	13
2	Integrated iron & steel	22	174,050	3829.100	265,350	5837.700	273,300	6012.600	547,050	12035.100
3	Smelters	82.5	203.6	16.76	292.6	24.14	391.6	32.31	537.60	44.35
4	Petrochemicals and Refinery	17	1381	23.47	1800.59	30.61	2221	37.76	3,271	55.61
5	Chemicals-Caustic soda	5.5	1,600.00	8.65	1,854.55	10.20	2,303.50	12.67	3,467.70	19.07
6	Textile & jute	200	51,193.00	8,153.72	95,093.90	19,018.78	183,507.00	36,701.40	234,617.50	46,923.50
7	Cement	4.5	120,000	600	219,000	986	395,000	1,778	749,000	3,371
8	Fertilizer	16.7	17,300.00	220.11	37,782.00	630.96	66,173.33	1,105.09	88,351.70	1,192.75
9	Leather products	30	1277.5	1244.65	2191.25	65.74	3102.50	93.08	4,927.50	147.83
10	Rubber	6.6	479.96	3.04	651.5	4.3	971.45	6.41	1,444.96	9.54
11	Food processing	6.8	124,223	992	506,150	3,442	1,386.730	9,443	1,808,576	12,298
12	Inorganic chemicals	200	3,730	165	8,000	1,600	16,730	3,346	30,076	615
13	Sugar	2.2	19,500	46	32,330	71	152,000	334	289,500	637
14	Pharmaceuticals	25	4,960.00	124.00	8,370.00	209.25	11,046	276.15	17,170.00	429.15
15	Distillery (Req. per 1000 litres)	22	1,790.80	6,357.20	3,059.59	66.31	4,454.60	318.00	6,020.00	5,203.92

16	Pesticides	6.5	195.3	6.67	306.15	1.99	742.05	4,82	1,288.8	8.38
17	Paper & Pulp	200	4,950	1,260	10,350	207	51,200	10,240	97,450	19,490
18	General engineering	2.2	6,515	1,433	10,754	24	12,644	28	25,287	56
	Total			**24482.97**		**32229.13**		**69768.77**		**102535.75**

Source: MOWR, 2000

Table 15 Wastewater generation from different types of industries and achievable reuse (Tyagi et al., 1994, cited in CWC, 2000)

Industry	Average volume of wastewater per unit or product	Per cent reuse achievable
Thermal power plant	155 x 10^3 L/h/MW	98
Pulp & Paper	250 x 10^3 L/tonne	50
Iron and steel	150 x 10^3 L/tonne	40
Pharmaceutical	4.5 x 10^3 L/Kg	40
Distillery	15 L/L of alcohol	25
Textile	250 L/Kg Cloth	15
Tannery	34 L/Kg of raw hides	12

Wastewater reclamation in industrial processes is often linked with recovery of valuable resources (by-products). For example, whey protein concentrate (WPC), a saleable protein supplement, can be recovered from the whey wastewater generated in cheese production. Dyes and salt can be recovered from the wash waters in textile industry.

2.3 Summary: Key issues in domestic and industrial water management

The key issues discussed in this chapter are summarized below.

Supply side

- Dwindling ground water availability
- Lack of adequate storage capacity
- Lack of revenue generation leading to financial burden
- Lack of metering of household connections
- Inappropriate system design resulting in wastage
- Water supply hours are considerably low
- Non-adoption of latest Operation &Maintenance technologies
- Overlapping responsibilities among multiple agencies
- High unaccounted for water (UFW) due to leakage, pilferage etc.
- Inequitable distribution
- Poor quality of water
- Urban and rural poor lack access to water supply
- Poor governance
- Inadequate training of personnel

Demand management

- Low tariff acts as a disincentive to conserve and manage water
- Illegal connections
- Cross subsidization of water tariff leads to skewed distribution of benefits
- Lack of efforts and initiatives for in situ conservation of water viz., rainwater harvesting
- Awareness level regarding water conservation and management is poor

- Resistance to increase in tariff
- Inadequate legalized initiatives by private and community organizations
- Extraction exceeds total recharge potential of ground water

Industrial wastewater

- Wastewater characteristics are industry specific; thus, the treatment scheme has to be customized to the wastewater components
- Wastewater treatment in small and medium industries continues to be a challenge; in particular, the treatment options applicable to large industries may not be economically feasible
- For small and medium scale units in close proximity, combined effluent treatment plants are a possible option; however, their effective functioning depends upon understanding and cooperation among the member units

Wastewater management and reclamation

- Wastewater treatment is often not cost effective
- Psychological barrier for wastewater reuse
- Current treatment technologies do not often meet the quality standards
- Lack of economic incentives for undertaking wastewater recycling
- Promotion of treated wastewater for non potable uses
- Ignorance about the untapped potential of treated wastewater
- Underdeveloped regulatory mechanisms
- Lack of proper pricing policy for wastewater
- Least preferred option amongst other water source alternatives
- Involvement of community/public-private /private agencies is poor
- Lack of proper scientific studies on treated waste water tariff structuring

3 Viable water management and conservation measures

In India the water management programmes have always been supply centric and the demand management got sidelined in the process. The current water management model is capital intensive and unviable due to various inefficacies detailed in the preceding chapter. Since the demand far exceeds supply, the pressure on surface and ground water sources are burgeoning leading to indiscriminate extraction at a higher rate than the replenishable rates. Evidences of dwindling ground water supply have been reported from across India in the recent past. Hence, it is imperative to have a paradigm shift in water management towards demand management together with supply augmentation through alternative sources. The demand management strategies have immense scope in inducing water saving culture that will ensure sustainability without depleting the water resources.

3.1 Demand management

3.1.1 Water conservation

Rainwater Harvesting

The domestic and industrial users should value the rainfall endowment through harvesting the resource through appropriate and cost effective methods. Rainwater harvesting is the method of conserving water in situ and in the process recharge the ground water aquifer. Traditionally, the method has been in existence across the country, which used low cost simple techniques and managed by local communities. The Arthashastra states that each region of India had its own technology to harvest rain to lie with its water endowment. It is also estimated that if an area receives only 100mm rainfall and if this quantum is harvested over one hectare of land, it would provide one million liters of water a year.

Rain water harvesting is essential because of the following factors.

- Surface water is inadequate to meet the demand and there is a strong dependence on ground water.
- Due to rapid urbanization, infiltration of rain water into the sub-soil has decreased drastically and recharging of ground water has diminished.

- Over-exploitation of ground water resource has resulted in decline in water levels in some parts of the country
- To enhance availability of ground water
- To arrest sea water ingress
- To improve the water quality in aquifers.
- To improve the vegetation cover.
- To raise the water levels in wells & bore wells that are drying up.
- To reduce power consumption.

The cost of different kinds of recharge structures is summarized in Table 16.

Table 16 Cost of groundwater recharge structures*

S. No.	Recharge Structure	Approximate cost (Rs.)
1.	Recharge pit	2500 – 5000
2.	Recharge Trench	5000 – 10000
3.	Recharge through hand pump	1500 – 2500
4.	Recharge through dug well	5000 – 8000
5.	Recharge well	50000 – 80000
6.	Recharge shaft	60000 – 85000
7.	Lateral Shaft with Bore well	Shaft per m. 2000 – 3000
		Bore well 25000 - 35000

(Source: www.cgwaindia.com; as quoted in http://www.ccsindia.org/ccsindia/policy/enviro/studies/wp0076.pdf)
* The costs can vary depending on the size of the structures and prevailing hydrogeological conditions

Roof top harvesting

The Ministry of Urban Development has forwarded the guidelines on roof top rainwater harvesting and artificial recharge of ground water (prepared by the Central Ground Water Board) to all the States including the CPWD to implement rain water harvesting and artificial recharge of ground water in all the government buildings to start with. The Town and Country Planning Organization (TCPO) has also prepared model building byelaws incorporating mandatory provision of rainwater harvesting and recycle of wastewater. This has been circulated to all the States for preparing similar byelaws by the respective Urban Local Bodies (ULBs), so that rainwater harvesting can be implemented in all the premises having plinth area more than 100 sq m. and recycle of wastewater of the premises discharging more than 10000 liters per day (for use in horticulture etc.) However, concerted efforts are required to achieve these objectives.

Aquifer recharge through rainwater harvesting

Rainwater may be charged into the groundwater aquifers through any suitable structures like dug wells, borewells, recharge trenches and recharge pits. Various recharge structures are possible; some of which promote the percoloation of water through soil strata at shallower depth (recharge trenches, permeable pavements) whereas others conduct water to greater depths from where it joins the ground water (e.g. recharge wells). At many locations existing structures like wells, pits and tanks can be modified as recharge structures, eliminating the need to construct any structures afresh.

Some of the successful initiatives in rainwater harvesting are illustrated by the following cases.

Rainwater harvesting at Bharat Electronics Limited (BEL), Bangalore

(Source: TERI, 2004)

Bharat Electronics Limited (BEL) is a Public Sector Undertaking (PSU), established in 1954 for electronics design and manufacturing. It employs about 7000 persons and occupies around 74 ha of land covering both manufacturing (factory) and residential area. The yearly average freshwater requirements were 1000-1200 million litres. The BWSSB (municipality) supply was only around 30 per cent and the balance was being met through bore well water. With increased extraction of ground water, the water table reduced by 25-50 m over the years and the yield also reduced by 65-90 per cent. As a result, TERI performed rainwater harvesting assessment study at this unit. The total catchments area was 740,000 sq m, with built up area around 275,000 sq m (factory premises) and 255,000 sq m (housing colony). It was estimated that at 90 per cent dependable rainfall of 467mm over the catchments would yield 500 ML per year – about 1.5 MLD. The maximum yearly storage was assessed to be up to 179,000 KL from factory area, which could be expanded to 211,000 KL with colony area.

The harvested rainwater quality was expected to be moderate, with high turbidity. The as collected water could therefore be used for gardening, toilet flushing (with dedicated distributory network); with solids removal and pH adjustment, the water can be used in cooling towers. Further treatment was suggested for process use. The total project cost was estimated to be Rs 65 lakhs on an actual basis. The annual savings would be Rs 14.04 Lakhs (as an alternative to borewell source) and Rs 28.08 Lakhs (as alternative to tanker source at Rs17/kL). The payback would be 3.5 years and 1.8 years respectively.

Rainwater harvesting in Japan and Germany

(Source: SANDRP, 1999)

After battling both water scarcity and floods, Sumida City in Tokyo has become a trailblazer in catching and using rainwater. Rainwater utilization policies have been promoted with three basic aims: developing water resources by community efforts, restoring the regional natural water cycle, and ensuring water supply for emergencies. The ward office boasts of a rainwater utilization system that covers half of the water needs and saves 1.8 million-Yen for the government. One of the major achievements has been the installation of rainwater harvesting facility at Ryogoku Kokugikan, a well-known Sumo wrestling arena in Tokyo, where 70 per cent of the facilities use only rainwater. In August 1998 six ministries in the Japanese government announced to jointly draw out water conservation policies.

The German Municipalities have devised a taxation system that encourages rainwater harvesting. Residents are charged separately on the basis of paved and sealed areas in their houses, such as backyards and drive-in. A tax inspector measures the paved area and calculates the average run-off it will generate. Accordingly, tax is levied. Residents are compensated for carrying out rainwater harvesting structures by lowering the water bills to recover the cost of harvesting.

Different water harvest structures and case studies from India

(Source: Manual on Artificial Recharge of Ground Water; http://cgwb.gov.in/)

S. No.	State / Union Territory	No. of schemes for which impact assessment done	Artificial recharge structures	Impact assessment
1.	Andhra Pradesh	6	Percolation tanks	4500-5900 cubic meter runoff water recharged in one year
		3	Check dams	1000-1250 cubic meter runoff water recharged in one year
		1	Combination of recharge pits and lateral shafts	370 cubic meter runoff recharged in one year
2	Arunachal Pradesh	1	Roof top rainwater harvesting	7000 cubic meter runoff water harvested in one year
3.	Assam	1	Roof top rainwater harvesting	5500 cubic meter run off water harvested in one year
4.	Bihar	1	Roof top rainwater harvesting	4700 cubic meter runoff water recharged in one year
5.	Chandigarh	6	Roof top rainwater harvesting	1440-13000 cubic meter runoff water recharged in one year
		1	Rain water harvesting through roof top & pavement catchments	34.50 lakh cubic meter runoff water recharged in one year
		1	Recharge trenches	9.50 lakh cubic meter runoff water recharged in one year
6.	Gujarat	3	Rain water harvesting through roof top & pavement catchments	11000-45000 cubic meter runoff water recharged in one year
7.	Haryana	1	Roof top rainwater harvesting	2350 cubic meter runoff water recharged in one year

		1	Combination of recharge shafts and injection wells	3.50 lakh cubic meter runoff water recharged in one year. Declining rate reduced from 1.175 m/yr to 0.25 m/yr.
8.	Himachal Pradesh	3	Check dams	1.20-21.00 lakhs cubic meter runoff water recharged in one year
9.	Jammu and Kashmir	2	Roof top rainwater harvesting	300-1200 cubic meter runoff water recharged in one year
10.	Jharkhand	1	Roof top rainwater harvesting	4500 cubic meter runoff water recharged in one year
11.	Karnataka	1	Combination of percolation tanks, watershed, structures, recharge wells, roof top rainwater harvesting	2-3.5 m rise in water levels and 9-16 ha area benefited from percolation tanks. 8.60 lakh cubic meter water recharged through recharge well 3-5 m rise in ground water levels through water shed structures 530 cubic meter recharged from roof top rainwater harvesting
12	Kerala	1	Sub-surface dyke	Augmented 5000 cubic meter of ground water in upstream side with 2 m rise in ground water levels
		1	Recharge wells	2800 cubic meter runoff water recharged in one year
		3	Percolation tanks	2000-15000 cubic meter runoff water recharged in one year
		1	Tidal regulator	4000 cubic meter runoff water conserved and a difference of 1.5 m was observed in upstream and downstream water level
		2.	Check dam	5100-30000 cubic meter runoff water recharged in one year

13.	Lakshadweep	1	Roof top rainwater harvesting	3000 cubic meter rainwater harvested in one year
14.	Madhya Pradesh	4	Sub-surface dykes	Rise in water level in dug wells in the range of 0.80-3.80 m and 6-12 m in hand pumps have been observed
		1	Percolation tank	Rise in ground water levels by 1-4 m in command area downstream of tank has been observed
		1	Roof top rainwater harvesting (1000 houses)	More than 2 lakh cubic meter runoff water recharged in one year
		1	Combination of sub-surface dykes and check dam	Rise in water level in existing tube wells in upstream area by 0.30 m to 2.00 m has been observed
15.	Maharashtra	2	Roof top rainwater harvesting system	196-280 cubic meter runoff water recharged in one year
		1	Combination of percolation tanks and check dams	Benefited area – About 60-120 ha per percolation tank. 3 to 15 hectare per check dam water level rise – upon 1.5 m
		1	Percolation tanks, recharge shaft, dug well recharge	Benefited area – 400-500 hectare around the scheme
16.	Meghalaya	1	Roof top rainwater harvesting	6800 cubic meter runoff water harvesting in one year
17	Mizoram	1	Roof top rainwater harvesting	50000 cubic meter runoff water harvesting in one year
18.	Nagaland	3	Roof top rainwater harvesting	2480-14065 cubic meter runoff water harvesting in one year

19.	NCT Delhi	2	Check dams	Water levels have risen up to 2.55 m in the vicinity of check dams and area benefited is up to 30 hectare from each check dam in JNU & IIT. 1.30 lakh cubic meter of rainwater was recharged in one year in Kushak Nala
		7	Roof top rainwater harvesting	800-5000 cubic meter runoff water recharged in one year
		8	Rainwater harvesting through roof top & pavement catchments	8500-20000 cubic meter runoff water recharged in one year
20.	Orissa	1	Rainwater harvesting through roof top & pavement catchments	1200 cubic meter runoff water recharged in one year
		1	Renovation of creeks & sub-creeks, construction of control sluices and recharge bore wells	Quality of fresh water impounded is 798119 cubic meters and irrigation potential is 11000 ha in a year
21	Punjab	1	Roof top rainwater harvesting	500 cubic meter runoff water recharged in one year
		3	Recharge wells	9-15.50 lakh cubic meter runoff water recharged in one year
		1	Trenches	Average rise in water level up to 0.32-0.70 m has been observed
			Combination of vertical shafts, injection wells & recharge trenches	Recharge of 1.70 lakh cubic meter runoff water caused average rise of 0.25 m in ground water levels around the scheme area

		1	Combination of recharge shafts and injection wells	14,400 cubic meter runoff water recharged in one year
22	Rajasthan	1	Check dams	88000 cubic meter runoff water recharged in one year. Water level rise – 0.65 m
		12	Roof top rainwater harvesting	350-2800 cubic meter runoff water recharged in one year
		3	Sub-surface barriers	2000-11500 cubic meter runoff water recharged in one year. Water level rise from 0.25 to 0.60 m.
23.	Tamil Nadu	1	Sub-surface dyke	39.25 ha area benefited
		7	Percolation tanks	10,000-2,25,000 cubic meter runoff water recharged in one year
		1	Roof top rainwater harvesting	3700 cubic meter runoff water recharged in one year
24.	Uttar Pradesh	7	Roof top rainwater harvesting	350-23033 cubic meter runoff water recharged in one year
25.	West Bengal	1	Combination of farm ponds, nala bunds, sub-surface dykes	Water level rise of 0.15 m observed
		1	Sub-surface dykes	Rise in water levels by 0.45 m observed.

Action plan

- To set the minimum standards for water conservation in commercial buildings, a water conservation code for buildings can be developed. This can be on the lines of the Energy Conservation Building Code (ECBC) which empowers the Central Government to prescribe ECBC for commercial buildings and building complexes with the state government having the flexibility to amend the code to suit local or regional needs.
- State Governments, Development Authorities and Urban Local Bodies (ULBs) need to be persuaded to promote and implement provisioning of rainwater harvesting in new buildings, if necessary through suitable amendments in the building bye-laws.

- It must be made mandatory to install rainwater harvesting systems in both public and private buildings including industrial and commercial establishments. Also, buildings having a courtyard should allocate a prescribed proportional area for rainwater harvest and recharge. The ULBs should make it a point not to approve building plans having no provision for such systems.
- Proper implementation of the approved rainwater harvesting systems by the builders should be ensured. Technical support may be extended so as to ensure the standards; also, awareness progammes may be organized at residential areas and offices as part of the campaign.
- Pre and post evaluation of rainwater harvest technology ensures better efficiency and scope for improvement. The recharge effect should be monitored and quantified for assessing the technological efficacies.
- In the long run, the option of pricing and marketing the roof top harvested water may be thought of as an incentive for the stakeholders who resort to this practice.

3.1.2 Wastewater recycling and reuse

Different central ministries / agencies at Government of India level, namely Ministry of Urban Development, Ministry of Environment and Forests, Ministry of Development of North Eastern Region and Planning Commission, are providing funds for creation of infrastructure in water supply, sewerage and sewage treatment, drainage and solid waste management in the urban areas of country. These objectives are similar. This amounts to over lapping of duties and duplication of work to some extent.

As per Government of India Business Rules, Ministry of Urban Development is the nodal Ministry, at the Central level, for planning, policy formulation and assisting State Governments and ULBs in provision of water supply, sanitation (sewerage, sewage treatment, low cost sanitation), drainage and solid waste management in urban areas of the country. Ministry of Environment and Forests through NRCD (National Rivers Conservation Directorate) has been implementing the interception and diversion of wastewater projects by laying trunk mains along the bank of rivers, pumping of wastewater and construction of wastewater treatment plants. The funding pattern under NRCD is 70:30 between the Centre and States. Creation of the aforesaid infrastructure is limited only along the sides of river / lakes and particularly in urban areas. This does not comprehensively address the sanitation problems of the cities and towns / pollution of water bodies in rivers / lakes, in totality.

On the societal front, there is a general apprehension regarding the quality of the treated wastewater as the process in not evaluated regularly and there is not enough scientific information on the impacts of the treated water on different ecosystems. Besides, there is a psychological barrier (‘yuck factor’) for adopting the practice of wastewater reuse.

The following are the specific issues / constraints relating to the use of reclaimed wastewater for various purposes.

Potable use

- Aesthetics and public acceptance
- Constituents in reclaimed water, especially trace organic chemicals and their toxic effects
- Health concerns about pathogen transmission, particularly enteric viruses.

Non-potable use

- Public Health concern about pathogens transmitted by aerosols
- Effects of water quality on scaling, corrosion, biological growth
- Cross connection of potable and reclaimed water lines in dual piping system.

Agriculture irrigation, landscape irrigation, parks, golf courses

- Public Health concerns relating to pathogens
- Surface and groundwater water contamination, if not managed properly
- Effect of water quality on soils and crops
- Marketability of crops and public acceptance.

Ground water recharge

- Possible contamination of groundwater aquifer used as a source of supply.
- Organic chemicals in reclaimed water and their toxic effects.

Notwithstanding, a few cities such as Chandigarh, Delhi, Chennai, Bangalore etc. have undertaken reuse of tertiary treated wastewater for non-potable uses like horticulture, gardening etc. For instance, in Chandigarh about 40 per cent of gardening requirement is being met by tertiary treated wastewater. Karnataka state has plans to use the tertiary treated water for drinking purpose (see box).

Wastewater reclamation in training complex

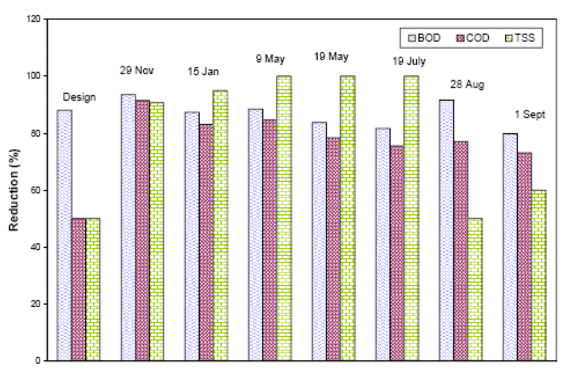
Source : TERI, 2008

Decentralized wetland systems have been used largely for institutional and residential complexes in several parts of India and other countries across Asia. The technique has also been used for tertiary treatment of wastewater including those from industrial sources. The root zone system consists of the combination of physical and biological process provided by the sand-gravel-soil packing and aerobic and anaerobic microorganisms. The contaminants present in the wastewater are treated as they seep through the root-zone of the plants by a combination of plants, soil, bacteria and hydraulic flow systems.

The root zone treatment system has been successfully installed and operated since the year 2000 at TERIs training complex (RETREAT building) at Gual Pahari, Haryana. The building, which offers a training facility for 100 people and residential facility for 36 occupants, generates $5m^3$ of sewage daily. The actual performance was better than the predicted performance based on the system design. The treated water is used for horticultural purposes.

Parameters	Average inlet wastewater	Treated wastewater*
pH	5-8	5.5-9.0
BOD, mg/l	200-250	<30
COD, mg/l	450-500	<250
Suspended solids, mg/l	200	<100
Oil and grease, mg/l	50	<10 mg/l

**as per design data from supplier*



Low-cost sewage treatment schemes

Source: SANDRP, 1999

A scheme involving treatment of 6 MLD of the nearly 50 MLD of water collected from the city of Sangli has been developed by Shivasadan co-operative society The actual purification will be done with the help of water hyacinth (which has scavenging potential) at stabilization ponds admeasuring four hectares. Water thus treated will be utilized for agricultural purposes or drained into the Krishna river. The estimated capital expenditure on the Shivsadan wastewater treatment scheme will be Rs 48 lakhs and the maintenance cost Rs 9.63 lakhs per annum. About 30 tonnes of water hyacinth biomass could be harvested from four hectares daily, yielding nearly 6 tonnes of rich organic manure at Rs 9.31 lakhs annually. While the capital investment on a conventional advanced water treatment system operated mechanically will be Rs 15 lakhs per MLD, Shivsadan's scheme will cut it down to Rs 8 lakhs. Power consumption will be reduced to one tenth.

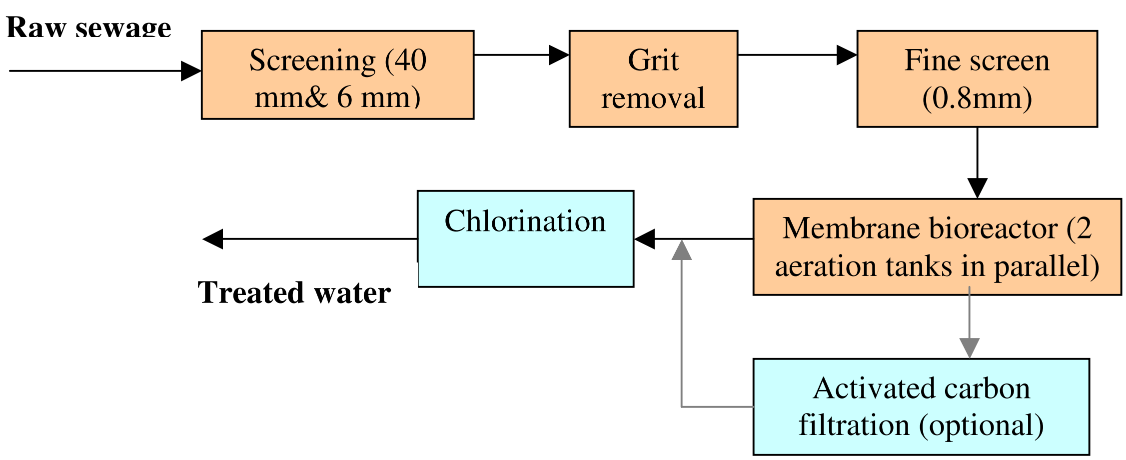
At the Environmental Education Center of the Anglade Institute of Natural History, Shembaganur near Kodaikanal in Tamil Nadu, sewage is treated by root zone treatment Simple and effective wastewater treatment in TamilNadu (Source: Hindu 23.10.92; quoted in SANDRP, 1999). A pilot project with funding from GTZ, the German development agency, has been put up by Palani Hills Conservation Council. The root zone cleaning system technology uses certain aquatic plants to clean and purify the wastewater with minimum operating costs. Such systems have been successful in various parts of Europe, on the plains as well as in mountain regions. In the Shembaganur pilot plant, about 6 KL of wastewater from the campus where about 60 people live are treated each day.

The Coimbatore Municipal Corporation has set up two sewage farms at Ukkadam (114 acres) and Vellalur (700 acres) to use the sewage water of Coimbatore (Source: Hindu 5.3.96; quoted in SANDRP, 1999). Here lagoons have been set up and plantation done from the water passed through oxidation ponds. These two farms have established beyond doubt that sewage water has beneficial use and if streamlined, it can be used to extend the green cover and augment the income of the civic bodies.

Decentralized sewage reclamation and reuse in a city

Source: Raffi, 2006

A 1.5 MLD sewage reclamation system, employing advanced membrane bioreactor technology, has been in operation since 2005 at Cubbon Park in Bangalore. The system, integrating biological treatment and membrane filtration using a 0.45 µm hollow fiber membrane, treats raw sewage collected from the surrounding office complexes. The treated water is clear (< 2 NTU) and of high quality. The treatment cost is Rs 6-7/m^3 and the treated effluent is used for irrigation / horticulture.



Parameter	Design feed characteristics	Treated effluent characteristics (normal average values)
pH	6.8-8.8	6.5-8.0
Biochemical Oxygen Demand (BOD5) 20C (mg/L)	330	<4
Total Suspended Solids (TSS) (mg/L)	450	≤3
Total Coliform (MPN/100 ml)	109-1010	<23

Combined wastewater reclamation and power generation

Source: CMWSSB, 1999

Sewage generated in Chennai city is being treated in nine sewage treatment plants with a combined capacity of 486 MLD. Till 1978, the secondary treated effluent from the STPs were partially used for cultivation of paragrass which was auctioned annually and fetched marginal revenue. The remaining treated sewage was discharged to the nearby water courses. From 1993 onwards, after the commissioning of the Kodungaiyur STP, the CMWSSB started supplying secondary treated sewage at the rate of Rs 8.75/KL to the nearby industries in Manali Town. The industries having their own tertiary treatment plants / RO plants for further polishing for their usage in the cooling water and for process purposes. Revenue of about Rs.10 crores is being generated per year through the sale of secondary treated sewage to the industries. About 3.0 lakhs litres per day of secondary treated sewage is supplied free to the Chennai Municipal Corporation for watering of plants and lawns at public parks and traffic islands.

The four new STPs commissioned during 2005 and 2006 viz., Kodungaiyur, Koyambedu, Nesapakkam, and Perungudi contribute 264 MLD to the treatment capacity. Further, in these new STPs, the biogas generated from sludge treatment is being used for electricity production thereby making them self-supporting without any need for additional power from the electricity grid. The average electrical energy production from bio-gas is about 2 KWh / m3 of bio-gas. Energy cost savings through power production per year is 373.50 lakhs (9 months / year).

Bangalore wastewater reuse project

Source: CPHEEO, 2008

Under JNNURM, a project for reuse of tertiary treated wastewater from Vrishabhavathi Valley has been approved. This will augment the present water supply of 840 million liters per day (MLD) to Bangalore city by an additional 135 MLD. This project envisages appropriate treatment of the city sewage at the specified treatment plants of the city; the treated water will then flow in the Vrishabhavathi Valley for 18 km, with a fall of 60 m. It will be then pumped back to one of the city's fresh water reservoir site after further treatment in an ultrafiltration plant. The reservoir water will then be treated in a water treatment plant for hardness removal.

The estimated project cost is Rs. 471.33 crores. The cost of the treated water will depend upon the degree of wastewater treatment. For treatment up to secondary level, the cost is about Rs. 5-7 / KL of raw sewage (to treat for BOD standards alone). This will increase to Rs. 10 / KL (if N and P are to be removed) and Rs. 15 / KL (if TDS is removed by lime soda process).

Several technologies have been used for sewage reclamation. These include both low end treatment (e.g. constructed wetland) and high-end technologies (e.g. membrane bioreactor) as illustrated by the box items. The choice of the technology is determined by parameters such as land availability, capital and operation cost, requirement of electricity / skilled manpower as well as the proposed end-use of the treated effluent. In order to utilize the treated wastewater for potable use, advanced tertiary treatment (such as reverse osmosis technology / activated carbon adsorption etc.) is required. The various parameters typically used for assessing water and its fitness for reuse in specific industries is presented in Table 17.

Table 17 Variables for assessment of water quality with respect to some key industries uses

General variables	Heating	Cooling	Power generation	Iron & Steel	Pulp and paper	Refinery	Food processing
Temperature	XXX	XXX		XX	X		
Color	X				X		XX
Odor							XXX
Suspended solids	XXX	XXX	XX	XX	X	XXX	XX
Turbidity	XX					XX	XX
Conductivity	X	X					
Dissolved solids	XX	XX	XXX	XX	XXX	X	XXX
pH	X	XXX	XXX	XX	X	XXX	XXX
Dissolved oxygen	X		X	XXX	X		
Hardness	XXX	XX	XXX	XX	XXX	XXX	XXX
Ammonia	XXX		X				X
Nitrate						X	XX
Phosphate					X		
Chemical oxygen demand		X	XX				
Calcium		XXX	XXX		X	XXX	X
Magnesium			X		X	XXX	X
Carbonate compounds	XX		XXX		XXX	X	X
Chloride	X	X	XX	XX	X	XXX	XXX
Sulphate		X	XX	XX	XX	X	XXX
Other inorganic variables							
Hydrogen sulphide	XXX	X					XX
Oil & hydrocarbons	X	X	X	X			X
Organic solvents							X
Phenols							X
Pesticides							X
Surfactants	X	X	X				X
Pathogens							XXX

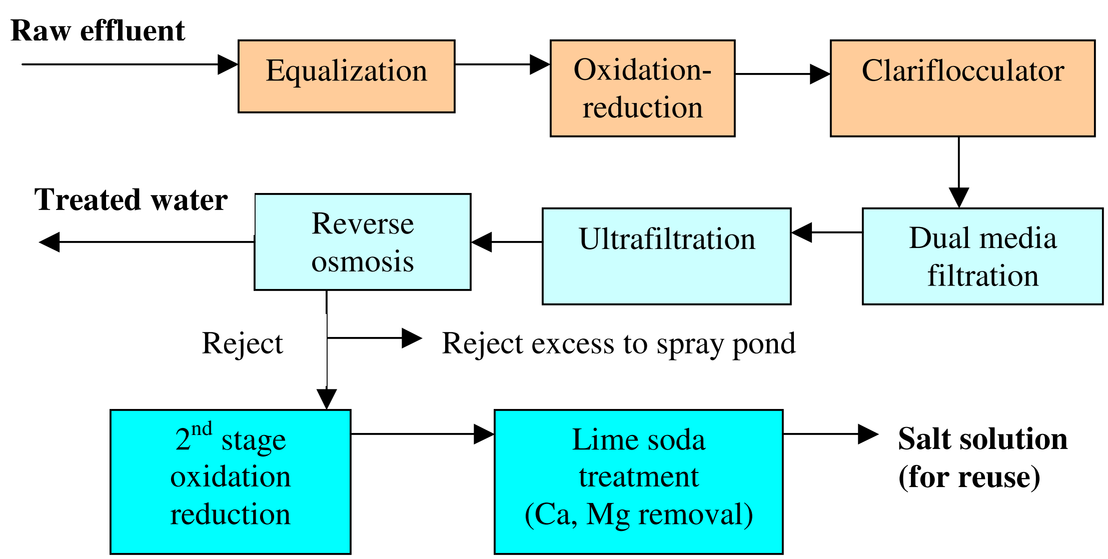
Source: CWC, 2000

Process industries, which are the major users of water, can recycle water or reuse for lesser duty purpose. Cascade concept is adopted reusing water discarded from a process requiring higher purity to a process requiring lower purity. If required, a simple treatment process may be interposed between the processes. In several instances, it is possible to segregate the high and low pollution wastewater streams and treat them separately (as in the dye and wash wastewaters in textile industries). Thus the cost of water that can be recycled or re-used can be kept lower than the marginal cost of one unit of water.

Combined water and resource recovery

Source: Saktheeswaran, 2006

Common Effluent Treatment Plants (CETPs) in the textile cluster at Tirupur, Tamil Nadu recover both water and the salt solution. There are a total of 19 CETPs, with 20-75 member industries in each. The capital cost for a 1 MLD plant is Rs 4 crore and the treated water cost is Rs 50/m^3.



Wastewater recovery and reuse in Indian industries

Source: Balakrishnan, 2007

Treated wastewater is reused in industrial cooling as well as in municipal public areas such as watering lawns and trees; further, it can also be employed in the process after suitable quality upgradation. A petrochemical refinery in Chennai, for example, has a 4000m^3/d system for recycling its process effluent. The influent is subjected to physico-chemical treatment for removal of silica & COD, followed by dead-end ultrafiltration (UF) and reverse osmosis (RO) operated at 85 per cent recovery. This scheme reduces the feed TDS from 1800 ppm to 50 ppm, thus rendering it fit for use in cooling towers & in the process. This initiative saves 200m^3/h of freshwater; further, the cost of recycled water is less than half the freshwater cost.

In addition to the above interventions, it is a common practice among many industrial units to recycle the cooling tower blow down and reject from demineralization plant after suitable treatment. The recycling cost works out to Rs 25/m^3 in data reported by a fertilizer unit. Membrane filtration, particularly RO and less commonly UF with RO, is now being employed extensively in various sectors such as textile, food processing, alcohol distillery, engineering component manufacturing etc. as the final treatment step prior to reuse in the process. Apart from restricted freshwater availability, the growth of RO in the wastewater treatment sector has also been motivated by regulations that are forcing several industrial units to become “zero-discharge” units.

Positive water balance: the case of PepsiCo India

Source: WBCSD, 2008

Agriculture is the primary consumer of water; thus, some agro- based companies are promoting interventions in this sector to attain overall positive water balance. One example is PepsiCo India that in 2003, initiated efforts to achieve Positive Water Balance by 2009.

Positive Water Balance was defined as:

In-plant water recharge and harvesting + *Water recharged through community programs* + *Savings through agricultural interventions*	≥	Total water used in *manufacturing process*
CREDITS ⇩ *Launch Interventions*	≥	**DEBITS** ⇩ *In-process improvements*

The company "revalued" water as a resource across the organization, leading to efforts to conserve and optimize water usage within the manufacturing process (debit side of the water balance equation). Innovative reuse and recycling initiatives in the manufacturing process that focused on the reduction of water use were also encouraged. Over a 5 year period, the company was able to achieve 60 per cent reduction in water use in manufacturing; savings over a two year period were estimated to be over 2 billion liters of water.

On the credit side of the water balance equation, the company constructed rain and roof water harvesting structures across its network of manufacturing facilities. A variety of community water projects were undertaken and comprehensive watershed management programs in geographically diverse locations initiated in partnership with TERI. PepsiCo has also begun exploring options to improve water efficiency in agricultural practices. In this context, "direct seeding trials" for paddy have been conducted 1,800 hectares; as a result, the water savings are estimated to exceed the quantity of water PepsiCo uses to manufacture its beverages and snacks in the country. This single initiative has the potential to deliver Positive Water Balance for PepsiCo India and thereby conserve this scarce resource.

Wastewater management and Clean Development Mechanism

Source: UNFCC, 2004

The Rajburi Sugar & Ethanol Plant in Thailand shifted from traditional wastewater treatment in open, anaerobic ponds (with uncontrolled release of methane to the atmosphere) to a closed tank digester system with biogas capture and utilization. The ultimate purpose is to reduce greenhouse gas emissions to the atmosphere and contribute to an environmentally and socially sustainable development of sugar and ethanol production at Rajburi. The project activity belongs to category 13: *Waste handling and disposal as listed in the sectoral scopes for accreditation of the operational entities.* According to Gold Standard, the project activity is part of category A.1 Renewable Energy (Electricity, Heat) with the subcategory A.1.1.2 Biogas from wastewater treatment projects. The project activity does not use genetically modified organisms.

A modern wastewater treatment technology will be implemented at Rajburi Ethanol Co., Ltd. to clean the wastewater generated in the production processes. The sugar factory produces approximately 1,000 m^3/day (operation from January – March each year). The ethanol factory produces approximately 2,010 m^3/day when molasses are used as feedstock (January – March), and approximately 860 m^3/day when cassava chips are used as feedstock (May – December). The discharges of these processes are characterized by a high chemical oxygen demand (COD) – in the range of 85 to 150 kg COD/m^3 for the case of the ethanol plant. The project activity involves the avoidance of methane emissions from open lagoons through installation of an anaerobic digester with biogas extraction capacity at an existing organic wastewater treatment plant to treat the majority of the degradable organic content in the wastewater. Hence, there is a process change from open lagoon to accelerated CH_4 generation in a closed tank digester.

The range of expectation of annual additional income generated by selling certified emission reduction (CERs) is 23,473,398 to 42,252,117 Baht annually. These figures are based on CER prices of 5.0 to 9.0 EUR/CER.

3.1.3 Promotion of treated wastewater for non potable uses

The ‘repackaged wastewater good’ is yet to find takers in India. When an investment is made on a product that has no market, there are practically no incentives to develop or improve the system. The National Water Mission (NWM) envisages a framework to optimize water use by increasing water use efficiency by 20 per cent through regulatory mechanisms with differential entitlements and pricing. This focus on the industrial and domestic water pricing could be extended and applied to wastewater as an incentive mechanism for the stakeholders. This would help in improving the existing scenario where most of the wastewater generated receives only primary treatment and flows into water bodies like rivers and streams without being recycled (high cost) adding to the pollution concerns.

In countries like Australia, the urban domestic users are charged for the amount of water consumed and the amount of sewage disposed. They charge an amount of 81 cents and 1.05 AUD per kiloliter of water supplied and sewage water disposed respectively (IWMI, 2008). The IWMI study also projected that in India, only Rs. 6 / KL is paid for water supply and 35 per cent of the water supply charges are charged as sewerage cess and no money is charged for sewage disposal or treatment. The wastewater recycling and reuse is accepted as a non conventional method of augmenting the dwindling water resource and this could only be promoted by way of creating incentive mechanisms for the industries who are already adopting the same. Selling of surplus treated water (after use by the concerned industry) can be promoted through introduction of effective wastewater tariffs.

China through its national environment protection agency (NEPA) initiated a process of devising a tariff structure (National Guidelines for Urban Wastewater Tariffs) for the urban wastewater and the guidelines for the same were prepared by the Asian Development Bank (ADB, 2003; see following boxes). India should initiate measures to adopt similar tariff structures as an incentive to promote the concept.

Action plan

- Per capita cost of provisions of sewerage, wastewater treatment and drainage is higher in bigger towns; thus, small size towns should be given priority to ensure larger population coverage. Also, since centralized sewerage service provision is capital-intensive, especially in rapidly expanding urban regions, appropriate decentralized systems should be encouraged. This will enable the utilization of treated wastewater for non-domestic purposes close to the point of origin.
- Fringe areas of cities and colonies of economically weaker sections and slum dwellers should be covered in the first instance with low cost sanitation facilities, either on individual household basis or community basis with "pay & use system" with adequate maintenance arrangements. Municipal bye-laws may be suitably amended with necessary penal clause and enforced effectively to stop open defecation practice.
- The urban local bodies (ULBs) must ensure that the existing municipal bye-laws are so amended that it will become mandatory for all the residents to connect their toilets to the existing sewerage system, wherever it exists.
- ULBs should be equipped with adequate skilled manpower to implement, operate and maintain the proposed water reuse projects and with adequate financial resources.
- There is huge resource gap even if private sector including capital markets is accessed in full measure. Thus, ULBs should be exhorted to access the capital markets as that would also put pressure on them to perform efficiently. Appropriate training should also be provided to them to raise aware of the opportunities and enhance their capacity in resource generation.
- Incentives should be created for wastewater recycling and reuse. These could be in the form of rebate on water cess, concessions in customs and excise duty on equipment and machinery, tax holiday etc. for agencies dealing with planning, developing and operating such reuse treatment plants as well as users of treated sewage and buyers of untreated / partially treated effluent.
- As a disincentive to using freshwater, tariff rates should be so fixed that industries are compelled to examine technological interventions leading to less use per unit production. This will eventually reduce pollution load generation and consequent cost of treatment. Further, differential rates of pollution cess depending upon the use of water (with the rate

being higher where pollution load is expected to be more) can be used to promote more economical use of water.

- To promote wastewater recycling, it should be made mandatory, *albeit* in phases, that large industries and commercial establishments should meet at least 50 per cent of their known potable water requirements from reclaimed water. Similarly, for irrigating crops including horticulture, watering public lawns / gardens, flushing of sewers, fire fighting, etc., reclaimed water may be utilized. Simultaneously, an awareness campaign needs to be launched in the community, particularly amongst the school children to inculcate the habit of conserving water and prevent its wastage.
- Guidelines, similar to the 2004 US EPA "Guidelines for Water Reuse", should be formulated by Ministry of Environment & Forests suggesting the level of treatment for each reuse category. The corresponding appropriate technologies for different end uses of potable and non-potable use of reclaimed wastewater should also be recommended.
- On the lines of industrial energy audit, comprehensive water audit of industries should be promoted. Also, for water intensive industries, specially the 17 highly polluting sectors in the CPCB "red category", national / international benchmarks for water consumption and water reuse should be fixed and efforts be made to achieve these benchmarks within a specified time frame.
- A comprehensive study on the tariff structure for wastewater may be initiated for assessing the economic and social viability of the concept.

3.1.4 Regulatory measures for water conservation

Water metering

Metering is important to fully account for water production and consumption in reducing unaccounted for water (UFW). Consumption metering is also important for consumers to pay for what they are using, which could help in promoting prudent use of water. Not much has been done on this important aspect in many urban local bodies in the country except a few larger cities which have undertaken some measures by way of installing water meters in the consumer connections. The major reason for slow progress in this regard is that good quality meters are not available on a large scale since the meter manufacturing facility is vested with small scale industries at present, which do not have the wherewithal to produce in a large scale.

Water tariff

Low tariff and low collections lead to vicious cycle in which the consumers are tempted to use water inefficiently and higher usage and system losses drive up costs. Since all the utilities suffer from financial problems, they tend to postpone investments in maintenance, which lowers the quality of service. Consumer confidence and willingness to pay goes down with the deteriorating services, creating a vicious cycle in which the utilities look for government subsidies and grants. It is necessary to operate water supply systems treating water as an economic good and not as a free commodity.

Water pricing systems at present do not cover even the minimum cost of operation and maintenance Most of the Indian cities charge a water tariff that is equivalent to only one-tenth of the operation and maintenance cost (O&M cost), according to a survey by the National Institute of Urban Affairs. Even in the increasing-block tariff structures the charges to consumers in the highest block do not recover the O&M cost (Raghupathi and Foster 2002). This under pricing of water by domestic users lead to cross subsidies wherein industrial users are charged at a much higher rate to compensate for lower domestic tariff. In Mumbai, about 15 per cent industrial users generate 65 per cent of the revenues and in Chennai 40 industries located in the north of the city account for a major share of the revenues generated. In India, drinking water subsidies have been estimated at 0.5 per cent of the gross domestic product (GDP) (Jellinek et al. 2006). Subsidies are introduced and encouraged as a proactive measure to make water affordable and accessible to the poor. However, poor households capture only half as much of the value of the subsidy as they would if the subsidies were distributed randomly across the entire population and many poor households are excluded from subsidy programs altogether because they are not connected to the network (IWMI, 2008).

The responsibility of operation, maintenance and revenue collection in domestic and industrial water sector is generally vested with the elected urban local body (ULB), while the specialized bodies are not able to raise the water tariff without the approval of the provincial Governments. The local bodies generally receive grant assistance ranging from 10 per cent to 60 per cent for capital works on water supply and sanitation from the State Government. Usually, they do not receive any grant assistance for operation and maintenance (O&M) of water supply and sewerage. Municipal bodies in many parts of the country suffer from inadequate resources. Much is to be done on this important aspect. Successful initiatives are presented in boxes.

Water demand management (WDM) in cities: domestic

Source: TERI, 2006

TERI conducted a study on water demand management (WDM) in four cities of Madhya Pradesh viz., Bhopal, Gwalior, Jabalpur and Indore. Aimed at efficiency improvements in management and utilization of water, this study was funded under the Water for Asian Cities (WAC) Programme, which is a collaborative initiative between the UN-HABITAT, the Asian Development Bank (ADB) and Governments of Asia. The scope of the assignment involved conducting a water balancing study, preparing a detailed database on a GIS platform and making recommendations for reducing unaccounted for water so that available water supply is efficiently and effectively distributed. Water balance analysis based on the available information suggested that Non-Revenue Water (NRW) was very high viz., 33-50per cent for Bhopal, 37-44per cent for Jabalpur. Further, the likely error in the calculated values was also rather high since the audit was based on the best information available and involved several assumptions. This current water supply problem could therefore be attributed more to the lack of infrastructure and current management practices rather the lack of water availability.

Thus, specific measures such as identification of district-metering areas (DMA), implementation of domestic consumer metering, conducting water audit, identification of leakages and repair, preparation for GIS database based on extensive survey of pipelines, pressure management, asset management program, awareness campaign and regularising illegal connection were proposed. It was also suggested that there should be phased replacement of tanker-based supply with small piped water networks or implementation of water kiosk in the areas supplied through tankers. On the financial side, instead of a flat rate, a ‘two part’ tariff structure was suggested. Such a tariff design typically includes a consumption/ volumetric rate in addition to the fixed water charge. Lastly, it was proposed that the municipalities should develop an Infrastructure Development Plan and also restructure the water works department clearly demarcating all functions like planning, construction, design, distribution O&M and plant O&M. The municipality should further develop a comprehensive Management Information System (MIS) that covers all aspects of water management and interlink with Geographic Information System (GIS), while also providing an opportunity to undertake performance measurement.

Water management through tariff regulation: a case of Singapore

Source: Cecelia, 2006

In Singapore, the average monthly household consumption has steadily declined during the 1995-2004 period. The consumption in 2004 was 11 per cent less than in 1995. During the same period, the average monthly bill has more than doubled. These figures indicate that the new tariffs had a notable impact on the behavior of the consumers, and have turned out to be an effective instrument for demand management. This is a positive development since the annual water demands in Singapore increased steadily, from 403 million m^3 in 1995 to 454 million m^3 in 2000. The demand management policies introduced have resulted in lowering of this demand, which declined to 440 million m^3 in 2004. In terms of equity, the Government provides specially targeted help for the lower income families. Households living in 1- and 2-room flats receive higher rebates during difficult economic times. For hardship cases, affected households are eligible to receive social financial assistance from the Ministry of Community Development, Youth and Sports.

The current tariff structure used by PUB has several distinct advantages, among which are the following:

- There is no "lifeline" tariff that is used in many countries with the rationale that water for the poor should be subsidized since they cannot afford to pay high tariffs for an essential requirement for human survival. The main disadvantage of such a lifeline tariff is that it also subsidizes water consumers who can afford to pay for the quantity of water they actually consume. The poor who cannot afford to pay for the current water tariffs receive a targeted subsidy. This is a much more efficient policy in socio-economic terms, instead of providing subsidised water to all for the first 20-30 m^3 of water consumed by all households, irrespective of their economic conditions.
- The current domestic tariff of water consumption up to 40 m^3/month/household is identical to the non-domestic tariff. Both are set at S$1.17/$m^3$. In other words, commercial and industrial users do not subsidise domestic users, which is often the case for numerous countries.
- The tariff structure penalises all those households who use more than 40 m^3 of water per

month. They pay the highest rates, S$1.40 m^3, for consumption above this level. This rate is higher than the commercial and the industrial rates, and is a somewhat unusual feature compared to the existing norm.

- Water conservation tax (WCT) is 30 per cent of the tariff for all consumers, except for domestic households who use more than 40 m^3/month. The WCT on consumption of each unit higher than 40 m^3/month goes up by 50 per cent, from 30 per cent to 45 per cent, which must be having perceptible impacts on household behaviour in terms of water conservation and overall demand management.
- Water-borne fee (WBF) is used to offset the cost for treating wastewater and for the maintenance and extension of the public sewerage system. It is set at S$0.30 m^3/s for all domestic consumption. For non-domestic consumption, this fee is doubled, S$0.60/$m^3$, presumably because it is more difficult and expensive to treat non-domestic wastewater.
- A Sanitary Appliance Fee (SAF) is also levied per sanitary fitting per month. It is currently set at S$3.00 per fitting.
- There are two components to water tariff. A major component of the overall revenue collected through water tariffs accrue to the PUB recovering all operation and for considering maintenance costs and new investments. However, revenue from WCT accrues to the government and not to PUB.

Action Plan

- Metering of water supplies should be made mandatory in a gradual manner with a view to conserve precious water as well as to generate revenue on a realistic basis. Bulk revenue meters may be installed at the relevant locations. All bulk meters should be connected to an online logging device to enable data transfer to data management system. Regular calibration of the bulk meters may be undertaken to ensure machine accuracy.
- Good quality water meters must be made available to the water utilities for achieving the aforesaid objective. External funding may be utilized for this purpose. Also, joint ventures of Indian and foreign companies may be encouraged to manufacture requisite quantity of such meters with desired precision. Concessions in excise and customs duty etc. may also be considered to promote such joint ventures.

- Existing capital investment limit of Rs. 5 crore of Ministry of Small Scale Industries (SSI) may be raised to 100 crore or so to attract reputed companies in this field to meet the requirement of good quality, long lasting water meters to meet the surging requirement of water meters in wake of launching of Jawaharlal Nehru National Urban Renewal Mission (JNNURM) / Urban Infrastructure Development Scheme for Small and Medium Towns (UIDSSMT). Ministry of Small Scale Industries (SSI) may be advised to take up this issue on priority.
- Telescopic water tariff/user charges should be set to discourage excessive use. At the same time, efforts should be made to see that the revenue generated through sale of water is adequate, at least**,** to maintain the created systems in the initial years and gradually increased to recover the capital cost with interest thereon, in a phased manner to make the systems financially viable and self supporting.
- Water tariff should be revised according to the city, per capita income, consumption level and availability of water and it should reflect the scarcity value of water. Flat rate system may be abandoned and other relevant volumetric measures viz., IBT, Ferrule based etc may be adopted after evaluation. The cross subsidies in water price should be eliminated for improving the efficiency of the system. The scale and magnitude of the problem should be studied before policy formulation.
- Micro level studies may be initiated to assess the willingness to pay of the consumers based on which tariff may be revised and restructured. This would assess the scope for adopting 'full cost recovery' policies to achieve financial sustainability.
- The consumers who are resorting to rainwater harvesting may be given concession on the water tariff as an incentive. Studies may be initiated to assess the feasibility of the concept.

3.1.5 Waste minimization

Unaccounted for water

It is a known fact that due to poor operation and maintenance of water supply schemes, the assets created by investing millions of rupees is either under utilized or defunct in some cases without accruing anticipated benefits to the community. This has lead to wastage of water that is not accounted for. However, it is equally important that unaccounted for water (UFW) is obtained through accurate measurement of production and consumption with no less than 100 per cent metering of all sources of production and all service connections. Once the levels of UFW at the different areas of the distribution system are determined, the necessary measures can then be taken to reduce losses from all sources to reasonable levels. These include leak detection and control, flushing out illegal connections, meter calibration and replacement, meter protection, training on meter reading to minimize human error, proper supervision during construction, etc. The cost of reducing UFW and the resulting revenue water could be less than the cost of developing new sources for the same amount of recovered losses (ADB, 2007). As such, adequate thrust may be given to the O&M of the assets created for their optimal and efficient use by evolving suitable strategy and creating adequate infrastructure facilities within State Departments/concerned ULBs as the case may be. There is need for systematic approach for reduction of wastage of water through leaks and preventive maintenance should form an integral part of O&M on a regular basis. If such measures are taken by the water supply agencies, then there may not be any immediate need to take up augmentation scheme and it will also help increase revenue to make the system self-sufficient.

Leak detection in water supply, Cornwall, UK

Source: Lallana et al. 2001

In an initiative in Cornwall, United Kingdom during the period 1992–95, the water company South West Water developed a leakage control programme, and enough water was saved to supply the domestic needs of Cornwall. The company started to install valves and measuring equipment in its 471 district meter areas (DMAs). They were split into 20 leakage control types – pubs and farms, for instance – and a survey was undertaken into legitimate night use in each category. It also introduced the so-called 'super-key meters' which measure the water that leaves each water treatment works. The company also developed a mathematical model known as MELT (modeling economic leakage targets). The first step in creating the model was to break down the company into 65 'water into supply' zones. Any water entering or leaving or being produced in a zone was measured. The measuring devices were connected to telemeters to obtain details of instantaneous demand. The model sets leakage targets for each zone.

Leak detection, Nagpur Maharastra

Source: Pangare et al. 2004

Reforms in Nagpur's water supply were long overdue; the quantity of water available was adequate, but huge losses in distribution due to 35000 illegal water connections and 18000 authorized but non metered connections caused acute water shortage. Motivated by the requirement to augment revenues, Nagpur Municipal Corporation (NMC) in October 2001 declared a time-bound programme aimed at regularizing illegal water connections and also applying universal metering policy. For identifying unauthorized and unmetered connections, the licensed plumbers were involved in the programme since they were the ones who generally installed water connections and were probably instrumental in installing the illegal connections to begin with.

The incentive of Rs 50-100 for every illegal connection motivated about 200 plumbers. They were organized into teams and assigned to the seven water zones of the city.

They undertook a door-to-door survey, convincing the illegal connection holders to regularize their connections, getting the connections sanctioned, depositing the requisite charges, fixing meters and reporting those who refused to regularize their connection to respective zonal office. The water connections of those who refused to avail the scheme were immediately disconnected. Like the plumbers, a fixed monthly target of revenue collection from respective zones also motivated the NMC staff working on the team.

With insignificant expenses of about Rs 0.2 million as incentives for plumbers and a minimum amount spent on publicity drive, the programme achieved regularization of about 25,000 (71 per cent) connections within a short period of four months. There was significant and evident increase in revenue generation as the quantity of water billed reached 300 MLD in 2002-2003 from 163 MLD in 1998-99, translating into over three-fold increase in revenue from Rs 148.3 million in 1998-99 to Rs 500 million in 2001-02.

The NMC has also had some luck with private sector participation. It was found that after receiving a very high quotation for one of its water supply and sanitation expansion schemes, the NMC decided to go in for a target oriented and focused tendering process. This brought in a lot of new ideas along with substantial reduction in the costs and time span for project completion. Local consulting organizations suggested some innovative options such as use of pulsator technology for water treatment and also professionalising the whole process.

The leakage detection work was sourced out to a consulting firm and suggestions from them to avoid further leakages was seriously implemented, such as bringing the water through pipelines from the source itself, rather than through open channels. The NMC now also has a contract with a private firm for conducting repairs. Limited but vital Public Service Publisher (PSP) initiatives are able to bring in a new culture of solving problems, and improving efficiency.

Action plan

- A comprehensive water audit of the 423 class I cities may be conducted to establish the baseline. A comprehensive assessment of UFW may be carried out by the local authorities.
- Corrective measures to improve the hourly supply should be taken after taking stock of the existing points of leakage
- The standards should meet the bench mark criteria fixed
- Municipal corporations should adopt a systematic approach towards reduction of leakage; this can be done by incorporating preventive maintenance as an integral part of operation & maintenance on a regular basis
- Proper regulatory and monitoring framework should be ensured
- Illegal connections to the supply channel should be curbed
- Pressure gauges should be installed to monitor pressure at different points

3.2 Supply augmentation

3.2.1 Storage capacity

As per information received from the Ministry of Water Resources, there are about 4050 completed large dams in the country and 475 are under various stages of construction. The live storage capacity of the existing projects is around 225 billion cubic meters (BCM), which is about 12 per cent of the available water resources potential of the river basins of the country. Projects under construction are likely to add another 64 BCM, while 108 BCM will be contributed by the projects under contemplation, as per information furnished by the State Governments. Even with the completion of the contemplated projects, it would, thus, appear that the storage capacity achieved will still remain about 20 per cent of the water resources potential of the country. In the absence of proper storage facilities, the water is being wasted. There is, therefore, an urgent need for creation of more storage capacity in the country. There is a dearth of reliable town-wise data on availability of ground water, surface water, water quality status and requirement of water for drinking and allied use. This would help in analyzing the reliability and availability of source and better formulation of project proposals. The GIS platform would also help state governments and departments to comprehensively plan the reliability and availability of water sources for the towns for next 30 years or so.

3.2.2 Quality of water

Water quality surveillance and monitoring should be given top most priority by the State Govts./ULBs so as to ensure prevention and control of water borne diseases. For this purpose, water quality testing laboratories have to be set up in every city and town backed by scientific personnel to handle such laboratories and where such labs are already existing, adequate care should be taken to strengthen them with equipment, chemicals, manpower etc., if necessary as per demand.

Action Plan

- Water quality monitoring may be ensured at intake, storage and delivery levels
- Mobile labs may be introduced in high priority areas
- Public private participation/community level labs may be developed

3.2.3 Alternative sources of water

The non-conventional methods for utilization of water are artificial recharge of ground water, desalination of brackish/sea water and inter basin transfers.

Artificial recharge of ground water

Artificial recharge is the planned, human activity of augmenting the amount of groundwater available through works designed to increase the natural replenishment or percolation of surface waters into the groundwater aquifers, resulting in a corresponding increase in the amount of groundwater available for abstraction. Although the primary objective of this technology is to preserve or enhance groundwater resources, artificial recharge has been used for many other beneficial purposes. Some of these purposes include conservation or disposal of floodwaters, control of saltwater intrusion, storage of water to reduce pumping and piping costs, temporary regulation of groundwater abstraction, and water quality improvement by removal of suspended solids by filtration through the ground or by dilution by mixing with naturally-occurring groundwaters (Asano, 1985). Artificial recharge also has application in wastewater disposal, waste treatment, secondary oil recovery, prevention of land subsidence, storage of freshwater within saline aquifers, crop development, and streamflow augmentation (Oaksford, 1985).

In India the CGWB ((2002); *Master Plan for Artificial Recharge to Ground Water in India*) has given guidelines for artificial recharge and the area feasible for artificial recharge have been demarcated into four categories as follows in most of the states:

- Areas showing water levels between 3 and 6 mbgl and declining trend of more than 10 cm/year.
- Area showing water levels between 6-9 mbgl and declining less than 10 cm/year.
- Water levels between 6 and 9 mbgl and declining trend of more than 10 cm/year
- Water levels more than 9 mbgl.

The annual replenishable ground water resources in the country are assessed to be of the order of 433 BCM. Keeping 34 BCM for natural discharge, the net annual ground water availability for the entire country is 399 BCM. The annual ground water draft is 231 BCM out of which 213 BCM is for irrigation use and 18 BCM is for domestic and industrial use. Ground water, which is the source for more than 85 percent of India's rural domestic water requirements, 50 percent of its urban water requirements and nearly 55 percent of its irrigation requirements is depleting fast in many areas due to its large scale withdrawal for various sectors. For example, out of a total of 5723 assessment units (Blocks/Mandals/Talukas) in the country, 839 have been categorized as 'Overexploited' as assessed on 31st March 2004, with ground water extraction in excess of the net annual recharge. There are also 226 'Critical' assessment units where the ground water draft is between 90 and 100 percent of the net annual recharge (CGWB, 2006).

Over-exploitation of ground water depletes the water table. It may also increase brackishness and may lead to addition of contaminants like arsenic, fluoride, iron and manganese, etc. which are extremely injurious to health. In order to mitigate this situation, Central Ground Water Board of the Ministry of Water Resources is engaged in the promotion of artificial recharge of ground water by utilizing monsoon runoff on the basis of availability of surplus flows. This initiative needs to be pursued with the seriousness that it deserves, particularly, in the over-exploited and critical water sheds.

Out of total geographical area of 3614156 sq. km of the country, an area of 448760 sq. km has been identified for artificial recharge. The total quantity of surplus monsoon runoff to be recharged works out to 36453 MCM. The total number of artificial recharge structures proposed are 2.25 lakh in rural areas at an estimated cost of Rs. 19874 crores and 37 lakh in urban areas (roof top rainwater harvesting) at estimated cost of Rs. 4586 crores. The master plan envisages the number of artificial recharge and water conservation structures in the country as 39.25 lakh at an estimated cost of Rs. 24500 crores. This plan can be implemented in a phased manner over a time period of 10 years with an annual outlay of Rs. 2400 crores. This would take care of availability of funds for implementation and would enable the implementing agencies to review and modify the schemes based on data generated and experience gained in initial phases.

The major issue in determining the utility of this technology is the economic and institutional aspects of artificial recharge to groundwater. Experiences with full-scale artificial recharge operations in India and elsewhere in Asia are limited. As a consequence, cost information from such operations is incomplete (UNEP, 2000). The available data, from certain hydrological environs in which recharge experiments have been initiated and/or are in progress, suggest that the cost of groundwater recharge can vary substantially (UNEP, 2000). These costs are a function of availability of source water, conveyance facilities, civil constructions, land, and groundwater pumping and monitoring facilities (CGWB, 1994). An overview of the areas identified, extent of recharge feasible from proposed programme, number of artificial recharge structures and cost estimate are illustrated in Annexure III.

Artificial recharge techniques are adopted where (CGWB and UNESCO, 2000)

- Adequate space for surface storage is not available especially in urban areas.
- Water level is deep enough (> 8 m.) and adequate subsurface storage is available.
- Permeable strata is available at shallow / moderate depth.

- Where adequate quantity of surface water is available for recharge to ground water.
- Ground water quality is bad and our aim is to improve it.
- Where there is possibility of intrusion of saline water especially in coastal areas.
- Where the evaporation rate is very high from surface water bodies

Supply source augmentation, Chennai water supply board

Source : CMWSSB, 1998

Chennai has the lowest per capita water availability out of all the metros in the country. In the absence of perennial rivers, the Metro Water had to exploit ground aquifer to complement water from reservoirs. However in recent years, the Chennai Metropolitan Water Supply and Sewerage Board (hereafter referred to as Metro Water), the agency responsible for water supply and sewerage systems in Chennai, is shifting its strategy from extraction-based to conservation-based water supply. The metro faced problem of ground water depletion and seawater intrusion into the aquifers in the last three decades. In 1987, Chennai Metro evolved strategies to overcome this crisis through water harvesting at macro and micro level. At macro level, check dams were constructed along the river basins and floodwaters were injected into ground aquifer though injection wells. Minjur area, north Chennai, was well known for the availability of ground water aquifer in mid 1960's (CMWSSB, 1998). But the aquifer was not been able to reach its expected yield and the extraction only gave way to intrusion of saline water. To overcome this, Metro Water evolved strategies to harvest rainwater on a large scale through check dams along the Araniyar- Korataliyar basin. These check dams have shown significant results in improving the water table in various observation wells set-up by the Metro Water (Nair, 1998).

To further reduce the seawater intrusion caused by over-extraction of ground water, pollution from industries and existence of saltpans, along the same area, large scale recharging wells were constructed between the coast and Minjur. Floodwater was injected in these wells as a recharge to create a barrier to the salt-water intrusion. These measures have shown significant results in the decrease of electrical conductivity values, one of the measures to assess the saline content in the water. (CMWSSB, 1998:45).

Learning from the experience in Minjur area of north Chennai, the Metro Water realized the importance of saving the coastal aquifers and other ground water potential zones in and around the city. The Board introduced an Act to regulate and control extraction, use or transportation of ground water, called "The Chennai Metropolitan Area Ground Water (Regulation) Act 27, 1987." The Act envisages registration of existing wells, regulations for sinking new wells, issuing licenses to extract water for non-domestic use and issue of licenses for transportation through goods vehicle. The Act covers the city and the adjoining 243 villages. The Act has been able to control the private water market, to regulate water extraction and improve the ground water levels in the southern aquifers, in particular, and Chennai city in general (CMWSSB, 1998).

Restoring the existing water harvesting structures

Source: SANDRP, 1999

In recent years the importance of lakes and ponds have gained importance in urban centers. Hyderabad once had about 532 lakes, tanks and *kuntas* around the city (Vyas, 1998). The undulating rocky terrain of Telangana region has made it easy to collect rainwater through these storage structures. These tanks, which played an important role in recharging groundwater and supplying water for the urban people, are being destroyed systematically due to rapid urbanization encroaching the storage structures and channels, and polluting the water. A group of people, comprising of scientists, local people and fishing community have come together under the Save the Lakes of Hyderabad campaign to protect the lakes in the city. Taking Saroornagar Lake (the biggest fresh water lake in the eastern part of the city) as a pilot project, the group aims to raise awareness on the importance of protecting and conserving these ecosystems. Saroornagar Lake is important tank system in the city, as it acts as shock absorber by containing the sudden gush of flooding rainwater during heavy rains and provides a major source of livelihood for the fisherman community. The group has been able to mobilize support from the government officials. The chief minister of Andhra Pradesh has initiated steps to protect and conserve 12 lakes in the city and has also promoted measures for rainwater harvesting to augment water supply in the city. He is expected to constitute a Lake Protection and Information Cell to protect, conserve and develop lakes around the city. Similar efforts are underway to save lakes and tanks from being encroached and from becoming dysfunctional in different urban centers.

In another initiative, Chennai Rotary Club (a voluntary association) has taken efforts to revive the temple tanks in the city. While in Bangalore, the city with 127 tanks, 83 per cent of the water comes from Cauvery Water Supply Scheme. The City spends Rs. 40 million every month on electricity charges to supply this water (CSE, 1997).

Action Plan

- Evaluation of the artificial recharge programme in India to generate baseline information
- Additional location identification and mapping using GIS
- Database generation for simulation exercises to assess the hydrological impacts
- Pre and post evaluation for assessing the change in quantity available
- Cost efficiency parameters for each region needs to be estimated
- Awareness creation through campaigns

Desalination of brackish water/sea water

A desalting device essentially separates saline water into two streams: one with a low concentration of dissolved salts (the fresh water stream) and the other containing the remaining dissolved salts (the concentrate or brine stream). The device requires energy to operate and can use a number of different technologies for the separation. The various desalting processes are listed below:

Major Processes

- Thermal
  - Multi Stage Flash Distillation (MSF)
  - Multiple Effect Distillation (MED)
  - Vapor Compression Distillation (VC)
- Membrane
  - Reverse Osmosis (RO)
  - Electrodialysis (ED)

Minor Processes

- Freezing
- Membrane Distillation
- Solar Humidification

Initially the development activities in the field of desalination was initially based on thermal processes. Later, the programme for development of membrane processes was also included in the 1980s when it showed signs of commercial viability. In India desalination technologies based on multi-stage flash (MSF) evaporation, reverse osmosis (RO) and low temperature evaporation (LTE) are carried out by institutes like Bhabha Atomic Research Centre (BARC), as well as the Central Salt and Marine Chemicals Research Institute (CSMCRI) . In the field of thermal desalination, efforts are directed towards utilizing the low-grade heat and the waste heat as energy input for desalination. In membrane desalination, work is being carried out on newer pre-treatment methods such as the use of ultrafiltration, energy reduction and higher membrane life.

Desalination technology has been extensively developed over the past 40 years to the point where it is reliably used to produce fresh water from saline sources. This has effectively made the use of saline waters for water resource development possible. The costs for desalination can be significant because of its intensive use of energy. However, in many arid areas of the world, the cost to desalinate saline water is less than other alternatives that may exist or be considered for the future.

Desalinated water is used as a main source of municipal supply in many areas of the Caribbean, North Africa and the Middle East. The use of desalination technologies, especially for softening mildly brackish water, is rapidly increasing in various parts of the world including India. In Chennai it is proposed to undertake a project on desalination using reverse osmosis technology. This project is entitled "Setting up of 100 MLD Sea Water Reverse Osmosis Plant Desalination at Nemmeli near Chennai". The estimated cost of the project is Rs.908.28 crore on 4.4.2008. The project envisages two main components i.e. installation of 100 MLD desalination plant at Nemmeli, which is located at 35 km south of Chennai and conveyance of treated water from the plant to city. The estimated costs of these components are Rs.778.09 crore & Rs.130.19 crore respectively.

Action Plan

- Options for making desalination cost effective; these could include combined power generation and desalination, use of low grade heat as well as technological development and upgradation (e.g membrane distillation)
- Further studies should be initiated for assessing the benefits, costs and impacts of desalination projects
- Scope for public private partnership may be explored
- Standards need to be fixed for the desalinated water

3.3 Institutions and policies

3.3.1 Government utilities

Inadequate attention to operation and maintenance of the assets created leads to the deterioration of the useful life of the systems up to 50 per cent to 60 per cent necessitating premature replacement of many components. The key issues that contribute to the poor operation and maintenance are as follows:

- Lack of funds and inadequate revenue generation
- Inadequate data base on O&M
- Multiplicity of agencies and overlapping of responsibilities
- Inadequate training of personnel and lesser attraction for maintenance jobs, investigation and planning
- Lack of performance evaluation and monitoring
- Inadequate emphasis on preventive maintenance

It has been observed that about 30 per cent to 40 per cent of the total O&M cost goes towards establishment and 40 per cent to 50 per cent is incurred on power and the balance is used for consumables, repairs, etc. Thus hardly any funds are left for preventive maintenance of infrastructure. To augment the resources and improve the service levels of consumers, it is important that availability of funds for preventive maintenance of infrastructure may be ensured. In this respect, Public Private Partnerships (PPP) may be encouraged in the functions of operation, maintenance, distribution and billing and collection of revenue from consumers. At the same time, to improve the reliability of water supply and reduce the wastage occurring due to intermittent supply, the options of providing 24/7, water supply, water audit, energy audit and bench marking etc. may be implemented in some selected towns in each State to start with. This would help to spread positive message and build confidence among consumers/utilities.

States need to expedite the transfer of responsibility for O&M of water supply and sanitation schemes including devolving power to ULBs to revise tariff on their own, as per requirements, for sustainability of the schemes. Strategy to effectively equip and ensure the involvement of ULBs in creating and maintaining such infrastructure is the need of the hour and they may be made independent of State Governments for fund requirements.

At present, a lot of thrust has been given to this sector in creating infrastructure through JNNURM / UIDSSMT. However, in most of the States / ULBs because of their poor financial health and lack of trained technical manpower, operation and maintenance of the infrastructure/ assets created is a cause of concern and gradually, they are likely to become defunct/unfit for use, without accruing the desired benefits to community. Preventive maintenance mechanism is absent in most of the ULBs. Thus, the funds invested in creation of infrastructure are likely to fail to fulfill the desired goals. All possible steps may be taken for putting in place suitable mechanism for sustainable O & M so that the infrastructure created under JNNURM / UIDSSMT is maintained effectively and the envisaged benefits accrued during the design life of the project. For this, adequate financial resources are required to be generated through water tax, realistic user charges, connection fees, development charges, cess etc.

Unrealistic tariff structures, poor collection efficiency, lack of finance, poorly directed subsidies, absence of commercial accounting systems have brought down the creditworthiness of the utilities disabling them to access capital markets for funds. Lack of capacity building with community participation and regulatory mechanism and inability of ULBs to run the utilities on commercial lines and absence of public private partnerships have also added to the vicious cycle. In order to ensure universal access to safe drinking water to all the citizens in urban areas, it is necessary to introduce operational, financial and institutional reforms, besides improved resource management, which would lead to water conservation and avoidance of wastage of water.

Action plan

- Work in partnership with States and ULBs to ensure universal access to services by providing incentives for improved utility efficiency and creating an enabling regulatory environment. This is sought to be achieved through the proposed new scheme of "National Urban Renewal Mission (NURM)". The thrust of the scheme is to accelerate the process of development of infrastructure services in 60 select cities with effective linkages between asset creation and asset management, through reforms along with delivery of civic amenities and provision of utilities with emphasis on access to the urban poor.
- Operational efficiency of water utilities is sought to be achieved through some specific mandatory reforms to be undertaken by States/ULBs, which include levy of reasonable and adequate user charges so that operation & maintenance cost of the water utilities is fully recovered within a time frame of five years.
- Mechanisms to strengthen consumer voice have been envisaged through reforms which mandate Public Disclosure Law, Community Participation Law and association of ULBs in city planning function. This should not only increase consumer confidence in the water utilities, but also ensure better compliance in the payment of water tariff and surveillance over the distribution network to prevent any pilferage, theft or wastage.
- Setting up of regulatory mechanisms as envisaged in the reforms should also help in more efficient delivery of services in the sector.
- Adoption of modern accrual based double entry system of accounting should improve fiscal discipline and creditworthiness of the ULBs enabling them to access market capital.
- Setting up of regulatory mechanism, improvement of credit worthiness of ULBs, public disclosure of their accounts, community participation and recovery of adequate water tariff should improve the confidence of the community in the water utilities leading to Public Private Partnership models in the sector.

- Structural reforms and administrative reforms provided in the basket of optional reforms are expected to result in the professional management of water utilities, their capacity building and autonomy in their functioning.
- Targeted subsidy may be made available to SC and ST and other disadvantaged groups living in urban slums on taking house service connections for water supply/sewerage, metering, construction of latrine and subsidized water rates etc. and accordingly adequate funds may be ear-marked for the purpose so as to avoid any possible diversion of funds by the State Governments / ULBs.

3.3.2 Public private partnership

Government may also help investors through viability gap funding so that in the initial stages public private participation (PPP) may be made viable. Also, municipality may be enabled to raise funds through Municipal bonds and other means to improve the financial health of municipalities for better operation and maintenance of systems. Municipalities may be encouraged to avail facilities available under newly approved Pooled Finance Development (PFD) Scheme. An outlay of Rs.600 crore has been made in the current financial year for Viability Gap Funding to support Public Private Partnership (PPP) projects in the urban infrastructure sector. Water supply and sanitation projects with Private Sector participation can access funds under this scheme. Guidelines for utilization of Viability Gap Fund are being finalized by the Ministry of Finance, which also has a provision of Rs.1500 crore in the current financial year for various infrastructure projects. These guidelines will also be made applicable to the Viability Gap Fund provided to the Ministry of Urban Development.

From the past experience, it can be stated that Government funding alone would be too meager to create infrastructure in the towns to the desired level and to maintain the same in tip top condition. Hence, there is an urgent need to explore the possibility to incentivise water supply and sanitation sector so as to attract private sector, financial institutions and other interested parties to create, operate and maintain water supply and sanitation schemes on a sustainable basis. This would happen only when desired reforms are undertaken where private entrepreneurs come forward to invest the money in creation of infrastructure, in operation and maintenance of the system to ensure the desired service level and at the same time they could be assured of satisfactory return on their investments made in the sector. The desired reforms/concessions should be extended to attract private sector participation for water supply, sewerage and solid waste management. Provision for safe drinking water is very vital for the community health. There is an urgent need to change the mindset of people not to treat water supply as free commodity and pay for water consumed by them. This would help in attracting private sector participation to invest fund in creation of infrastructure as well as maintaining the same into tip top condition and to minimize losses to public due to water borne diseases.

Chennai service contracts

Source: GOI, 2007

In Chennai, the operation and maintenance of 14 sewage pumping stations was contracted out in 1992. The success of this contract led to further contracting out of an additional 61 pumping stations, on a mixture of two and three-year contracts. In addition, the operation and maintenance of four water boreholes has been contracted out and it is planned to extend this to a new water treatment plant and a new sewage treatment plant. The contracted-out stations have achieved cost savings of 45-65 per cent, compared to the Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB). This has been achieved without any compulsory redundancies, instead, CMWSSB has re-deployed excess staff to vacancies resulting from retirement elsewhere within the organization.

Contracting out in Rajkot

Source: MoUD, 2006

Rajkot, like many other cities in India, has contracted out a number of municipal services to private firms as well as community groups. The most prominent of these are solid waste management, and maintenance of street lights, public toilets and gardens. Other services include recreation services and afforestation. While this has led to some cost savings, (estimated at 5 percent of the total revenue expenditure on service provision), the major purpose has been rationalization of labor management within the Corporation. This has been done without any effort at retrenchment (which, in any case, would be impossible given the labor laws) but by freezing new recruitment for existing vacancies. Contracting has also helped the Corporation to increase service coverage for essential services and provide extra services (like aviary, aquarium and afforestation) that may not have been possible otherwise. In case of neighborhood gardens, maintenance has been handed over to local residents with positive results. RMC has been careful in controlling the extent of contracting out to ensure the public department has the capacity to provide essential services in the event of service disruption. More studies are necessary to assess the effect of competition on costs and service performance.

Public–private partnership in urban service delivery: performance based service contracts in Navi Mumbai, India

Source: NIUA, 2003

The city of Navi Mumbai is situated to the east of Mumbai. It has a population of 800,000 and is spread over an area of 162 sq km. The City and Industrial Development Corporation (CIDCO) planned the city, with a Central Business District (CBD) and eight nodes (the node is a planning area identified by a specific land use). The city is now governed by the Navi Mumbai Municipal Corporation (NMMC), which was constituted in the year 1991. In 1998 all major infrastructure services were handed over to NMMC by CIDCO. The city consists of 64 political/electoral divisions, managed by eight administrative wards. Three core municipal services—water supply, wastewater services and solid waste management—are currently managed by the private sector on a *labor contract* basis. Each component of the service is divided into contracts and covers:**:**

(a) Water Supply

- Operation, repairs and maintenance of ground and elevated storage reservoirs, and pump houses within the reservoir premises;
- Repairs and maintenance of internal distribution; and
- Meter reading and raising bills to customers.

(b) Wastewater Services

- Operation, repairs and maintenance of sewage pumping stations;
- Operation, repairs and maintenance of sewage treatment plants; and
- Repair and maintenance of sewer lines.

(c) Solid Waste Management

- Street sweeping and drain cleaning;
- Transportation of waste (dumper placers and refuse compactors); and
- Maintenance of dumping grounds.

The aforesaid services are based on 'percentage rate' contracts and renewed on an annual basis.

Visakhapatnam industrial water supply project using public private partnership format

Source: Zérah, 2006

The Government of Andhra Pradesh (GoAP) had mandated Andhra Pradesh Industrial Infrastructure Development Corporation (APIIC) for the development of a water supply project on Build Own Operate and Transfer (BOOT) basis through a Public Private Partnership (PPP) format during 1997. Following this, a Special Purpose Company Visakhapatnam Industrial Water Supply Company Limited (VIWSCo) was set up for the development and implementation of the project on a BOOT basis. Larsen and Toubro Ltd. (L&T) have been inducted as a Strategic Partner in VIWSCo through an international competitive two stage bidding process. L&T along with their strategic investors will be holding majority equity in VIWSCo (51 per cent). L&T will also be responsible to construct, operate, and maintain the project facilities over the concession period of 32 years. The balance 49 per cent equity will be held by the governmental agencies namely APIIC and Visakhapatnam Municipal Corporation (VMC). The major existing consumers extended a loan of Rs 3500 million to the project with the balance being raised by APIIC. While VIWSCo will realize commercial tariff, the GoAP is subsidizing the tariffs in the initial years applicable to existing consumers (Rashtriya Ispat Nigam Limited, National Thermal Power Corporation, Viskhapatnam Municipal Corporation) by providing Rs 2000 million contingent sub-debt support over 7 years to VIWSCo to cover the difference in commercial and subsidized tariffs. VIWSCo will later repay the same to the government after the main lenders have been repaid, resulting in the burden of repayment being shared by new consumers. The project aims to supply about 520 MLD bulk water to develop industrial areas around Visakhapatnam including Visakhapatnam City. This project is a part of the growth plans for Visakhapatnam under VISION 2020 of the GoAP and is expected to catalyze development of major industrial areas like Pharma City, Gangavaram Port and Special Economic Zone, in addition to meeting water demand of existing consumers like Visakhapatnam Steel Plant, NTPC Simhadri Power Plant and VMC and domestic demands of urban agglomerations like Gajuwaka. The water requirement for all these developments will have to be met through this project, as there is no other economically viable source of water in the area. The project is being implemented in two phases. In Phase 1 a 56-km long 2600 mm steel pipeline was laid from River Godavari to pump 5000 million cubic feet (TMC) water to supplement the 5 TMC water allocation from the Yeleru Reservoir. In Phase 2, the conveyance efficiency of the canal will be improved to reduce losses from a present level of 50–60 per cent to minimum 32 per cent to generate more water at the tail end of the canal. VIWSCo has entered into Bulk Water Supply Agreements (BWSA) with consumers for the supply of water on a take or pay basis. This is the first mega project in the water sector that has been commissioned on a BOOT basis through a PPP format and can prove to be a model for other such initiatives.

Action plan

- Suitable public private partnerships may be explored by roping in private developers. At the same time, excise and customs duty concessions, income tax concessions, tax holidays etc. may also be considered by the Govt. of India for import of equipment and machinery needed for the development of such systems, so as to encourage private agencies to develop such systems and operate and maintain them effectively.
- Appropriate rebate in taxes on capital invested in this sector may also be considered for
- Assured return on investment made by private entrepreneurs may be very useful to start with
- Sewerage system is highly cost intensive with long design period without any direct approach to charge from beneficiaries for the service provided. Various options may be explored to make this sector viable for private sector participation. Sewage treatment plants (STPs), are highly power intensive and should be provided electricity at subsidized rates as those available for agriculture, so as to help the sector become financially viable.

3.3.3 Community participation

Groundwater recharge in Rajkot

Source: SANDRP, 1999

In arid Saurashtra region of Gujarat, the water situation is made difficult by destruction of forests, local water systems, by over use of groundwater and consequent salinity ingress along the long coast line. In this region, a people's movement to recharging existing wells by diverting local streams to the wells via a filtration pit has lead to remarkable change in water availability situation. Over 300,000 of the total 700,000 wells have already been recharged. Hundreds of local tanks have been renovated or dug up. In the urban areas, the movement has lead to groundwater recharging through hand pump tube well. In Rajkot city alone, in 1995, more than 4 000 hand pumps were recharged by this method. Roof or terrace water is diverted into a small tank from which it is allowed to flow in the casing pipe of hand pump. (Parthasarthi, et al., 1997)

Community participation in slums

Source: SANDRP, 1999

New modes of service delivery are observed in slums where enterprising inhabitants dig tube wells, install power motors and set up a small network to supply water to a few lanes. Such arrangements can serve an average of 200 households whose up front cost is limited to the plumbing work. However, once the connection is given, the households pay a hefty monthly contribution that is six to seven times the cost of municipal water. Nevertheless, supply is provided and there is a reliable service as the 'owner' of the network is a close neighbor. The investments made can be recouped in two years' time. Consequently, some of these entrepreneurs take loans in order to build these networks or to expand them.

Sustainable water resource use

TERI has developed sustainability indicators for different cities as part of developing good practices in water use for sustainable cities research programme (TERI, 2008)

Based on the literature review of good practices and measures adopted to make water and wastewater sector in urban areas more sustainable, the following definition for a sustainable water resource management in an Indian city was arrived at: "**Providing people with equitable access to water while ensuring socio-environmental and economic sustainability of the resources**".

The overall vision is to come up with a sustainability framework for urban water sector, with a source to sink approach, integrating technological, socio-economic and environmental considerations. Based on the above definition, a research framework/agenda for assessing sustainability in the urban water and wastewater sector in the selected cities was created. The research framework primarily translated the above definition of sustainability of water resources into a set of parameters important for a city to consider to ensure sustainable management of water resources in a city. The study concluded that the parameters undertaken for this study are yet to be properly addressed in each city. Although some efforts have been made by these cities to address few of the issues within the chosen parameters, but to be able to address the various issues related to water and wastewater management, an integrated and multidimensional approach is crucial.

These parameters, which formed the basis of questions to be posed to various stakeholders in a city are given below in Table 18.

Table 18 Sustainability indicators for water and wastewater

Parameter	**Sector**	
	Water	**Wastewater**
Resource Management	*Supply side management* ▪ Availability ▪ Demand-Supply gap ▪ Accessibility ▪ Quality ▪ Unaccounted for Water ▪ Infrastructure ▪ R & D *Demand side management* ▪ Conservation practices	▪ Coverage ▪ Infrastructure ▪ Reuse
Economics of water	▪ Pricing Mechanisms ▪ Accounting Reforms	Pricing Mechanisms
Institutional Mechanisms	▪ Policy & Regulations ▪ Service delivery ▪ Public – private participation	▪ Regulation & compliance ▪ Public Private participation

3.3.4 Labeling and grading of water fixtures

Labeling of water efficient fixtures enables consumers to make informed choices on the water efficiency of a product while purchasing. It also helps to raise public awareness on water conservation and encourages more water efficient products on the market. Several countries have well-established schemes to label water efficient fixtures and services (see box).

Labeling of water efficient fixtures in different countries

Sources: USEPA, 2007, Australian Government. 2007, Singapore Government, 2008

- WaterSense (a partnership program by USEPA with various companies) wherein the company's products bearing the WaterSense label meet EPAs specifications for water efficiency and performance. The products are tested and certified by independent, third-party licensed certifying bodies following protocols specific to each product category. WaterSense labeled products are typically ~20 per cent more water efficient as compared to corresponding conventional products. As an example, Annexure IV presents the detailed specifications for a water efficient toilet.
- Water Efficiency Labeling and Standards (WELS) Scheme of the Australian Government is responsible for the WELS water efficiency star ratings on products.Testing procedures are specified by the Australian Standard - *AS/NZS 6400-2005 Water efficient products - Rating and labeling* (the WELS Standard), and are conducted by certified laboratories.
- New Zealand has water efficiency labeling regulations modeled on the Australian WELS scheme. However, unlike the Australian scheme that requires all products to be registered before they are labeled and sold, no government mandated registration scheme exists in New Zealand. Also, no minimum performance requirements would be imposed, in contrast to the Australian scheme where toilets and urinals not meeting minimum performance are either disallowed or strongly discouraged from sale.
- In the United Kingdom, the Bathroom Manufacturers Association (BMA) promotes Water Efficient Product Labeling. BMA is a lead trade association for manufacturers of bathroom products in the country. The scheme raises awareness of bathroom products that save water and therefore energy. Details of this labeling scheme are presented in Annexure V.
- Singapore has the Water Efficiency Labeling Scheme (WELS), which is a voluntary scheme introduced by the national water agency (PUB) in 2006. The scheme covers taps, showerheads, dual flush low capacity flushing cisterns, urinals and urinal flush valves, and clothes washing machines. The scheme will become mandatory in July 2009 for water fixtures. Testing and certification is done by a conformity assessment body (product certification body/testing laboratory) accredited by the Singapore Accreditation Council (SAC) or its Mutual Recognition Arrangement (MRA) partners.

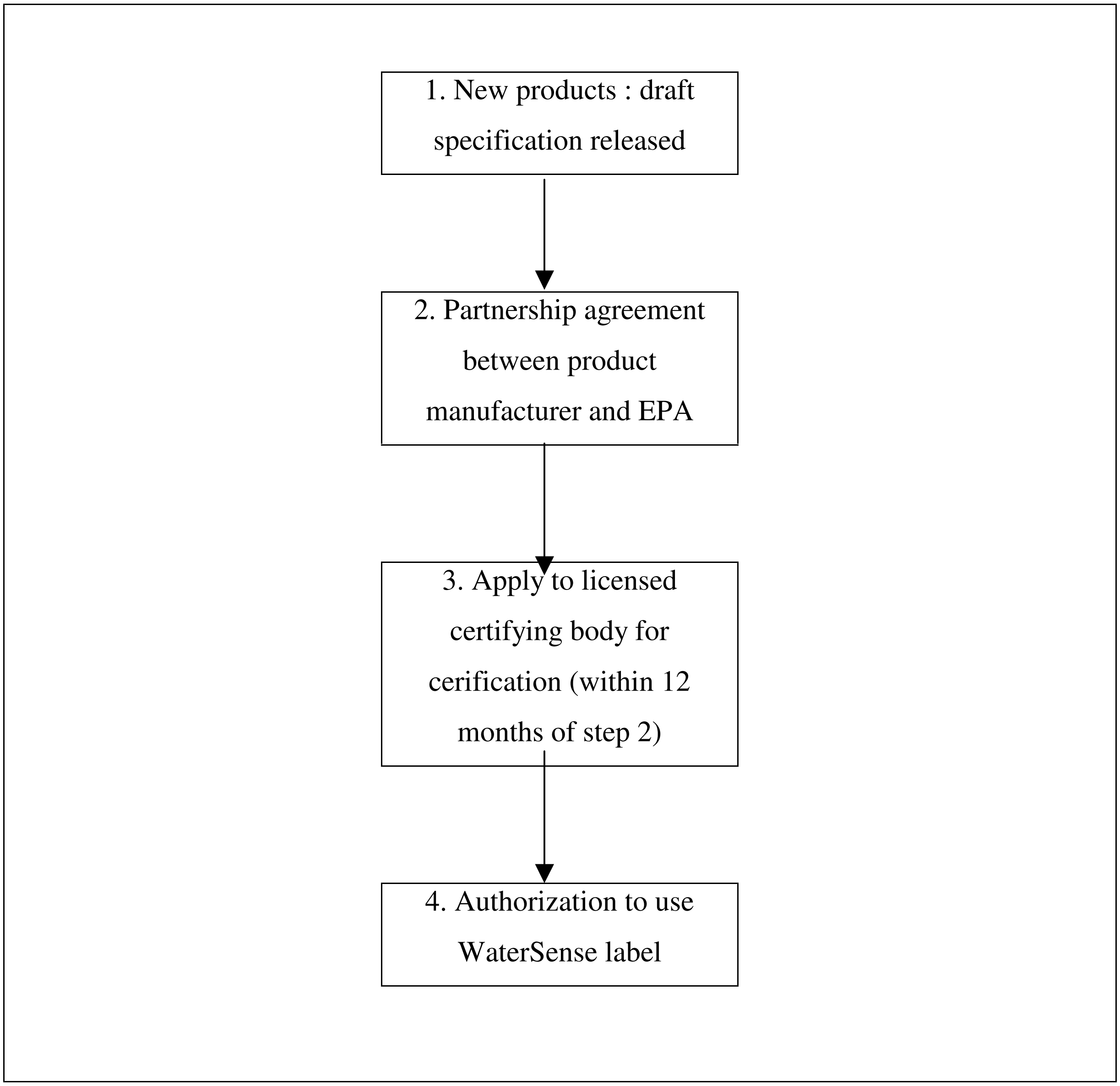
WaterSense label in USA

Source: USEPA, 2007

The WaterSense label is used to identify water efficient products in the USA. Certification includes product testing and may also include factory visits, periodic retests, or other approaches to monitor ongoing conformance. The certified products bear a characteristic wasteSense label; also, the EPA maintains a master list of certified WaterSense products on the WaterSense web site.

Licensed certifying bodies, approved by the USEPA, conduct the certification. The certifying body should be accredited by ANSI (in accordance with ISO/IEC Guide 65, General requirements for bodies operating product certification systems), should have related products included in its scope of accreditation and should possess the necessary technical expertise. The certifying bodies sign a licensing agreement with EPA and also include their names with the WaterSense label. This, in turn, assists in tracking the use of the label in the marketplace.

EPA encourages participation from all stakeholders in developing the product specification and certification processes. There is a provision to register with EPA (on their website) and thereby provide inputs when various programmatic elements are developed and released for public contributions. Also, where data is insufficient for developing product specifications, EPA works towards filling the gaps through research sponsored by interested parties.



Action plan

- Evolve a scheme for labeling water efficient products (on the lines of the energy efficiency certification provided by Bureau of Energy Efficiency, Ministry).
- Minimum standards for water use can be set for commercial buildings (on the lines of The Energy Conservation Building Code (ECBC) which sets minimum energy performance standards for commercial buildings). In this context, use of water efficient fixtures can be made mandatory; to begin with it can be incorporated in all new

construction and remodeling involving replacement of plumbing fixtures in government buildings / commercial complexes

- The impacts of savings through using water efficient products should be adequately highlighted, so that the general public becomes conscious about adopting these products.
- In the presence of proper water tariffs, water savings can be directly linked with cost savings and thus could be an incentive to adopt water efficient fixtures.
- Provide incentives to save water using labeled products.
- Enact laws which would make it mandatory for the consumers to adopt it and also ensure strict monitoring for quality parameters
- A study may be initiated for rapid assessment of the market potential of the product and also possibility of public private partnership.
- Funds may be ring fenced for developing the concept and assisting potential stakeholders/players.

4 Priority measures for climate change adaptation

Climate change is expected to have a significant impact on the water sector, which, in turn, will have far-fetching consequences on related sectors such as agriculture, industry, domestic water use etc. India is already facing high variation in rainfall, decreased water availability in perennial rivers, decreased annual per capita renewable freshwater and low per capita water storage availability. This has led to a huge gap in the demand and supply due to the exponential population growth, rapid industrialization and resource use conflict between sectors. Since water is being extracted at a faster rate than the rate at which it is being replenished, there is need for alternative management strategies that reduces the pressure on this resource. In this context, it is essential that necessary steps be taken to conserve and manage the water resources through various adaptation measures. Thus as per the National Water Mission, it is therefore important to "*increase the efficiency of water use, explore options to augment water supply in critical areas, and ensure more effective management of water resources*".

This report covers the following aspects.

(a) Identification of the key issues in domestic and industrial water management in the realm of climate change

(b) Presentation of adaptation measures in terms of water management and conservation, with illustrative cases and

(c) Formulation of action plan under each identified key issue.

This chapter synthesizes the action plans listed in Chapter 3 and presents a Policy vision, Action and Implementation Structure for adaptation to climate change. **It is suggested that a separate budgetary allocation be made to address the issues highlighted in this report**, so as to improve the institutional efficacy in coping with climate change. <u>Research & development activities to address the key issues may be given priority and separate funds be earmarked.</u> **Although adequate financial support is required, in view of the scale and magnitude of the task, we suggest a modest budget of Rs 100 crores to initiate the**

programme that is to be distributed among various adaptation strategies. This amount may be suitably enhanced and re-distributed across priorities in the future.

Management options	**Proposed budget (Rupees in crores)**
Supply augmentation	35
Wastage minimization	25
Ensure water quality	10
Regulatory measures	10
Institutional reforms	10
Sustainable water use promotion	10
Total	**100**

The detailed action plan is presented in the following section along with the responsible key ministries. These ministries, in turn, may identify sub-agencies / other organizations (NGOs, institutions etc.) and assign tasks and responsibilities appropriately. The timeline for the action plan is defined as (a) Short-medium term : 11th plan period (2007-2012) and (b) Long term : 12th plan period (2012-2017).

Climate change adaptation action plan for domestic and industrial water management

Management options	Action	Timeline	Implementation agency
Source augmentation	**Rain water harvesting (RWH)** Awareness generation among all the stakeholders on regular monitoring and maintenance of RWH structures including the existing water conservation measures, code for buildings, building bye laws vis-à-vis water conservation (refer Annexure VI for guidelines)	Short-medium term	MoUD, MoWR
	Promotion of rooftop RWH activities; assessing the feasibility and viability of rooftop water harvesting systems in *existing* buildings (commercial/residential).	Short-medium term	MoUD, MoWR
	Evolve monitoring mechanism for rooftop harvesting systems	Short-medium term	MoUD, MoWR
	Identify incentives for adopting and sustaining rooftop RWH systems (e.g. property tax rebate, refer Annexure VII for options)	Short-medium term	MoWR
	Capacity building of stakeholders viz., community (area sabhas, self-help groups etc.) and training of Block Development Officers (BDOs), Village Level Workers for conservation of water / augmentation of water supply	Short-medium term	MoUD, MoWR, MoRD, MoA
	PPP may be encouraged on a larger scale (e.g. Corporate Social Responsibility initiatives to conserve water) and also NGOs encouraged to participate	Short-medium term	Corporate

Promote restoration of traditional water structures	Long term	MoWR
Artificial recharge	Long term	MoWR
Pre and post evaluation of *existing* artificial recharge initiatives to assess effect on groundwater table on a watershed level		
Create provision for additional artificial recharge and explore scope for new technologies (e.g. aquifer storage and recovery)	Long term	MoWR
Desalination (Sea/brackish water)	Short-medium term	MoEF, MoUD, MoWR
Promote desalination plants in water scarce areas		
Wastewater recycle/reuse	Short-medium term	MoWR
Implementation of benchmarks for the use of reclaimed waste water as a supply augmentation measure		
Incentives (tax rebates, excise exemptions etc.) for industries and commercial establishments meeting at least 50 per cent of their water requirements from reclaimed sources	Short-medium term	MoI, MoUD
Create a *knowledge bank* (a) linking level of treatment and water quality for each reuse category (b) recommending best practice corresponding to appropriate technologies for different end uses of potable and non-potable use of reclaimed wastewater (c) on socio-economic and environmental impacts of using reclaimed water	Short-medium term	MoI, MoWR

Raise awareness on potential of wastewater reclamation and reuse at village, state, national levels (through educational institutes, offices, residential areas etc; media coverage)	Short-medium term	MoUD, MoRD
Empower user groups to undertake small scale low cost treatment of sewage through one time finance for pilot systems	Short-medium term	MoUD, ULB
Promotion of decentralized sewage treatment systems	Long term	MoUD
Amend municipal bye-laws so that it is mandatory for all residents to connect their toilets to the existing sewerage system, wherever it exists	Short-medium term	MoUD
Develop a tariff structure for reclaimed wastewater after assessing the economic and social viability of the concept (Annexure VIII)	Short-medium term	MoWR
Storage capacity	Long term	MoWR
Upgrade existing storage facilities to increase capacity and efficiency (e.g. desilting of dams) and assess scope for additional cost effective storage (e.g. using GIS and remote sensing)		
Creation of additional storage capacity (barrages, mini dams, check dams etc.) for domestic (rural & urban) and industrial consumption	Long term	MoWR
Undertake adequate monitoring of ground water table and mapping of recharge zones in 423 class I cities for ecosystem conservation	Short-medium term	MoWR, MoUD, MoEF

Waste minimization	**Unaccounted for Water (UFW)** Promotion of efficient use of water through comprehensive water audit of water utilities and industries; promote methods like *pinch analysis* to predict potential water savings with reuse as well as with reuse and regeneration	Short-medium term	MoI
	Benchmarking of water consumption and water reuse in industries ; this should be done on a priority for water intensive industries, specially the 17 highly polluting sectors in the CPCB "red category"	Short-medium term	MoI
	Build sustainable capacity for ULBs to conduct comprehensive assessment of UFW in 423 cities and towns; in particular, train ULBs in leak localizing (identifying and prioritizing areas of leakage) and leak location (pinpointing of leaks)	Short-medium term	MoUD
	Explore possibility of demarcating District Meter Areas (DMA) in 423 cities for leakage monitoring (Annexure IX)	Long term	MoUD
	Instrumentation Install bulk revenue meters at relevant locations in city water supply. All bulk meters should be connected to an online logging device to enable data transfer to data management system (Annexure IX).	Long term	MoUD
	Promote development and production of *good quality* water meters through PPP	Long term	MoUD
	Upgrade facilities in ULBs (e.g. pressure gauges, appropriate flow measuring	Short-medium	MoUD

	instrumentation) and the infrastructure for their upkeep and calibration	term	
	Water neutral and water positive industry concept Provide suitable incentives (tax breaks, duty exemption etc.) for industries going water positive/neutral	Short-medium term	MoI
	Create awareness of water neutral and positive industry concept by establishing demonstration systems	Short-medium term	MoI
Ensure water quality	Upgrade and build additional capacity of ULBs to undertake water quality monitoring at intake, storage and delivery levels for trace contaminants (including mobile labs)	Short-medium term	MoUD, MoWR
Regulatory measures	Revise water tariff based on cost recovery principle, considering the following aspects: • Differential tariff based on willingness to pay • Higher incremental tariff • Tariff reduction based on scale of adoption of water harvesting • Tariff based on scarcity value/opportunity cost • Revise and restructure tariff as a measure to encourage industries to use less water per unit production ("industrial water productivity" concept)	Short-medium term	MoUD, MoWR
	Provide rebate on water cess, concessions in customs and excise duty on equipment and machinery, tax holiday etc. for agencies dealing with planning,	Long term	MoI

	developing and operating such reuse treatment plants as well as users of treated sewage and buyers of untreated / partially treated effluent.		
	Fix differential rates of pollution cess depending upon the quantum of water used	Long term	MoUD
Institutional reforms	Develop a mechanism for sustained operation and maintenance through generation of funds by viable tariff restructuring	Short-medium term	MoUD. MoWR, MoRD, MoI
	Capacity upgradation of institutions targeted at (a) coping with climate change and its effect on water resources (b) aspects such as people centric approach, compliance, proper external and internal auditing mechanisms, regular performance evaluation and monitoring, preventive maintenance etc.	Short-medium term	MoUD. MoWR, MoRD, MoI
	Develop benchmark for bringing down high staff-population ratio and replacing with more skilled technicians	Long term	MoUD
	Promote E-governance (Government to Government (G2G), Government to Business (G2B), Government to Employee (G2E) and Government to Citizen (G2C) services).	Short-medium term	MoUD. MoWR, MoRD, MoI
	Define specific tasks and responsibilities thereby eliminating multiplicity of agencies with overlapping of responsibilities	Long term	MoUD. MoWR, MoRD, MoI
Sustainable water use promotion	**Water foot prints** Promote best practices in water use; develop a ‘package of practice’ for India on efficient and sustainable water use under different conditions	Short-medium term	MoUD. MoWR, MoRD, MoI

Initiate studies on scope of adopting water efficient fixtures (grading and labeling) in India	Short-medium term	MoEF, MoUD. MoWR, MoI
Promote water efficient fixtures in buildings through campaigns, trainings and eventually make this mandatory	Long term	MoUD. MoWR
Encourage PPP in labeling and marketing of water efficient products	Short-medium term	MoUD. MoWR, MoEF
Clean development mechanism (CDM) Explore the options of programmatic CDM in industrial and domestic wastewater as against project approach. This will include various CDM Program Activities (CPA) in the implementation period.	Short-medium term	MoUD. MoWR
Explore potential of energy efficient water use systems	Short-medium term	MoUD. MoWR
Explore bilateral joint ventures for funding for CDM projects	Short-medium term	MoUD. MoWR

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Annexure I
Market Profile: Water Tariff Survey
The 2005 GWI Water Tariff Survey
(http://www.neoperl.ch/net/english/service/water_conservation/water_tariffs_worldwide.pdf)

Water and wastewater tariffs for 150 significant cities around the world

The full listing of the 2005 GWI Water Tariff Survey is below. Commentary on the survey can be found on p9. The survey includes 150 cities with a population of over 700 million. The first column gives the water tariff. The benchmark for this is the volumetric price of water including sales tax for a domestic consumer using 15m3 per month supplied through a 5/8 inch pipe with any fixed charges added to the volumetric rate on a pro-rata basis.

Most water utilities have progressive tariff structures with lower rates for customers who use less water, and penal rates for those who use more water. The wastewater tariff is calculated on the same basis. In some cases, water and wastewater are not charged for separately or are difficult to separate.

For these cities only the combined charge has been recorded. There are also some cities for which it has been difficult to obtain wastewater data, and it has therefore been omitted. The listing is in order of the highest to lowest water tariff. The final column shows the average expenditure on water per head as a percentage of GDP per head. It is calculated by taking the benchmark tariff and multiplying it by the average domestic consumption per head for the relevant country from Aquastat (*see www.fao.org/ag/agl/aglw/aquastat/main/*)to get a figure for the average expenditure on water per head per year,then to divide this by the GDP per head.

City	Country	Domestic drinking water tariff in US$ per m³	Domestic wastewater tariff in US$ per m³	Total domestic tariff in US$ per m³	Average annual expenditure on water as % of GDP per head
Curacao**	Netherland Antilles	6.11	–	6.11	–
Cayman Islands	Cayman Islands	4.89	5.00	9.89	–
US Virgin Islands**	US Virgin Islands	4.86	–	4.86	–
Tokyo	Japan	2.86	0.20	3.06	1.10%
Copenhagen	Denmark	2.84	2.39	5.22	0.48%
Zurich*	Switzerland	2.59	–	2.59	0.46%
Berlin	Germany	2.56	2.56	5.11	0.53%
Lyon	France	2.23	1.0	3.23	0.73%
Brussels	Belgium	2.20	0.37	2.57	0.26%
Nagoya	Japan	2.19	0.66	2.85	0.84%
Manchester	UK	2.00	2.05	4.05	0.20%
Birmingham	UK	1.96	1.25	3.21	0.20%
Amsterdam	Netherlands	1.85	1.63	3.48	0.95%
London	UK	1.80	1.05	2.86	0.18%
Luxembourg	Luxembourg	1.75	1.11	2.86	0.14%
San Diego	US	1.74	2.00	3.74	0.97%
Palma-de-Mallorca	Spain	1.72	1.28	3.00	0.79%
Rotterdam	Netherlands	1.65	1.63	3.28	0.85%
Marseille	France	1.61	1.50	3.11	0.53%
Munich	Germany	1.60	1.93	3.53	0.33%
Paris	France	1.53	1.37	2.90	0.50%
Vienna	Austria	1.59	2.88	4.47	0.41%
Glasgow	UK	1.45	1.63	3.07	0.15%
Oslo	Norway	1.42	1.74	3.16	0.29%
Chicago	US	1.36	0.76	2.12	0.75%
Seattle	US	1.35	2.32	3.67	0.75%
Los Angeles	US	1.29	0.94	2.23	0.72%

Helsinki	Finland	1.27	1.91	3.19	0.24%
Barcelona	Spain	1.24	0.74	1.98	0.57%
Montreal*	Canada	1.23	–	1.23	1.23%
Rome	Italy	1.23	0.00	1.23	0.59%
Doha*	Qatar	1.20	–	1.20	0.00%
Brisbane	Australia	1.13	1.50	2.62	0.67%
Sydney	Australia	1.08	2.31	3.39	0.65%
Ramallah	Palestine	1.04	0.27	1.31	0.00%
Boston	US	1.03	0.18	1.21	0.57%
Casablanca *	Morocco	1.03	–	1.03	2.36%
Belo Horizonte	Brazil	1.03	1.03	2.05	2.18%
Istanbul*	Turkey	1.00	–	1.00	0.00%
Philadelphia	US	0.97	1.57	2.54	0.54%
Prague	Czech Republic	0.96	0.84	1.80	0.94%
Tallinn	Estonia	0.92	0.75	1.67	0.76%
Phoenix	US	0.91	0.72	1.63	0.51%
San Francisco	US	0.91	2.25	3.16	0.51%
New York City	US	0.90	0.90	1.80	0.50%
Jerusalem	Israel	0.89	0.52	1.41	0.50%
Tel Aviv	Israel	0.89	0.52	1.41	0.50%
Denver	US	0.88	1.30	2.18	0.49%
Madrid	Spain	0.88	0.53	1.41	0.40%
Melbourne	Australia	0.87	1.33	2.20	0.52%
Cairo*	Egypt	0.87	–	0.87	7.24%
Washington DC	US	0.77	1.39	2.16	0.43%
Budapest	Hungary	0.77	0.95	1.72	0.53%
Vilnius	Lithuania	0.72	1.46	2.17	0.68%
Warsaw	Poland	0.66	0.66	1.32	0.58%
Lisbon	Portugal	0.64	0.57	1.21	0.45%
Detroit	US	0.63	1.17	1.80	0.35%
Cape Town	South Africa	0.61	0.72	1.33	0.75%
Fortaleza	Brazil	0.60	0.60	1.20	1.27%
Jakarta*	Indonesia	0.60	–	0.60	1.76%
Gothenburg	Sweden	0.59	0.67	1.25	0.19%
Zagreb	Croatia	0.55	0.63	1.18	0.00%
Milan	Italy	0.55	0.51	1.06	0.27%
Hong Kong	China	0.53	0.15	0.68	1.46%
Brasilia	Brazil	0.52	0.52	1.05	1.11%
Bamako*	Mali	0.51	–	0.51	8.94%
Santiago de Chile	Chile	0.50	0.44	0.94	0.77%
Río de Janeiro	Brazil	0.50	0.50	1.01	1.07%
Stockholm	Sweden	0.49	0.65	1.14	0.16%
Riga	Latvia	0.45	0.29	0.74	0.52%
Kathmandu	Nepal	0.44	0.22	0.65	2.36%
Montevideo	Uruguay	0.42	0.34	0.75	0.21%
Seoul	South Korea	0.40	0.11	0.51	0.99%
Bucharest	Romania	0.39	0.20	0.59	1.10%
Bratislava	Slovakia	0.37	0.24	0.61	0.20%
Lagos	Nigeria	0.37	1.27	1.64	0.96%
Lima*	Peru	0.36	–	0.36	0.90%
Sofia	Bulgaria	0.35	0.19	0.54	0.42%
Beijing	China	0.35	0.11	0.46	0.95%
Gaberone	Botswana	0.35	0.37	0.72	0.20%
Venice	Italy	0.34	0.56	0.90	0.16%
Kinshasa*	Congo	0.33	–	0.33	18.03%
Athens	Greece	0.32	0.49	0.81	0.19%
San José	Costa Rica	0.32	0.32	0.64	1.36%
Belgrade	Serbia	0.32	0.08	0.40	0.94%
Buenos Aires	Argentina	0.30	0.21	0.51	0.98%
Taipei	Taiwan	0.30	0.12	0.42	0.00%
Johannesburg*	South Africa	0.29	–	0.29	0.36%
Tianjin	China	0.28	0.07	0.36	0.78%
Quito*	Ecuador	0.27	–	0.27	1.95%

Guayaquil	Ecuador	0.27	0.21	0.48	1.94%
Asunción	Paraguay	0.26	0.13	0.40	0.42%
São Paulo	Brazil	0.26	0.26	0.51	0.54%
Chonqing	China	0.25	0.07	0.33	0.70%
Beirut	Lebanon	0.25	–	0.25	0.00%
Nairobi	Kenya	0.24	0.26	0.50	0.81%
Saratov	Russia	0.23	0.10	0.33	0.57%
Manila	Philippines	0.22	0.11	0.33	1.44%
Addis Ababa*	Ethiopia	0.22	–	0.22	5.31%
Moscow	Russia	0.22	0.19	0.41	0.54%
Yekaterinbourg	Russia	0.22	0.10	0.32	0.54%
Karachi	Pakistan	0.22	0.07	0.29	0.87%
Algers*	Algeria	0.21	–	0.21	0.36%
Ulan Bator	Outer Mongolia	0.21	0.12	0.34	1.39%
Caracas*	Venezuela	0.21	–	0.21	0.76%
Rabat*	Morocco	0.21	–	0.21	0.48%
St Petersburg	Russia	0.21	0.21	0.42	0.52%
Chisinau*	Moldova	0.21	–	0.21	1.74%
Bogota	Colombia	0.21	0.11	0.32	1.15%
Yerevan	Armenia	0.20	0.08	0.28	4.90%
Kharkiv	Ukraine	0.19	0.05	0.25	1.26%
Volgograd	Russia	0.19	0.02	0.21	0.47%
Rostov-on-Don	Russia	0.18	1.03	1.21	0.44%
Hanoi*	Vietnam	0.16	–	0.16	2.12%
Salvador	Brazil	0.15	0.44	0.59	0.32%
Antananarivo*	Madagascar	0.15	–	0.15	27.84%
Krasnoyarsk	Russia	0.14	0.13	0.28	0.36%
Hangzhou	China	0.14	0.07	0.22	0.39%
Amman	Jordan	0.14	0.04	0.18	0.00%
Mumbai	India	0.13	0.19	0.32	1.03%
Odessa	Ukraine	0.13	0.10	0.23	0.86%
Shanghai	China	0.13	0.11	0.24	0.35%
Novosibirsk	Russia	0.12	0.08	0.20	0.30%
Manila Water Company	Philippines	0.12	0.06	0.18	0.77%
Guangzhou	China	0.11	0.09	0.20	0.31%
Ufa	Russia	0.11	0.05	0.16	0.27%
Ho Chi Minh City*	Vietnam	0.11	–	0.11	1.44%
Kiev	Ukraine	0.10	0.06	0.16	0.68%
Astana	Kazkhstan	0.10	–	0.10	0.17%
Córdoba	Argentina	0.10	0.10	0.19	0.32%
Tbilisi	Georgia	0.09	0.05	0.14	1.16%
Almaty	Kazakhstan	0.09	0.07	0.16	0.14%
Santa Fe	Argentina	0.08	0.08	0.16	0.27%
Baku	Azerbaijan	0.08	1.05	1.13	0.78%
Manama*	Bahrain	0.07	–	0.07	0.00%
Kolkata*	India	0.07	–	0.07	0.55%
Damascus	Syria	0.07	0.01	0.08	0.20%
Minsk	Ukraine	0.06	0.05	0.11	0.40%
Tehran*	Iran	0.05	–	0.05	0.16%
Tegucigalpa	Honduras	0.05	0.01	0.06	0.05%
Omsk	Russia	0.03	0.03	0.06	0.07%
Riyadh*	Saudi	Arabia	0.03	–	0.03
0.04%					
Colombo*	Sri Lanka	0.02	–	0.02	0.03%
Tashkent	Uzbekistan	0.02	0.01	0.04	0.59%
New Delhi	India	0.02	0.01	0.03	0.16%
Havana*	Cuba	0.01	–	0.01	–
Baghdad*	Iraq	0.01	–	0.01	0.17%
Dublin	Ireland	–	–	–	0.00%
Ashgabat	Turkmenistan	–	–	–	0.00%

(*= water and wastewater tariff combined, **= water only)

Annexure II

BIS (ISI) standards for discharge of sewage and industrial effluent in surface water sources and public sewers

Sl.No.	Characteristic of the effluent	Tolerance limit for sewage effluent discharged into surface water sources s per IS 4764-1973	Tolerance limit for industrial effluents discharged into	
			Inland surface waters as per IS 2490-1974	Public sewers as per IS 3306-1974
1.	BOD	20 mg/l	30 mg.l	500 ** mg/l
2.	COD	-	250 mg/l	-
3.	PH value	-	5.5 to 9.0	5.5 to 9.0
4.	Total suspended solids 30 mg/l (TSS)	100 mg/l	600 mg/l	
5.	Temperature	-	40 Deg.C	45 Deg.C
6	Oil and grease	-	10 mg/l	100 mg/l
7.	Phenolic compounds (as Phenol)	-	1 mg/l	5 mg/l
8.	Cyanides (as CN)	-	0.2 mg/l	2 mg/l
9.	Sulphides (as S)	0	2 mg/l	-
10.	Fluorides (as F)	-	2 mg/l	-
11.	Total residual chlorine	-	1 mg/l	-
12.	Insecticides	-	Zero	-
13.	Arsenic (as As)	-	0.2 mg/l	-
14.	Cadmium (as Cd)	-	2 mg/l	-
15.	(as Cr)	-	0.1 mg/l	2 mg/l
16.	Copper	-	3 mg/l	3 mg/l
17.	Lead	-	0.1 mg/l	1 mg/l
18.	Mercury	-	0.01 mg/l	-
19.	Nickel	-	3 mg/l	2 mg/l
20.	Selenium	-	0.05 mg/l	-
21.	Zinc	-	5 mg/l	15 mg/l
22.	Chlorides (as Cl)	-	-	600 mg/l
23.	% sodium	-	-	60%
24.	Ammoniacal nitrogen (as N)	-	50 mg/l	50 mg/l
25.	Radioactive materials	-		
	(i) α-emitters		10^{-7} $_{\mu}$C/ml	-
	(ii)β-emitters		10^{-6} $_{\mu}$C/ml	

*includes rivers, estuaries, streams, lakes and reservoirs

**Subject to relaxation or tightening by the local authorities

CPCB notification for the standard issued under Environment (Protection) Act 1986 by MOEF through notification dated Feb 12, 1993 setting target dates for installation of ETP's.

Annexure III

State wise Feasibility and Cost Estimates of Artificial Recharge Structures as Envisaged in the Master Plan

Source: http://cgwb.gov.in/documents/MASTER%20PLAN%20Final-2002.pdf

Sl.no	Name of State	Area identified for Artificial Recharge (sq. km.)	Quantity of Surface Water to be Recharged in MCM	Type and Number of Artificial Recharge Structures	Total Cost of Plan (Rs. in crores)		
					Rural	Urban	Total
1	2	3	4	5	6	7	8
1	Andhra Pradesh	65333	1095	3800 Percolation Tanks 11167 Check Dams Rain Water Harvesting in Urban Area.	1229	468	1697
2	Bihar & Jharkhand	4082	1120	2695 Percolation Tanks 9483 Nala Bunds 1303 Contour Bunds 1630 Recharge Shafts	644	330	974
3	Chhattisgarh	11706	258	648 Percolation Tank 2151 Nala Bunds / Cement Plug / Check dam 2582 Gravity Head / Recharge shafts 7740 Gully plugs, Gabion structures	223	51	274
4	Delhi	693	444	23 Percolation tanks 23 Existing dug wells 10 Nala Bunds 19216 Lateral trench with recharge wells 2496 Roof top rain water harvesting	232	25	257
5	Goa	3701	529	1410 check dam / KT weirs 10,000 Roof top rain water structure	63	10	73
6	Gujarat	64264	1408	4942 Percolation Tanks with Recharge Tubewell 13210 Check Dams Rainwater Harvesting (4.5 lakh houses)	1155	450	1605
7	Haryana	16120	685	15928 Recharge Shafts and Recharge Trenches Roof Top Rain Water Harvesting (1.7 lakh houses)	159	173	332

8	Himachal Pradesh	--	149	1000 Sub surface dykes 500 Check dams 300 Revival of Ponds 500 Revival of spring 2000 Roof top harvesting structures	458	7.5	465.5
9	Jammu & Kashmir	--	161	500 Nala bund / check dam 336 Revival of Kandi Ponds Roof top harvesting (1.5 lakh houses	234	12.5	246.5
10	Karnataka	36710	2065	1040 Sub Surface Dams 5160 Percolation Tanks/ Desilting of old Tanks 17182 Check Dams 8.3 lakh roof top rain water harvesting with Filter Bed.	1233	499	1732
11	Kerala	4650	1078	4312 check dam 7181 sub surface dykes 10780 gully plugs 10780 nalah Bunds Rooftop rainwater harvesting (0.7 lakh houses) Runoff water harvesting (1200 structures)	1221	57	1278
12	Madhya Pradesh	36335	2320	5302 Percolation Tanks 20198 Nala Bunds/ Cement Plug/ Check Dams 23181 Gravity Head/ Dug wells/ Tubewells/ Recharge Shafts 69598 Gully Plugs, Gabian Structures.	1909	244	2153
13	Maharashtra	65267	2318	8108 Percolation Tanks 16598 Cement Plugs 2300 Recharge Shafts, Urban schemes of Roof Top Rain Water Harvesting (8.78 lakh houses) 3500 Run off Harvesting	2000	562	2562

North Eastern States							
14	Arunachal Pradesh ---	--		500 Check dams 1000 Weirs 1000 Gabian Structures 480 Roof top harvesting 300 Development of Spring	87	7	94
15	Assam	--	--	250 Check dams 500 Weirs 1000 Gabian Structures 600 Roof top harvesting 250 Development of Spring	49.5	9	58.5
16	Manipur	--	--	300 Check dams 500 Weirs 500 Gabian Structures 300 Roof top harvesting 150 Development of Spring	48.5	4.5	53
17	Meghalaya	--	--	300 Check dams 600 Weirs 600 Gabian Structures 300 Roof top harvesting 200 Development of Spring	53.5	4.5	58
18	Mizoram	--	--	500 Check dams 1000 Weirs 1000 Gabian Structures 300 Roof top harvesting 200 Development of Spring	82. 0	4.5	86.5
19	Nagaland	--	--	500 Check dams 1000 Weirs 1000 Gabian Structures 300 Roof top harvesting 200 Development of Spring	82.0	4.5	86.5

20	Tripura	--	--	300 Check dams 500 Weirs 1000 Gabian Structures 240 Roof top harvesting 100 Development of Spring	47	3.5	5.05
21	Orissa	8095	406	569 Percolation Tanks 761 Converted Percolation Tanks 698 Sub Surface Dykes 809 Nala Contour Bunds 679 Check Dam weir 1981 Water spreading/flooding 668 Induced recharge 334 Recharge shafts Roof top harvesting (1 lakh)	414	100	514
22	Punjab	22750	1200	40030 Recharge shafts and Recharge Trenches 12800 Roof Top Harvesting structures in Urban Areas	400	128	528
23	Rajasthan	39120	861	3228 Percolation Tanks 1291 Anicuts 2871 Recharge shafts Rooftop Rainwater Harvesting structure (4 lakh houses)	740	400	1140
24	Sikkim	--	44	2100 Spring Development 2500 Cement Plugs/ Nala Bunds 5300 Gabian Structures 69596 Roof Water Harvesting	103	70	173
25	Tamil Nadu	17292	3597	8612 Percolation Ponds 18170 Check Dams 5 lakh rain water harvesting structure	2086	300	2386
26	Uttar Pradesh & Uttaranchal	45180	14022	4410 Percolation Tanks 12600 Cement Plugs (Check Dams) 2,12,700 Recharge Shafts. Roof top rain water harvesting structures (10 lakh)	3561	600	4161

27	West Bengal	7500	2664	11200 Percolation Tanks with shaft 3606 Gabian structure 1054 Nala Bund/ Cement Plug 1680 Re-excavation of tanks 500 Desiltation of village pond 1000 Spring Development 70 Sub Surface Dykes. 1500 Roof Top Harvesting for Calcutta & Darjeeling	1333	7.5	1340.5
28	Andaman& Nicobar Islands	--	3	145 Spring Development 270 Cement Plugs 38 Percolation Tanks 150 Sub surface dykes 2600 Roof Top Harvesting	23	13	36
29	Chandigarh	33	26	597 Recharge shafts, recharge trenches, check dams and Gabian structures.	0.6	5.4	6
30	Dadra & Nagar Haveli			50 check dams / cement plugs 58 Sub surface dykes 1000 houses rain water harvesting	2	1	3
31	Daman & Diu			100 Nala bund/check dams 2000 roof top rain water harvesting structures		15	15
32	Lakshadweep			1000 roof top rain water harvesting structures		10	10
33	Pondicherry	--	--	5 Percolation Tanks 14 Recharge pit 20 Check Dams 40 Desilting of ponds 10 Nala bund 20 Desilting/Recharge wells. Rainwater harvesting 10,000 houses	2.2	10	12.2

GRAND TOTAL (Rs. in crores) **19874.3** **4586.4** **24460.7**

Say Rs. 24500 Crores

Annexure IV
Specifications for a Water Efficient Toilet

I. Introduction

The WaterSense Program released its performance specification for tank-type high-efficiency toilets (HETs) (Specification) on January 24, 2007, to promote and enhance the market for water-efficient toilets. The goal of this Specification is to differentiate products in the marketplace that meet this Specification's criteria for efficiency and performance and help consumers identify these water-efficient products.

This Specification addresses toilets typically found in homes, and in light commercial settings, such as hotels and restaurants. It does not address valve-type commercial toilets typically found in public restrooms (e.g., airports, theaters, arenas, schools) or composting toilets, both of which have different designs, patterns of use, and performance requirements.

II. Current Status of Toilets

WaterSense estimates there are currently 222 million residential toilets in the United States. This estimate is based on an assumed one-to-one ratio of toilets to bathrooms.[1] In addition to the existing stock, approximately 10 million new toilets are sold each year for installation in new homes or replacement of aging fixtures in existing homes.[2]

Residential toilets account for approximately 30 percent of indoor residential water use in the United States—equivalent to more than 2.1 trillion gallons of water consumed each year.[3]

The Energy Policy Act of 1992 established the maximum flush volume for all gravity tank-type, flushometer tank, and electromechanical hydraulic toilets at 1.6 gallons per flush (gpf). These requirements are codified in the Code of Federal Regulations at 10 CFR Part 430 (specifically §430.32(q) Water Closets). Federal regulations also require that all toilets sold in the United States be tested and certified in accordance with the test requirements specified in American Society of Mechanical Engineers (ASME) A112.19.2–Vitreous China Plumbing Fixtures and Hydraulic Requirements for Water Closets and Urinals. All dual-flush toilets sold in the United States also must comply with ASME A112.19.14–Six-Liter Water Closets Equipped with a Dual Flushing Device.

In addition, there are several voluntary, non-certification toilet testing programs. These tests are frequently required by water utilities for toilets to qualify for rebates under local water conservation toilet replacement programs. Two of the most popular and widely used voluntary testing programs in North America are the Maximum Performance (MaP) Testing of Popular Toilet Models and the Los Angeles Department of Water and Power Requirements for Ultra-Low-Flush-Toilets, Supplementary Purchase Specification to ASME A112.19.2 (LADWP SPS).

MaP is entirely performance based, testing a toilet's maximum ability to remove waste starting with a 50 gram soybean paste sample and increasing at 50 gram intervals. A minimum passing score is 250 grams. The LADWP SPS requires the use of durable, chemical-resistant flush valve

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[1] U.S. Census Bureau, American Housing Surveys for the United States, 1970-2003.

[2] Plumbing Fixtures market Overview: Water Savings Potential for Residential and Commercial Toilet and Urinals. D&R International. September 30, 2005.

[3] Mayer, Peter W. and William B. DeOreo. Residential End Uses of Water. Aquacraft, Inc. Water Engineering and Management. American Water Works Association. 1998.

seals, and restricts maximum flush volumes under maximum trim adjustment and pressure conditions.

One problem with the number of different voluntary toilet testing programs in existence was the lack of uniformity or consistent requirements. Manufacturers found it difficult and costly to develop products that met the requirements of multiple testing programs, and water authorities were unsatisfied with the limited availability of qualified products. Consumers found the patchwork of toilet specifications, requirements, and “approved toilet lists” confusing at best. To remedy this situation, in 2004, members of the plumbing industry and water utilities combined the MaP Testing and LADWP SPS standards to create the Uniform North American Requirements (UNAR) for Toilet Fixtures: Guidelines and Specifications. UNAR is a voluntary system for qualifying toilet fixtures that achieve sustainable water savings and ensure a high level of customer satisfaction with flushing performance.

In developing this Specification, WaterSense adopted the framework of the UNAR standard while making several significant changes to the water-efficiency and performance criteria. WaterSense estimates that there are currently 68 toilet models on the market that meet the requirements of this specification and would be qualified to apply for and use the WaterSense label.

III. WaterSense Tank-Type High-Efficiency Toilet Specification

Scope

The WaterSense Program developed this Specification to address criteria for improvement and recognition of water-efficient and high-performance tank-type toilets. These toilets are commonly found in residential and light commercial settings and include the standard gravity type found in most homes, pressure assisted, and electrohydraulic assisted toilets. The majority of these fixtures are single flush toilets, toilets with one constant flush volume, though an increasing number of dual flush models are coming to market. Dual flush toilets have two flush volumes—a full flush for solids and a reduced flush for liquids only. WaterSense initially focused on residential toilets because they are the largest water consuming fixture in homes.

Commercial valve-type (a.k.a., flushometer valve) toilets were excluded from this specification because of their differing design, patterns of use, and performance expectations. Commercial valve-type toilets are tankless, relying on water pressure controlled by flushing valves to remove waste rather than gravity. Because of the fundamental difference in design, a different set of technical requirements is needed. Commercial valve-type toilets also have a different pattern of use than residential or light commercial tank-type toilets and will likely require different performance specifications. For example, the test media needing to be cleared by a commercial valve-type toilet may need to include a paper toilet seat cover and potentially more paper. If WaterSense decides to address this type of toilet, it will do so under a separate specification at a later time.

Water Efficiency Criteria
The water-efficiency component of the Specification establishes a maximum effective flush volume of 1.28 gpf for all HETs. This value represents a 20 percent reduction from the current 1.6 gpf standard and is consistent with WaterSense's stated goal of increasing product efficiency by at least 20 percent. Under this Specification, there are two ways by which an HET can meet the effective flush volume criteria:

- Single flush toilet must use 1.28 gpf or less; or
- Dual flush toilets must have a full flush no more than 1.6 gpf and a reduced flush no more than 1.1 gpf. Field studies indicate that in actual use such toilets will flush 1.28 gpf or less, on average.

Performance Criteria
In light of the history of poor performance and user dissatisfaction with several of the early 1.6 gpf ultra-low flush (ULF) toilets in the early 1990's, WaterSense wanted to ensure that WaterSense labeled HETs consistently perform at a high level and meet or exceed user expectations. The Flush Performance Criteria (Section 4.0) of the Specification ensures this level of performance and is based on the UNAR standard, with two key differences. First, the WaterSense specification increased the mass of the soy bean paste test media from 250 grams to 350 grams. WaterSense decided to make the Specification more rigorous in order to establish a higher level of performance for HETs and ensure customer satisfaction with these products.

Second, WaterSense also decided to switch from cased media, as used in UNAR, to an uncased media. Several manufacturers reported variability in test results when using cased media and expressed concern over the sample reliability. In addition, the primary justification for using cased media—reusability to save time and reduce costs—while important requirements in a research and development mode when many repeated tests are performed, were not as critical in regards to this HET specification, as a maximum of only five tests are required. The uncased media provides a more realistic sample and has a more established testing track record. For these reasons, WaterSense adopted the use of uncased media.

Potential Water Savings
The 222 million residential toilets in use today are a mix of the current standard 1.6 gpf fixtures and older, pre-1992 models. Water consumption in these older models range from 3.5 gpf to more than 5.0 gpf, depending on age and model. Table 1 provides a breakdown of the mix of the existing toilet stock.

To estimate the potential water savings impact of HETs, WaterSense assumed that the average person flushes 5.1 times per day at home.[4] With an estimated population of 296 million people in the United States and 222 million residential toilets in use, this equates to 6.8 flushes/toilet/day (see Calculation 1). Assuming that 10 percent of the existing 222 million toilets in the United States could reasonably be expected to be replaced with WaterSense labeled HETs, the total daily savings potential is approximately 246 million gallons per day (see Table 1 and Calculation 2). This equates to more than 89.7 billion gallons each year (see Calculation 3).

[4] Peter W. Mayer and William B, DeOreo. Residential End Uses of Water. Aquacraft, Inc. Water Engineering and Management. American Water Works Association. 1998. p. 94.

Calculation 1.Average Daily Flushes per Toilet

(5.1 flushes/person/day)(2.96 x 10^8 people) / (2.22 x 10^8 toilets) = 6.8 flushes/toilet/day

Table 1. Number of Toilets by Flush Volume and Potential Savings[5]

GPF	# of toilets (millions)	# of toilets replaced given 10% replacement of existing fixtures (millions)	Savings per flush by switching to 1.28 HET (gpf)
5.0	67	6.7	3.72
3.5	33	3.3	2.22
1.6	122	12.2	0.32
Total	222	22.2	—

Calculation 2.Total Daily Savings
(If 10% of all existing toilets replaced with 1.28 gpf HET)

5.0 gpf: (6.7 x 10^6 toilets) (3.72 gpf) (6.8 flushes/toilet/day) = 169,483,200 gallons/day

3.5 gpf: (3.3 x 10^6 toilets) (2.22 gpf) (6.8 flushes/toilet/day) = 49,816,800 gallons/day

1.6 gpf: (12.2 x 10^6 toilets) (0.32 gpf) (6.8 flushes/toilet/day) = 26,547,200 gallons/day

Total Daily Savings = 245,847,200 gallons/day

Calculation 3.Total Annual Savings

(245,847,200 gallons/day) (365 days/year) = 89,734,228,000 gallons/year
89.7 billion gallons/year

[5] Plumbing Fixtures market Overview: Water Savings Potential for Residential and Commercial Toilet and Urinals. D&R International. September 30, 2005

Annexure V

Water Efficient Product Labeling; Bathroom Manufacturers Association (BMA)

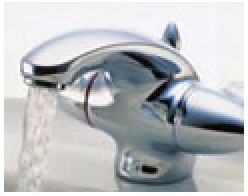
Source: http://www.bathroom-association.org/faq-watersaving.asp

Types	**Benefits**
Basin tap, single pillar construction.	Inexpensive, simple to install, 1/2” inlets
Bath taps, single pillar construction.	As above but with 3/4” inlets, for increased flow for bath usage.
Monobloc.	Compact design combines hot and cold supply into one tap unit.
Basin mixer - hot and cold mix in the body.	Good waterflow, accurate temperature and supply control.
Dual flow basin tap, divided waterways.	Prevents unequal pressure causing operating difficulty. Usually used to keep mains fed cold water separated from the tank fed hot water.
Bath/shower combined mixer with shower head.	Combined taps and shower attachment. Cost effective option for additional shower facility over a bath.
Pop up waste integral to the tap body .	Eliminates the need for a separate chain and plug, neat, safe and simple to use.
Finishes Electroplated, metal coating.	Tough, durable, chrome or gold finishes.
Enamelled - a painted finish.	Durable finish, available in numerous co-ordinating colours.
PVD - colour bonded directly to the tap substrate.	Colour bonded to the tap gives very hard wearing finish in numerous colour options.

Cleaning: Clean your tap using only a soft cloth and warm soapy water. Rinse and wipe dry using a dry clean soft cloth. DO NOT use abrasive compounds, pads, cloths or creams as these will damage the surfaces.

(1)

Pillar tap (1)
Simple design, single outlet tap for either hot or cold, either 1/2” inlet for washbasins or 3/4” inlet for baths.


(2)

Mixer taps (2)
Single body tap where the hot and cold water is mixed together before it leaves the.

Dual flow taps
The hot and cold water is kept separate within a single body tap and leaves alongside each other from the tap's outlet. Used where there is unequal pressure between hot and cold supplies.


(3)

Bath/shower mixer (3)
Bath tap set which also has a diverter mechanism to direct the flow to a shower head - usually hand held be often attached to a wall fitting.

Monobloc taps (4)
Mixer or dual flow tap which is mounted in a single tap hole on a washbasin or bath.


(5)

Two hole taps (5)
As above but requiring two separate tap holes for the supply inlets.


(6)

Three hole taps (6)
The hot and cold control valves and the outlet nozzle are each mounted separately on the washbasin or bath.

Four hole taps
As previously but has a separate diverter mechanism which diverts the flow to a hand held shower unit.


(7)

Pop up waste(7)
The waste plug is connected via a linkage, usually rigid metal rods, to the taps body so that opening can be effected without the need for an unsightly chain.

Water Efficient Use

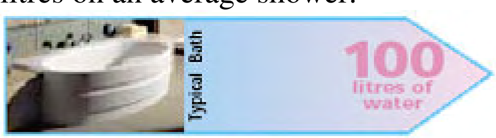
Members of the Bathroom Manufacturers Association have responded to Government's initiatives to encourage everyone to use less water.
Bathroom product ranges include water efficient WC's, taps, showers and baths. WC's are one of the largest users of water in the home.
It is estimated that there are currently 45million WC's in domestic premises that use 270 million litres of fresh water every day. Over 7 million WC's flush on 13 litres of water.
Install a new WC that uses less than 6 litres per flush and not only save water but help the environment.

Chart showing how the flush capacity of WC's has reduced since the 1950's


Today's 6/4 litre dual flush WC can give an average flush of 4.5 litres - half of the volume used in the 1960's

Make sure any new WC conforms with the Regulators' Specification for WC suites delivering a single flush of 6 litres maximum or a dual-flush of 6 litres maximum and a reduced flush of no greater than 2/3 of the maximum flush. Don't be afraid to ask the question. Members of the Bathroom Manufacturers Association produce WC's that conform to the specification.

Many of us enjoy a relaxing soak in the bath, especially after a stressful day.
But taking a refreshing shower uses about 1/3rd of the water of a bath.
So take a shower more often and save the bath for those relaxing moments. But be warned, Power Showers can use in excess of 20 litres of water a minute compared to 5 litres on an average shower.



Plumbing systems – If you are having a new bathroom, or major plumbing alteration, ask your plumber what he can do to avoid you having to wait for the hot water to reach the tap. The cold water that runs to waste is a huge amount – probably more than is actually used! The Bathroom Manufacturers Association is continuing to work with Government, the Water Industry and others to encourage everyone, to use water wisely.

Ways to be water efficient:

Spray taps
Use spray taps on basins that are mainly used for hand washing in cloakrooms – saving at least 30% of water used.
Baths
Consider the size before you buy, a smaller bath will use less water.
Meters
Think about having a water meter installed. It will help you to be more conscious about sing water- help the environment and you could be saving yourself £££££'s.
Planning
Careful siting of hot water storage and boilers will help reduce this expensive waste.

Top Water Efficiency Tips
- use plugs in washbasins rather than leave the tap running
- turn the tap off whilst brushing teeth
- wrap hygiene products in tissue and put them in the bin rather than flushing them down the WC.
- keep water in the refrigerator for drinking
- collect rain water for garden use

Maintenance
Fix leaking/dripping taps – saving 5 % of water used.

Annexure VI

Building Water conservation Code: UK
CODE FOR SUSTAINABLE HOMES: A STEP CHANGE IN SUSTAINABLE HOME BUILDING PRACTICE

http://www.planningportal.gov.uk/uploads/code_for_sustainable_homes_techguide.pdf
http://www.planningportal.gov.uk/england/professionals/en/1115316369681.html
http://www.communities.gov.uk/documents/planningandbuilding/pdf/153029.pdf

On the 27 February 2008 the Government confirmed a mandatory rating against the Code will be implemented for new homes from 1 May 2008. The Code measures the sustainability of a new home against categories of sustainable design, rating the 'whole home' as a complete package. The Code uses a 1 to 6 star rating system to communicate the overall sustainability performance of a new home. The Code sets minimum standards for energy and water use at each level and, within England, replaces the EcoHomes scheme, developed by the Building Research Establishment (BRE). The Code also gives new homebuyers better information about the environmental impact of their new home and its potential running costs, and offer builders a tool with which to differentiate themselves in sustainability terms.

Since April 2007 the developer of any new home in England can choose to be assessed against the Code.

Category 2: Water

Issue ID	Description	No. of credits available	Mandatory Elements
Wat 1	Indoor water use	5	Yes

Aim

To reduce the consumption of potable water in the home from all sources, including borehole well water, through the use of water efficient fittings, appliances and water recycling systems.

Assessment Criteria

Up to 5 credits are available for performance which reduces the amount of potable water used in the dwelling. There are minimum mandatory performance requirements for achieving all levels of the Code. The minimum mandatory requirements begin at level 1 increasing at level 3 and again at level 5. Credits are available for all the indoor potable water performance levels required in the Code. They are awarded according to the predicted average water consumption calculated using the Code Water Calculator (see *Calculation Procedures*). The table below gives the details.

Criteria		
Water consumption (litres/person/day)	**Credits**	**Mandatory Levels**
≤120 l/p/day	1	Levels 1 and 2
≤110 l/p/day	2	
≤105 l/p/day	3	Levels 3 and 4
≤90 l/p/day	4	
≤80 l/p/day	5	Levels 5 and 6
Default Cases None		

CODES

Category 2 – Water		
Issue	**Measurement Criteria**	**Points Awarded**
Internal potable water consumption	Where predicted water consumption (calculated using the Code water calculator) accords with the following levels:	One of the following point scores
	≤120 l/p/d	1.5
	≤110 l/p/d	3
	≤105 l/p/d	4.5
	≤90 l/p/d	6
	≤80 l/p/d	7.5
External potable water consumption	For providing a system to collect rain water for use in external irrigation/watering e.g. water butts	1.5

Mandating Water Efficiency in New Buildings - A Consultation (UK)

http://www.communities.gov.uk/publications/planningandbuilding/mandatingwaterefficiency

4. Options

The Government has already announced that there will be mandatory minimum standards for water efficiency in **new homes** to underpin the standards laid down in the Code for Sustainable Homes. This regulatory impact assessment explores options for delivering that commitment and the costs and benefits of enshrining minimum standards in law. In considering possible approaches the costs, benefits and risks of doing nothing has been used as a baseline.

Two approaches have been considered for comparison with a do nothing option:

- Whole building performance (option A)
- Key fittings performance (option B)
- Do nothing (option C)

For each of the new options target water demand reductions of: 120, 125, 130 and 135 litres per person per day (l/p/d) have been assessed. The table below shows the water savings, against current demand,[4] achieved by these targets.

Target	120	125	130	135
Saving (l/p/d)	34	29	24	19
Saving (%)	22.1	18.8	15.6	12.3
Savings (ML/yr)	6205.00	5292.50	4380.00	3467.50

Option D Whole Building Performance Standard

A whole building performance standard of 20 litres per FTE per day would apply, subject to certain conditions.

Option E Component Based Approach

A component based approach, mirroring Option B above, but with the addition of standards for male urinals and other fittings not in domestic use

Annexure VII
Incentives on rainwater harvesting in Indian states/ cities – examples

Source: http://www.unhabitat.org/downloads/docs/4179_35990_Policy%20Paper-2.pdf

New Delhi	Since June 2001, the Ministry of Urban Affairs and Poverty Alleviation has made rainwater harvesting mandatory in all new buildings with a roof area of more than 100 sq m and in all plots with an area of more than 1000 sq m that are being developed. The Central Ground Water Authority (CGWA) has made rainwater harvesting mandatory in all institutions and residential colonies in notified areas. This is also applicable to all the buildings in notified areas that have tube wells. The deadline for this was March 31, 2002. The CGWA has also banned drilling of tube wells in notified areas.
Indore	Rainwater harvesting has been made mandatory in all new buildings with an area of 250 sq m or more. A rebate of 6 per cent on property tax has been offered as an incentive for implementing rainwater-harvesting systems
Kanpur	Rainwater harvesting has been made mandatory in all new buildings with an area of 1000 sq m or more.
Hyderabad	Rainwater harvesting has been made mandatory in all new buildings with an area of 300 sq m or more.
Chennai	Rainwater harvesting has been made mandatory in three storied buildings (irrespective of the size of the rooftop area). All new water and sewer connections are provided only after the iinstalation of rainwater harvesting systems.
Haryana	Haryana Urban Development Authority (HUDA) has made rainwater harvesting mandatory in all new buildings irrespective of roof area. In the notified areas in Gurgaon town and the adjoining industrial areas, all the institutions and residential colonies have been asked to adopt water harvesting by the CGWA. This has also been made applicable to all the buildings in notified areas having a tube well, and March 31, 2002 was was fixed as the deadline for compliance. The CGWA has also banned drilling of tube wells in notified areas.
Rajasthan	The state government has made rainwater harvesting mandatory for all public establishments and all properties on plots covering more than 500 sq m in urban areas.
Mumbai	The state government has made rainwater-harvesting mandatory for all buildings that are being constructed on plots that are more than 1,000 sq m in size. The deadline set for implementation was October 2002.

Tax rebates on rain water harvesting measures prevailing in Municipal Corporations

Municipal Corporation Gwalior

By order dated 27th January 2006 rain water harvesting has been made mandatory for buildings having an area more than 250 sq m. The engineer in charge of the area has been authorized to impose a penalty of Rs. 7000 in case of non-compliance. A rebate of 6 % in property tax in the year in which the construction of rain water harvesting facility has been completed will be provided for the owner of the building as an incentive.

Municipal Corporation Bhopal

The Corporation has not taken any action to date.

Municipal Corporation Indore

Rainwater harvesting has been made mandatory in all new buildings with an area of 250 sq m or more from 2001-02. A rebate of 6 per cent on property tax has been offered as an incentive for implementing rainwater-harvesting systems in the building

Municipal Corporation Jabalpur

Rainwater harvesting has been made mandatory in all new buildings with an area of 250 sq m or more from 1 April 2005. A rebate of 6 per cent on property tax has been offered as an incentive for implementing rainwater-harvesting systems in the building.

Annexure VIII

Guidelines for wastewater tariff (Source: ADB, 2003)

National Guidelines for Urban Wastewater Tariffs

Guidelines for Urban Wastewater Tariffs are based on the PRC Water Pollution Prevention and Control Law, PRC Price Law, and relevant laws and regulations, with the objective of strengthening management and financing of urban wastewater systems, accelerating the development of urban wastewater infrastructure, and to protect the rights and benefits of the people and enterprises. Wastewater tariffs are levied to cover all costs of the wastewater service, including management, operation and maintenance and construction of the wastewater collection system and wastewater treatment facilities. Wastewater tariffs are to be classified as a business service fee. The tariff structure is based on the 'polluter pays principle' and tariffs must generate adequate profits to sustain wastewater utilities, balanced by affordability and equitable cost sharing among those who must pay for the wastewater services. Wastewater service costs consist of construction cost of wastewater facilities, management, O&M costs, including depreciation, tax and reasonable profits. The costs and other expenses will be reviewed and determined based on Enterprise Financial Regulations and Enterprise Accounting Regulations issued by the National Financial Department and other relevant regulations. Tax will be determined following national laws and regulations. Wastewater charges will be exempt from VAT. Acceptable profits will be determined following national laws and regulations regarding price management.

Clause 16 states that the principle of Beneficiary Contributes can be applied in developing and implementing a wastewater project, where such downstream beneficiaries are willing to contribute to cover additional costs associated with improved effluent quality or a change in delivery point of the effluent. On the basis of integrated water resources and pollution control planning, reuse or recycling facilities are encouraged to conserve natural resources. Wastewater reuse is to be encouraged through preferential taxation policies depending on local circumstances and where economically justified. The reuse water tariff should be defined by means of contract as per the water quality request of consumer (Clause 17).

Guidelines for deriving wastewater tariff structure in China

Parameters	Method of estimation
Starting Point	Two Part Fixed and Usage Tariff Usage set to equal marginal costs Fixed (balance) set to achieve Full Cost Recovery overall
Variations	
Economic	Use Short Run Variable Cost (SRVC) for usage charge when water tariff is only usage Use Medium Run Variable Cost (MRVC) for usage charge when water tariff includes significant fixed element Use Long Run Variable Cost (LRVC) for usage charge when raw water is in scarce supply Use LRVC for usage charge for long run contracts
Price equity	Allocate fixed charge according to capacity of discharge to the system
PPP	Set base usage charge to reflect domestic pollution load Vary usage charge according to pollution load from industry No charges to customers who could not be served by system and who treat their own discharge, and discharge to a water course and comply with discharge standards.
Administration	Use the Two Part Tariff only if all or most customers are individually billed and metered. If not, and if meters are used for non-domestic and apartment blocks, use a usage (volume) charge only. Identify individual users who do not use water company and monitored groundwater sources and estimate their consumption If meters are not used, apply a fixed charge only, based on estimated water consumption If the benefits of a single guideline are believed to outweigh economic efficiency benefits in places where a two part tariff would be applicable, use a usage (volume) charge only
Affordability	If domestic connections are individually billed, decrease the total charge for a lifeline block to affordable levels If there is no individual billing, ask the local government to identify people at risk and ensure that their water and/or wastewater charges are affordable
Definitions	SRVC is short run variable cost and includes only consumables and daily paid labour MRVC is medium run variable cost and includes all non capital related company costs LRVC is all company costs including depreciation and return on capital. In other words it equals full costs and, if applied, means that there is no need for a fixed charge Marginal costs are unit costs applicable as throughput increases. As such they can be any of the above variable costs.

Differential tariff and metering in Jamshedpur

Source: http://www.financialexpress.com/news/Jamshedpur-to-become-first-city-in-east-to-get-metered-water-supply/234733/

Customer metering and a volumetric tariff regime came into effect in Jamshedpur in 2007. Jamshedpur Utilities & Services Co (Jusco) supplies potable, clarified and raw water to consumers within the leasehold area of the city. The company supplies clarified and raw water to industrial units like Tata Steel, Tata Motors, Lafarge, Tinplate Co of India, etc. Jusco has around 26,000 direct consumers in the city, besides supplying potable water to 20,000 Tata employees. The company supplies 40 million gallons of potable water a day to the city and another 40 million gallons of both clarified and raw water to mainly industrial consumers. The new tariff system aims at providing 24- hour water supply to consumers from the thrice-a-day supply at present and also at making the consumer pay for what he consumes. Jusco, irrespective of the volume of water consumed, has so far been charging its consumers a flat rate, which for a majority of domestic consumers is fixed at Rs 140 a month.

Under the tariff system, domestic consumers will have to pay Rs 5 a kilolitre (kl) for monthly consumption of up to 10 kl, Rs 6 a kl for between 11 kl and 25 kl, Rs 8 a kl for between 26 and 50 kl and Rs 10 a kl above 50 kl. The same for bulk domestic consumers has been kept at Rs 6 a kl for consumption of up to 25 kl, Rs 8 a kl for between 26 kl and 50 kl and Rs 10 a kl above 50 kl. Similarly, for commercial consumers, between Rs 8 a kl and Rs 12 a kl for monthly consumption of between 50 kl and 'more than 100 kl'. Industrial consumers are to pay Rs 12.50 a kl for up to 500 kl and Rs 15 a kl above 500 kl. A meter charge ranging between Rs 25 and Rs 300 a month would be levied.

Annexure IX

Water use efficiency: A case of Jamshedpur

Source: http://www.ccsindia.org/ccsindia/interns2006/The%20Customer%20Citizen%20-%20Sharbani.pdf

Jamshedpur Utilities and Services Company Limited (hereafter to be referred as JUSCO), a wholly owned subsidiary of Tata Steel, is now responsible for the provision of civic Centre for Civil Society amenities and municipal services in Jamshedpur. It was incorporated on 25 August 2003 under the Companies Act, 1956. JUSCO produces raw water, clarified water, potable water and treated effluent. These products conform to the standards set by WHO and BIS. The rate of water consumption in Jamshedpur is among the highest in the country. As compared to the national average of 125 litres per person per day, water consumption in Jamshedpur is 261 litres per person per day. The same figure for Delhi is 100 litres; for Mumbai, 200 (see graph below). The availability of water during a day In Jamshedpur (eight hours per day) is also much higher than the national average (5.6 hours per day). In Delhi this figure stands at 4 hours per day; in Mumbai, 5; and in Chennai 1.5. It provides 'river-to-river' water and wastewater management. JUSCO provides approximately 40, 000 water connections, half of which cater to Tata Steel employees. Every day, 55 million gallons of water is treated10. Tata Steel employees are provided water for free; others have to pay a minimum of Rs 120 per month. Water charges are determined on the basis of the size of the plot and the number of floors in the particular building.To maintain water quality, over 5, 000 samples of water from customer taps, water tankers, storage tanks and treatment works are analyzed. All the water and wastewater services currently maintained by JUSCO have been built by Tata Steel (first under the supervision of Town Services and now under JUSCO) since 1934. These include various projects such as

- Dimna Reservoir, with a capacity of 34, 000 ML
- Raw Water Intake and Pumping Station, with a capacity of 342 MLD
- Potable Water Treatment Plant, with a capacity of 168 MLD
- Clarified Water Unit with Pumping station, with a capacity of 136 MLD
- 12 Towers for water distribution with a combined storage capacity of 46 ML and a

distribution network of 500 kilometres.

The Water Management Services of JUSCO is ISO 9001-2000 certified. Its standard for water conforms to the desirable limit set by the World Health Organization (WHO). It has recently tied up with Veolia Water in order to make the management of drinking water supply and wastewater services more efficient13. Various initiatives have been launched to maintain and improve upon the quality and quantity of water supply. These include

- Change in Chlorination practice
- Geographic Information System (GIS)
- Installation of meters to address the problem of Unaccounted-for-Water (UFW)
- Reduction in unaccounted water and leakage
- Use of HDPE pipes
- Use of improved testing methods and increased number of tests
- Analysis of increased number of parameters

The length of water mains in Jamshedpur is 500 kilometres, and that of drains is 356 kilometres15. There are two modern sewage treatment plants for treatment of wastewater. These have ten pumping stations of 65 million litres a day (MLD) combined capacity; and a network of 550 kilometres16. Jamshedpur remains the sole city in India where 100% of the sewage is collected and treated before disposal17. Street drains are cleaned daily using modern machinery, such as the sewer line cleaning machine. The GIS facilitates improved management of the water distribution network. Total Productive Maintenance has also been implemented to improve efficiency. UFW is monitored through electromagnetic bulk metering at different points of the water distribution network. The bulk metering programme has been undertaken in two phases by JUSCO at an approximate cost of Rs 3.75 crore. Phase I lasted for 13 months during which 41 bulk meters were installed. Phase II involved the installation of 89 bulk meters. This second phase lasted eight months18. To check leakages, JUSCO is implementing the notion of a District Metering Area (DMA), an area with a metered source of water and hydraulically closed boundaries. Leakages and pressure levels can be easily monitored. Table 1 details the bulk metering programme undertaken by JUSCO.

An integrated GIS system can be used for various purposes, such as:

- Building models to analyze low water pressure
- Establishing asset data base for further planning
- Linking asset data base to locate leakages

JUSCO has also adopted the Total Productive Management (TPM) principle. TPM is a Japanese system that highlights the role of people in operating technology. JUSCO analyses its own performance at the end of every month, through a Balance Scorecard that looks at four indicators: financial aspects, service delivery aspects, internal business processes and community concerns.

Report of Sub-Committee

on

Efficient Use of Water for Various Purposes

CONTENTS

CHAPTER 1 BACKGROUND

1.1 Climate Change and its Impact on Water Resources of India

Climate change may alter the distribution and quality of India's natural resources and adversely affect the ecological sustainability of India's development path. The rise on temperature, as a result of climate change is directly related to the processes such as evaporation, transpiration, condensation, etc., involved in the hydrologic cycle, which in turn impacts the temporal and spatial characteristics of water resource availability and their quality. Further, the rapid urbanization and industrialization also severely impact the water resources availability and their quality. Based on several theoretical studies, some of the impacts climate change on water resources of India include occurrence of more intense rains, changed spatial and temporal distribution of rainfall, higher runoff generation, low groundwater recharge, melting of glaciers, changes in evaporative demands and water use patterns in agricultural, domestic and industrial sectors, etc. These impacts lead to severe influences on the agricultural production and food security, ecology, biodiversity, river flows, floods, and droughts, water security, human and animal health, sea level rise etc. As most of the studies on climate change are qualitative in nature, there is an immense need for initiating research studies to obtain reliable quantitative assessment of the envisaged impacts, identify the measures required to mitigate / adapt to the adverse impacts of climate change.

To meet the increased food requirements of the country, there is increased demand of water for irrigated agriculture. At the same time availability of water for irrigation is reducing due to relatively sharp increase in demand from other sectors, where water has higher productive value. The available utilizable water resources would be inadequate to meet the future water demand of all the sectors. Further, it is known that a lot of water is wasted or used inefficiently. The situation can be salvaged by making concerted efforts to achieve higher standards of efficiency in water use in all sectors of use.

The proposed National Water Mission is one of the eight national missions identified to overcome the adverse impacts of climate change on water resources of India and their effective sustained utilisation in various sectors. The Sub-Committee on "Efficient Use of Water for Various Purposes" is a sub-committee of the National Water Mission.

I.2 India's Water Resources

Rainfall is the major source of water over the country barring a limited quantity of snow that occurs in the Himalayan region in the north. The rainfall over India is characterised by wide spatial and temporal variations. The annual rainfall varies from a about 310 mm in western Rajasthan to over 11400 mm in Meghalaya with an average value of 1170 mm for the entire country. About 85 percent of this rainfall occurs during four to five months of the year. The annual precipitation occurring over the geographical area of 329 m.ha of the country amounts to 4000 Billion Cubic Meters (BCM).

Due to the large spatial and temporal variability in the rainfall, water resources distribution in the country is highly skewed in space, and time. The average annual run-off in the rivers of the country is assessed as 1869 BCM, of which, only 690 BCM of surface water and can be beneficially harnessed through the presently available technology, while the total renewable groundwater resource is estimated to be about 431.8 BCM. Thus the total annual renewable utilisable water resources of the country are put at 1122 BCM. In addition, about 200-250 BCM of water can be utilised through inter basin transfers.

On completing all the on going and contemplated new projects, total storage capacity, excluding minor storages, of the country is likely to reach 382 BCM .

The national average annual per capita availability of water resources of the country at present is 1800 m^3 per year which is expected to dwindle to 1150 m^3 per year by 2050. There by it is estimated that by 2050, 30% of the geographical area and 16% of population in the country will be under water scarcity condition.

1.3 Key Issues Identified For the Sub-Committee

a. The Mission is to take into account the provisions of the National Water Policy and develop a frame work to optimize water use by increasing water use efficiency by 20%,
b. Mandatory water assessments and audits, ensuring proper industrial water disposal,
c. Increase in the efficiency of water use,
d. To seek optimization of efficiency of existing irrigation systems, and
e. To Promote Artificial Recharging Of Groundwater for Augmentation and Sustainability of Water Resources

1.4 Existing Policy Framework In Respect Of Efficient Use Of Water For Various Purposes

The existing national policies such as the National Water Policy (2002), National Environment Policy (2004), The National Agricultural Policy etc., provide several guidelines for efficient use of water resources, and these are consulted in preparing this report.

CHAPTER 2. OBJECTIVES

2.1 IRRIGATION SECTOR

2.1.1 To Develop Frame Work To Optimize Water Use By Increasing Irrigation Efficiency By 20% Taking Into Account The Provisions Of National Water Policy

It is estimated that currently about 83 percent of developed water resources is used by Irrigation sector alone in our country. This may get progressively reduced to about 75 percent in future, due to increased demand of other sectors. The overall efficiency in most irrigation systems is low and in the range of 35 percent to 40 percent. National Commission on Integrated Water Resources Development Plan (NCIWRDP) also tried to compile the data for national level assessment of overall irrigation efficiencies but they could not come to any conclusion. However, the National Commission opined that 35 to 40 percent efficiency in surface water and 65-70 percent efficiency in ground water will be a fair approximation.

Being, major consumer of water, even a marginal improvement in the efficiency of water use in irrigation sector will result in saving of substantial quantity of water which can be utilised either for extending irrigated area or for diverting the saving to other sectors of water use.

The National Water Mission therefore envisages increasing irrigation efficiency from its present level by 20% by the end of XII Plan.

2.1.2 Mandatory Water Assessments And Audits In Irrigation Sector

The per capita availability of fresh water in the World is continuously decreasing. For our country also, similar situation exists. It is estimated that population of the country may stabilize at around 1600 million by the year 2050. The available utilizable water resources would be inadequate to meet the future water needs of all sectors. Therefore, to meet the challenge of water shortage, it is imperative to properly assess the utilisable quantity of water and make audits in water use in irrigation to ensure its judicious and optimum use .

The National Water Mission therefore envisages adoption of mandatory water assessment and audits and ensuring proper use of water.

2.1.3 To Ensure Judicious And Optimum Use Of Water In Irrigation Sector

Since the available utilizable water resources would be inadequate to meet the future water needs of all sectors. Therefore, to meet the challenge of water shortage, it is imperative to use the water efficiently and increase the utilisable quantity by all possible means. Vigorous efforts would be needed by all concerned including people from all walks of life in water conservation effort. Irrigation being the largest consumer of fresh water, the aim should be to get optimal productivity per unit of water.

The National Water Mission therefore envisages adoption of scientific water management, farm practices and sprinkler and drip system of irrigation to ensure judicious and only optimum use of water in irrigation.

2.1.4 To Make Available Assured Water For Irrigation

The principal requirement of a good irrigation water distribution system is that it involves minimum loss of water and ensures timely and equitable supply of water to all the irrigators in the command irrespective of the relative locations of their fields in the command. Different states in the country have been following different systems of distributing irrigation water. Some of the important systems in use in different states are the Warabandi, Osrabandi, Shejpali, Block and Satta systems. It is seen that most of these regional systems have some drawbacks and do not have countrywide applicability. Many of them cannot ensure equitable allocation and distribution of water to all the irrigators. Implementation of measures like enforcing copping disciplines, equitable distribution of water, imparting information to the farmers based on scientific knowledge on climate factors for deciding optimal and timely application of irrigation would be required for making available assured water for irrigation. When schemes and canals stretch over hundreds of kilometers, it is very difficult to adjust supply and demand without proper advanced communications and control systems. Such large schemes are subject to large variations in water demand. The efficient operation of the schemes would require that canal flows be adjusted to these variations in water demand. There is a need for canal systems to respond quickly to flow changes.

Conjunctive utilization of surface and ground water in an optimal manner provides assurance of timely supply of water for irrigation.

The National Water Mission thus envisages making available assured water for irrigation.

2.1.5 To Prevent Waterlogging And Associated Salinity And Alkalinity Problems Due To Excessive And Unplanned Irrigation

The drainage system should form an integral part of any irrigation project right from the planning stage. While planning for new irrigation schemes, it should be mandatory to provide for adequate drainage so as to mitigate the problems of water logging and salinity and alkalinity which otherwise may subsequently develop due to application of surface irrigation in excess and unplanned manner. The command area which has already become water logged needs to be reclaimed to the extent feasible. The present rate of reclamation is reported to be far lower than the rate of increase of water-logging. Planned development of groundwater in waterlogged areas can help mitigate the problem to certain extent.

The National Water Mission calls for more concerted efforts on the part of various organizations dealing with the subject.

2.1.6 To Enhance Availability Of Utilisable Water

The water resources development and management will have to be planned for a hydrological unit such as drainage basin as a whole or for a sub-basin, multi-sectorially, taking into account surface and ground water for sustainable use incorporating quantity and quality aspects as well as environmental considerations. Non-conventional methods for enhancing availability of water such as through artificial recharge of ground water and desalination of brackish or sea water as well as traditional water conservation practices like rainwater harvesting, including roof-top rainwater harvesting, need to be practiced to further increase the utilisable water resources.

Water should be made available to water short areas by transfer from other areas including transfers from one river basin to another, based on a national perspective, after taking into account the requirements of the areas / basins.

The National Water Mission envisages water resources development and management planned for hydrological unit such as drainage basin / sub basin, ensuring conjunctive use of ground water and surface water and possibility of transfer of water from surplus basins to water deficit basins.

2.1.7 To Promote Artificial Recharging Of Groundwater for Augmentation and Sustainability of Water Resources

The Central Groundwater Board (CGWB) proposed to undertake various activities for effective and efficient management of ground water resources of the country during the Xth Plan. Central Sector Schemes of "Ground Water Management & Regulation" proposed during XI Plan was approved with a budget outlay of Rs.460 crores.

Artificial Recharge

Due to over draft, substantial ground water level declines are being witnessed both in hard rocks and alluvial areas. Ground water quality in coastal areas has also been affected by sea water intrusion due to excessive ground water development. Pollution of ground water due to increased industrial activity and sewage disposal also rising. The ground water development in such areas therefore needs to be augmented through suitable measures to provide sustainability and protection of ground water reservoirs.

It was estimated that annually about 36453 MCM of surplus surface run-off can be recharged to augment the ground water. The master plan developed by the CGWB envisages construction of 2.25 lakhs artificial recharge structures in rural areas at the cost of Rs.19,880 crores

A provision of Rs.100 crores has been made in the Xth Plan for demonstration of artificial recharge techniques. A total of 1320 artificial recharge and rain water harvesting structures are proposed to be designed and constructed. These involve construction of check dams, percolation tanks, recharge wells, subsurface dykes, roof water harvesting and other innovative artificial recharge works and monitoring of the impact of these structures.

Incentives for efficient use of Groundwater

In order to increase the ground water use efficiency suitable incentives for community management of new wells, for construction of recharge structures, for energy saving devices like installation of capacitors and frictionless foot valves and for adoption of micro irrigation can be offered to the users in water stressed areas (Over exploited and Critical blocks) instead of putting ban for further exploitation of ground water.

Provision of Subsidy for Artificial Recharge to ground water through Dug wells

A Scheme on "Artificial Recharge to ground water through Dug wells" has been launched by the Ministry for augmenting the ground water resources in 1180 blocks in 7 states at accost of Rs. 1798.7 crores of which Rs. 1499.27 is assigned for subsidies.

Bhoomijal Samvardhan Puraskar and National Water Award

Ministry of Water Resources has instituted annual awards namely Bhoomijal Samvardhan Puraskar and National Water Award in the Year 2007. The awards aim to encourage the Non-Governmental Organizations (NGOs) /Gram Panchayats/ Urban Local Bodies (for population up to 1 lakh) for adopting innovative practices of ground water augmentation by rainwater harvesting and artificial recharge through people's participation.

The National Water Mission Envisages To Promote Artificial Recharging Of Groundwater For Augmentation And Sustainability Of Water Resources Through Mandating Water Harvesting And Artificial Recharge And Enhancing Recharge Of The Sources And Recharge Zones.

2.2 DOMESTIC & INDUSTRIAL SECTORS

The main supply problems facing major urban centers are the depletion of local sources and their contamination, the high costs of water impoundment and conveyance, and conflicts of interest arising among the various users over these sources. Despite these problems, cities are plagued with a high incidence of leaks, water-wasteful technologies continue to be employed, there is virtually no reuse of water, billing and rate collection systems are inefficient, rates are usually insufficient to cover supply costs and there is a general lack of social conscience.

While there are guidelines formulated by the Ministry of Environment & Forests, and the Central Pollution Control Board, these are not mandatory. There is a need for making them mandatory.

2.2.1 Domestic Sector

On average, 71% of a city's total water production is used in homes, 12% in industry, 15% by commercial users and 2% by the services sector. The techniques for efficient use domestic and industrial use of water can be classified as: metering, leakage reduction, tariff systems, water saving devices, regulations, reuse and cultivation of appropriate plant species, and information and education.

Metering is required both at source level and user level. Metering at source level involves measuring the water flows impounded, conveyed and distributed. Metering at user level is to measure each user's consumption periodically in order to charge for the service. The meeting can have an influence on domestic water use, with reductions of up to 25% in areas that previously had no metering. This, however, involves high cost of capital and requires changes to the tariff structure. A strategy for the installation of meters at user level can be based on selective metering, metering by sectors and combined metering.

Leakage reduction through detection and repairs can save water up to 9%, but costs can be higher than that of water saved.

Tariff can be effective tool to control wasteful use of water and effect water savings up to 10%, but needs to overcome user's objections through well designed tariff structure.

Water saving devices can help save water up to 10 % but are expensive and need cooperation of users.

Regulations & restrictions have good water saving potential (up to 20%) but require cooperation of the users.

Reuse and cultivation of appropriate plants can affect water savings up to 25%. However, acceptance by users and availability of native plants are the limitations. While dual piping system has promise, the cost of implementation is high.

User education serves to save water substantially and requires well planned and coordinated efforts by Govt. Agencies. Scope for Public -Private participation (PPP) needs o be explored in this context. User education can include:

i. creation of knowledge bank on efficient ,low cost methods of reclaiming waste water and recommending best practices to various classes of end users, information generation on socio-economic and environmental impacts of reuse of recycled waste water ,
ii. raising awareness of waste water recycling and reuse at all levels of uses(villages, districts, states etc.,) through training programmes , exhibitions, extension activities, media coverage etc.

2.2.2 Industrial Sector

Industrial water use can be grouped into three main categories: heat transfer, power generation and use in processes. The main water use efficiency actions in industry are recycling, reuse, and reduction of consumption. Two basic activities are necessary in all three cases: measuring the amount and monitoring the quality of the water.

Metering is the most basic activity for efficient water use program in the industrial sector. Metering helps better use of water in processes, equipment, accessories, irrigation areas, dipping, etc. and to motivate employees to play an active role in saving water.

Recycling and reuse is mainly applicable **in** cooling systems, washing systems**,** material transport etc. immediate attention is required n respect of:

i. Mandatory guidelines for recycling and reuse on the lines of those proposed by the Ministry of Environment and Forests and the Central Pollution Control Board.
ii. Provision of incentives (tax relief, excise exemption, etc.,) for industries and commercial establishments to encourage recycling and reuse,

Reduction of consumption

It is possible to achieve reduction of consumption through optimizing processes, improving operations and modifying the equipment and the attitude of users. Further, industries have adjacent areas (gardens, sanitary services, etc.) in which significant reductions in water use can be achieved, for example by planting plants native to the area in which the industry is located, using efficient watering equipment, watering at night, etc. In washrooms and toilets, repairing leaks and the use of flow reducers in water-efficient toilets and showers will aid in reducing industrial water consumption.

Regulations

In general, regulations to improve water use efficiency are of a restrictive nature and have an impact on water savings; they may be of short or long duration, or applicable mainly during periods of shortage. These may include:

i. revision of price structure to encourage industries and commercial establishments to use less water per unit of production,
ii. fixing differential rates of pollution cess

Information, education and communication

With proper user participation, these types of programs can produce savings of between 4 and 5% of total water production.

2.3 BASIC RESEARCH IMPLICATIONS FOR PUBLIC POLICY

Moving toward more efficient, ecologically sound and sustainable patterns of water use requires major changes in the way water is valued, allocated, and managed. Appropriate pricing, the creation of markets for buying and selling water, and other economic inducements for better water use have a central role to play in easing the transition to an era of water scarcity.

CHAPTER 3.STRATEGIES TO ACHIEVE THE OBJECTIVES

3.1 IRRIGATION SECTOR

The irrigated agriculture in India has undergone a sea change during the second half of the 20th century. There was a marked shift from a low input, subsistence agriculture to one of high input, high productivity, and intensive agriculture. Irrigation being a major consumer of the water, low efficiencies obtained in the irrigation sector is a cause of concern. In view of the increased food requirements of the ever increasing population, and consequent increased irrigation demand, it is necessary to adopt measures for improving the water use efficiencies and economize on water use in existing irrigation systems besides exploring the new avenues for increasing the water availability. The motto of "**More Crop Per Drop**" shall be the guiding beacon for attaining sustainable development and management of water resources in irrigation sector.

A major area of concern regarding the water use in irrigation sector is the large gap between the irrigation potential created and its utilization. Over the time, the percent of the utilization of created potential has reduced considerably from about 94.8% at the end of IV Plan to 84.5% by the year 2003-04. The gap is as much as 14.5 m.ha. and is closely related to the issues of water use efficiencies. The National Commission for Integrated Water Resources Development (NCIWRDM-1999) observed that 35-40 percent in surface water irrigation and 65-70 per cent efficiencies in ground water irrigation have been achieved. The proposed National Water Mission aims at increasing these efficiencies by 20 percent.

Besides the ineffective utilisation of irrigation potential created, other major issues to be addressed in attempting to improve the efficiencies of irrigation water use include slow progress of irrigation infrastructure under construction, acute need for modernisation and rehabilitation of old irrigation systems including minor irrigation works and irrigation tanks, low reliability in timeliness and equity in irrigation water distribution, inadequate drainage facilities leading to waterlogging and soil salinity, major shifts in cropping pattern, unsustained use of groundwater resources, lack of scientific water management practices in both irrigated and rain fed areas, unrealistic pricing of irrigation water and lack of adequate attention to environment, absence of awareness among farmers of the need for efficient use of water, etc.

3.1.1 Evaluation Of Irrigation Projects

Ever widening gap between irrigation potential created and irrigation potential utilised has become matter of concern for the nation. In view of this, the National Water Policy envisages periodic conducting of evaluation studies of Water Resources projects. The need for undertaking post project evaluation studies has been expressed by the public Accounts Committee, Planning Commission and also by the State Water Resources / Irrigation Ministers' Conference. The Working Group constituted by the Planning Commission, Govt. of India on Major and Medium irrigation Projects recommended for 5 yearly evaluation of performance of irrigation projects.

3.1.2 Benchmarking Of Irrigation Projects

Benchmarking of irrigation projects may provide an effective tool for measurement of relative performance of irrigation projects and suggest ameliorative measures for performance improvement.

3.1.3 Water Audit In Irrigation Projects

The measurement of water is essential for calculation of water losses during conveyance in canal and distribution network and also during application in the field. Complete records of water withdrawn from the reservoir or the river system and of water that flows through the various branches, distributaries and other network channels and at outlets as well as water flowing through escapes are needed to be maintained. Simultaneously, the records on rainfall, crops sown, area irrigated and depth of water provided are also required to be maintained. Actual conveyance and field application losses and efficiencies of an irrigation system can be calculated from such records. These efficiencies are to be compared with the planned / achievable efficiencies to identify the scope of improvement. The corrective measures can be taken accordingly.

3.1.4 Reduction In Losses In Conveyance Systems

Water is lost from main canals, branches, distributaries, minors, water courses and field channels during conveyance through seepage. Conveyance loss accounts for 40 to 50 per cent of the water delivered into a canal system. Part of the seepage water reaches groundwater and recharges it, while part of the seepage water can be collected and reused. However, in areas of poor quality ground water the seeping water will also be wasted. Further, in drought prone areas efforts should be made to maximize the use of surface water. Lining of canal network should be done selectively, preferably by using locally available material. In areas of water scarcity the polyethylene films like LDPE/HDPE films can also be considered as they are more impermeable as compared to conventional methods.

3.1.5 Reduction In Losses In The Fields

When water is applied to the field, part of it evaporates. Other field application losses such as run off also takes place. Consumptive use of water is the quantity of water actually used by plants for their growth.

The application efficiencies obtained in traditional surface irrigation methods are not up to the mark, primarily because proper attention is not devoted to deciding the appropriate application method suitable for particular stream size, soil type, slope etc. For example, basin irrigation method is more suitable for small field with accurate land leveling and uniform textured soils with large stream size feeding the field for quick coverage of whole plot. Similarly in graded border method lengthwise slope has to be kept uniform and cross wise profile to be leveled to ensure uniform water coverage. This method should not be used for crop requiring prolonged flooding. Furrow provides better on-farm management capability as flow rate per unit width is substantially reduced. The water in this method is applied in furrow only which soaks into the soil to irrigate area between the furrows. As the water is supplied in small area only, the evaporation losses are reduced substantially giving high rate of efficiencies. By growing row crops, particularly cotton, maize, sugarcane, soybean, and sunflower under ridge and furrow irrigation systems, about 30 to 40 percent irrigation water can be saved compared to border irrigation. However, this method is not suitable for seed germination requiring light irrigation and for very shallow rooted crops grown on soils with high intake rate. Another effective method of irrigation is surge irrigation which is a variation of furrow irrigation with water delivered at intermittent intervals. This method ensures minimum percolation losses and hence higher application efficiencies.

Further, to reduce the evaporation from the surfaces of the irrigation farms mulching should be practiced and popularized. Mulches of straw, organic compost, coir waste, gravel, plastic sheets or chemicals and petroleum products have been tried on the research farms. It has been seen that introduction of scientific mulching practices on the agricultural farms in the drought areas can improve the retention of moisture in the farm soil by as much as 50percent and improve the yields by 75percent.

3.1.6 Early completion of ongoing major& medium irrigation projects

There are 471 ongoing major and medium irrigation projects in the country. Besides there are 231 unapproved projects undertaken by state Governments but remain incomplete. Thus a substantial irrigation potential is locked up undeveloped. Factors for contributing to this situation include delays in release of funds, inadequacy of funds, spreading of resources, delays in land acquisition, problems of relief and rehabilitation, forest land clearance, law and order problems, litigations, environmental issues, etc. This lead to the situation of huge amounts of investment locked up unproductively. At the same time, cost over runs occur due to undue delays in completion of these projects. Speedy completion of all these ongoing projects is the need of the hour.

In this back drop, the Govt.of India launched the Accelerated Irrigation Benefit Programme (AIBP) in 1996-97 with a view to help the States in ensuring early completion of ongoing irrigation projects through Central Loan Assistance (CLA.) Its implementation is now linked to the reforms in irrigation sector. The Government of India has also initiated a Fast Track Programme under AIBP with effect from 1st February, 2002. The approved major and medium irrigation projects, which will be completed in one year are entitled to get 100 percent CLA under the Fast Track Programme of AIBP. As per the modified guidelines of the programme with effect from the year 2002-2003, the Reforming States under general category, which agree to revise their water rates so as to recover full O&M cost within a period of 5 years will get CLA in the ratio 4:1 (Centre: State,) instead of existing 2:1 and under special category in the ratio 1:0 (Centre: State,).

To ensure the early completion of ongoing projects, the CLA be stopped to the states which approach for the assistance for the projects, whose cost has escalated for the only reason of delay in completion

3.1.7 Extension, Renovation And Modernisation (ERM) Of Irrigation Projects

MAJOR AND MEDIUM IRRIGATION PROJECTS

It is estimated that about 21 M.ha. of irrigated area from major and medium projects from pre-independence period and those completed 25 years ago have become less efficient. These projects require renovation/upgradation for restoration of the areas which have gone out of irrigation, either partly or fully, due to deterioration in performance of the systems. Schemes already taken up for modernization should be completed on priority. Detailed diagnostic analysis for evaluating performance of the schemes which have become 25 year old or more measures so that the potential created at a huge cost is not permanently lost. Benchmarking can help in identifying the system component requiring physical improvement.

MINOR IRRIGATION PROJECTS

Minor irrigation is developed from surface water resources through small storages and diversions, and exploitation of groundwater resources on a sustainable basis. Out of the ultimate irrigation potential of 81.42 m.ha. from minor irrigation, a potential of 58.46 m.ha. has been created by 2004. However, there is considerable variation in the development of minor irrigation from State to State.

The carrying capacity of tanks has decreased over a time for a variety of reasons and hence restoration and renovation of tanks and other local sources is a priority task. This would involve reforestation of catchment areas, removal of encroachments on the tanks beds, strengthening and improving the tank bunds and sluices, desilting (where appropriate), restoration, repairs and improvements to the feeder inlets, restoration of unlined channels to their original capacities, and renovation of the channels which inter-link tanks.

3.1.8 Adoption Of Scientific Water Management Practices

Productivity of irrigated areas in India leaves much to be desired. The productivity in terms of yield per hector of almost all the crops are way behind the best productivity values achieved elsewhere in the world. In a positive sense, this shows that a great scope exists to achieve higher yields. It is well recognised that a major reason for this situation is unscientific practices of water management.

The measures required include:

i) Proper assessment of command area size, and proper fixing of outlet sizes to match the crop water requirements, ii) lining of the critical segments of the water conveyance system including water courses, iii) linking timing of irrigation supplies to plant water needs and water availability not on "duty" values, iv) Scientific estimation of crop water demands following the FAO guidelines, v) scheduling of irrigation based on soil –water- plant interactions, vi) Adoption of efficient water scheduling policies and operating rules, vii) Application of irrigation water with least wastage avoiding field to field flooding irrigation, vii) Adequate provision for draining excess water from fields, viii) Proper control of wastage, leakages, losses and unauthorised uses, ix) tuning irrigation schedules to medium range weather forecasts (MRWF) to synchronise with the critically long dry spells to get maximum benefit of irrigation water, x) minimising evaporation losses from irrigated fields through use of mulches, xi) adoption of efficient methods of irrigation such as alternate furrow irrigation, surge flow irrigation, and pressurised irrigation (micro and sprinkler systems) etc.

3.1.9 Ensuring Optimum Utilisation Through Application Of Micro Irrigation

Considerable savings in water can be achieved by adoption of sprinkler, drip/micro-sprinkler irrigation systems in water scarcity areas, having conditions conducive to their application. Actual field studies indicated water saving of 25 to 33 per cent and increased yield up to 35 percent with sprinkler system compared with normal surface irrigation method. Further, 10-16 percent more area is available for crops as channels and ridges are not required. In sprinkler method as the water is sprayed, some loss in evaporation takes place. Sprinkler, therefore, should be avoided in zones of high wind. This loss of water is, however, eliminated in drip method in which water is directly trickled in to the soil near the root zone of the crop resulting in considerable saving and is particularly more suitable to row crops. 25 to 60 percent water is saved in drip method and increased yield up to 60 percent is obtained compared with conventional surface irrigation methods.

Normal drip systems are costly as pressurized release of water is required in the emitters for serving the whole command. Simple and inexpensive drip irrigation system called "Bucket Kit" is also developed and is especially popular in

African countries enabling women to grow vegetables during long dry seasons. The Bucket Kit drip system consists of 5 gallon bucket mounted one meter above ground and drip system covering total 30 meters to irrigate two/four or six rows of vegetables. The kit also includes a filter and necessary fittings. These kits save water, labour and are easy to use in small farms. In some of the systems overhead tanks are also used. About 2-3 m head available creates enough pressure to push water from one end of main pipe to the other end. Pitcher irrigation, a traditional Indian practice is also a variant of this method of drip irrigation.

- **Micro Sprinkler and Micro Sprayer:**

This is a combination of sprinkler and drip irrigation. Water is sprinkled or sprayed around the root zone of the trees with a small sprinkler which works under low pressure. This unit is fixed in a network of tubing but can be shifted from place to place around the area. Water is given only to the root zone area as in the case of drip irrigation but not to the entire ground surface as done in case of sprinkler irrigation method. This method is very much suited for tree/orchard crops.

- **Low Energy Pressurised Application (LEPA) System**

A recent development in micro irrigation is the LEPA system in which the micro sprinklers are installed downwards to sprinkle water under low pressure from about 10-15 cm above the ground surface. The irrigation efficiency of this method is reported to be as high as 97%.

- **Auto Irrigation System**

Rapid advances in electronics and its successful use in developing auto irrigation system have made it possible to practice efficient irrigation. This is particularly true in case of micro irrigation systems which can be easily automated to schedule irrigation and do not depend upon irrigator's judgment. To maximise crop yield irrigation should be applied at appropriate values of soil water stress in the root zone which is dependent on soil type, crop and its stage on growth etc. It is very difficult to control irrigation as per the values of soil water stress manually. In automatic irrigation system soil water stress is sensed continuously by tensiometers installed at suitable depths and location, the output of tensiometers is converted into an electrical signal with the help of a transducer. The anticlockwise and clockwise rotation of the motor actuated through control circuitry opens or closes the valves for initiation or termination of irrigation. Auto irrigation system using indigenous technology is reported to have been developed at Central Soil and Salinity Research Institute, Karnal. The system which is a low cost unit has been tested in the field with good results. A demonstration farm of electronically controlled auto irrigation system is operative for the past 12 years at the Indian Agricultural Research Institute (IARI), New Delhi.

3.1.10 Providing Knowledge to the Farmers on irrigation Scheduling

IRRIGATION SCHEDULING: The specific objective irrigation scheduling is to optimize yields and incomes by applying right amount of water at the most sensitive crop stages. This can be achieved with the information of "dated water production functions" developed for different crops. These are the functional relationships that express the responses of the crops to application of different levels of irrigation at different times of crop growth. Increased production invariably means more crops per drop. Deficit Irrigation is the scheduling method applied under limited water supply with the help of production functions.

Scheduling of irrigation in relation to water availability is an important aspect of on-farm water management for optimizing production. Where irrigation water supplies are plentiful, irrigation must be applied before a yield or quality reducing water stress sets in. In case of rice, two types of irrigation practices for scheduling irrigation are followed. These are continuous submergence, and intermittent submergence which includes rotational and occasional submergence. Extensive field experiments have been conducted on water management throughout the country to find out optimum irrigation schedules for the two irrigation practices. In intermittent irrigation, the saving of irrigation water to the tune of 40 to 60 percent is obtained, largely from reduction in the percolation loss which is dependent upon soil type. Irrigation scheduling for optimizing production with limited water supplies is a bigger challenge than that with adequate water supplies.

Considerable volume of field experiment based information on irrigation scheduling has been developed for a large number of crops by the Indian Council of Agricultural Research (ICAR) and the State Agricultural Universities (SAUs) .(Pl.See Annexure-1). However, this vast knowledge is yet to reach farmers. Appropriate extension mechanism for propagating water management technologies need to established as part of the existing Agricultural Extension Departments of the state Govts. and SAUs. Because of unreliability of availability of water, farmers tend to over irrigate when water is available. Such excessive irrigation leads to problems of water logging and soil salinity, affecting the productivity of the soils.

There is a need to organise massive water use literacy programmes to educate about the ill effects of misuse of irrigation water and need for adoption of proper water management practices, through various forums such as radio, television, farmers training programmes, news papers, pamphlets, bill boards, organising visits of farmers to well managed irrigated farms, etc.

3.1.11 Ensuring Adequate and Timely Irrigation Water Supply

Water allocation in an irrigation system should be done with due regard to equity and social justice. Disparities in the availability of water between head-reach and tail-end farms and between large and small farms should be obviated by adoption of an appropriate rotational water distribution system and supply of water on a volumetric basis subject to certain ceilings and rational pricing.

Rotational system of water supply, such as Warabandi practiced in North India, enforces some sort of equitable rationing of water in the period of shortages. The system is reasonably flexible as this attempts to match available supplies with farmer's demands. In South India, the rotation system is not in vogue. There are no well defined procedures to ensure predictability of supplies and equitable distribution of water to each outlet. Under such a situation, inevitably the areas close to head reaches of the distribution system are in a relatively advantageous position with the degree of reliability falling as one moves towards the tail end. In recent years efforts have been made to draw serious attention towards introduction of rotational water supply system in different parts of the country, especially where water resources are scarce.

There is a need for canal systems to respond quickly to flow changes. Computer technology is being recognised as a special tool for monitoring and analysing the data and development of decision support system (DSS). Special efforts by computer engineers and communication groups have helped in establishing Management Information System (MIS) for operation of reservoir and canals which helped in improvement in flood control, irrigation and hydropower. Through an effective MIS and DSS, precious water can be saved and efficiencies improved by quickly responding to sudden change in demand. In future, from manual operation of canal system, one could ultimately shift to automatic regulation as precise discharge measurements and better communication facilities are available. To ensure sustainability, more efforts are required in the area of adequate infrastructure such as power supply and communication network, adequate training of staff, implementation of available technology and security against vandalism with active participation of all the stakeholders in its implementation and operation.

Appropriate actions such as correction of system deficiencies and reduction in conveyance Losses of water, proper and timely maintenance of the water distribution systems, provision of adequate funding for proper up-keep of the water conveyance and distribution system, adoption of appropriate rotational water distribution schemes ensure timeliness of water distribution.

3.1.12 Adopting Suitable Cropping Patterns

For large irrigation systems, complete development of the command area including construction of field channels and drains takes up to 10 to 20 years. During this period, the farmers of the head reach tend to grow high water intensity crops such as paddy and sugarcane. Even after completion of the project, the head reach farmers continue to practice the same cropping patterns resulting in wasteful use of water in head reaches and depriving tail end farmers of their due share of water. This leads to distortion of the cropping pattern planned earlier. This distortion causes ineffective utilisation of irrigation potential developed. Further, despite the prescribed cropping patterns, the small and marginal farmers prefer staple food crops over the recommended ones. By and large, market forces influence the cropping patterns.

It is reported that 839 assessment units have been categorized as "Over-Exploited", in which significant decline in ground water level has been observed. There is a need to enforce cropping discipline in these areas.

While the governmental agencies can decide on optimal cropping patterns based on scientific analysis of the soils, water availability and agro climatic conditions, and anticipated market forces, farmers tend to have their own cropping patterns based on other own considerations and preferences. Multidisciplinary groups consisting of experts of agriculture, irrigation, agricultural economics and extension may develop cropping patterns for different irrigation command areas and advise the farmers accordingly.

3.1.13 Participation Of The Stakeholders In Allocation, Distribution And Optimum Utilisation Of Water

People and organizations that use water, provide such water for use and also all those that would be affected by decisions relating to water resources management and many others that are concerned with or have an interest in water resources management could be considered as "Stakeholders". There is lot of pressure on government exchequer along with the problems of utilization, operation and maintenance. It is well known that individual user provide irrigation to their field by their own judgment and apply water to the fields more than required as the availability is there in the head reaches. This practice results in over irrigation in head reach and less availability of water at tail ends. It has now been fully recognized that user's participation in the development and management of water resources is essential to achieve the objectives of efficiency and equity in the use of available water resources and maximization of productivity. It would perhaps be worthwhile at this stage to allocate some responsibility for operation and maintenance to the user groups. Water resources development and management cannot and should not remain a governmental concern. The National Water Policy 2002 also stipulate effective and decisive involvement of stakeholders particularly Water Users Associations (WUAs), local bodies and gram Panchayats in various aspects of management of irrigation system by making necessary legal and Institutional changes, duly ensuring appropriate role for women. Induction of Non-Government Organisation could perhaps be considered in the beginning to motivate the users in accepting this responsibility and also to educate farmers in efficient water use and management of the irrigation system.

In order to promote Participatory Irrigation Management (PIM), one time functional grant is given to the registered Water Users Associations. About 41,200 Water Users Associations covering an area of 8.68 million hectare have so far been formed all over the country. With the formation of Water Users Associations in various projects and enactment of legislation by various States, more and more irrigation projects are likely to be handed over to these associations for effective management. Under Restructured Command Area Development Programme more emphasis is being given to participatory approach. Under this programme, payment of central assistance to States is proposed to be linked with the formation of Water Users Associations. Apart from this, farmers will have to contribute 10 percent cost of the works in the form of cash/labour involving construction and maintenance of field channels, field drains, reclamation of water logged areas, desilting and renovation of tanks etc. Such a provision is considered essential to ensure involvement of beneficiary farmers in the construction and maintenance of field channels and imbibe in them a sense of ownership of the assets created. Action is also being taken to remove the constraints in implementation of PIM like policy changes in Irrigation Act by all the States, repairing of existing system which is in dilapidated condition before handing over them to WUAs. assured supply of water in bulk quantity to the associations etc. Water rates to be charged should be fixed on basis of volumetric supply of water. To promote the process of PIM, water rates for members of the WUAs can be pegged at slightly low level vis a vis individual farmers. To facilitate the process of PIM, States of Andhra Pradesh, Goa, Karnataka, Madhya Pradesh, Orissa, Rajasthan and Tamil Nadu have enacted exclusive legislation for effective involvement of farmers in irrigation management. Some other states are also taking appropriate action in this regard. To ensure the success of PIM there is a need to effectively implement and monitor the activities of WUAs for nation wide evaluation. NGOs can also play a greater role in action research programme.

3.1. 14 Prevention Of Waterlogging And Soil Salinity

Traditionally, drainage facilities are not provided in irrigation command areas at the time of construction of irrigation projects. Over a period of irrigation, the problems of water logging and soil salinity crop up. As much as 2.46 m.ha of irrigated area suffers from water logging. About 3.3 m.ha area suffers from soil salinity and alkalinity in the irrigation command areas of major and medium schemes. Problems of water logging and soil salinity are closely related. The primary cause of these two problems is excessive accumulation of groundwater coupled with inadequate drainage of irrigated areas. Excessive seepage losses in the canal water distribution network, mismatch between rainfall and irrigation schedules, poor on-farm water management, absence of or inadequate drainage facilities, poor maintenance of existing drains, existence of hard pans in the subsoil, inadequate groundwater outflow due to landlocked conditions, are some of the factors that cause water logging conditions.

Appropriate measures to contain the problems of water logging and soil salinity include I) using system analysis approach for water balance studies to assess groundwater conditions, ii) deciding appropriate cropping pattern required to contain water logging, iii) provision of adequate drainage infrastructure, iv) lining of water distribution system, and v) adoption of “bio drainage” in land locked areas. etc.

While planning for new irrigation schemes, it should be mandatory to provide for adequate drainage so as to mitigate the problems of water logging and salinity which otherwise may subsequently develop due to application of surface irrigation.

CONJUNCTIVE USE OF SURFACE WATER AND GROUNDWATER

Surface water and ground water are integral part of available water resources. However, planning for their use has generally been in isolation resulting in sub-optimal utilization. **.** For improved water use efficiency in canal irrigated command areas, optimal and efficient utilization of both ground and surface waters becomes imperative. Conjunctive use of surface water and groundwater should be ensured from the planning stage of irrigation projects and should form an essential part of a project. Using surface water during monsoon period and using groundwater during non-monsoon period for irrigation of the same land mass is a form of conjunctive use. Similarly, when a parcel of land is irrigated with surface water, the excess water percolates to the groundwater, which may be developed at a downstream location at a latter point of time for irrigation. This is another form of conjunctive use. Large-scale development of private tube wells in the canal command areas can be viewed as informal practice of conjunctive use of surface and groundwater. There is a high emphasis in recent times on conjunctive use of canal water and groundwater to exploit the additional potential to augment canal supplies and also to control the water table rise.

3.1.15 Developing Water Resources Planned As Basin Concept

Water resources development and management will have to be planned for a hydrological unit such as drainage basin as a whole or for a sub-basin, multi-sectorally, taking into account surface and ground water for sustainable use incorporating quantity and quality aspects as well as environmental considerations. All individual developmental projects and proposals should be formulated and considered within the framework of such an overall plan keeping in view the existing agreements / awards for a basin or a sub-basin and transfers of water from one river basin to another, based on a national perspective, after taking into account the requirements of the areas / basins so that the best possible combination of options can be selected and sustained.

3.1.16 Integrated Use Of Poor Quality And Good Quality Waters

Reuse of drainage water augments the availability of water for irrigation. At times saline ground water is also made use of for irrigation purposes. As a strategy, drainage/saline water and good quality water can be applied either separately or mixed. When the waters from two sources are supplied separately, waterings will have to be done in such a manner that poor quality watering is followed by good quality watering so that build-up of salinity, sodicity and toxic ions in the root zone does not exceed the levels that limit the productivity of soils and the salt balance in soil-water system is controlled. These constraints would have to be kept in mind while deciding the quantum of good and poor quality water proposed to be mixed and used.

Crops differ considerably in their ability to tolerate salinity/sodicity. These intergenic differences can be exploited for selecting the crops that give satisfactory yield under a given root-zone salinity. For successful irrigation with saline waters in specific agro-climatic zone, selection of crops should be such as to suit the salinity of the water because it may not be possible to change the quality of irrigation water.

Further, crops do not tolerate salinity equally at different stages of their growth. In most crops germination and flowering are the most critical stages Therefore, strategies for minimizing the salinity of the root zone should be followed. Saline waters should be avoided at some of the sensitive stages to minimize the damage.

3.1.17 Rational Pricing Of Irrigation Water

At present there is no uniform set of principles in fixing the water rates. The water charges vary from State to State, project to project and crop to crop. The rates vary widely for the same crop in the same state depending on irrigation season, type of system etc.

The water rates being charged at present are low and are not able to meet even the operation and maintenance costs of the irrigation projects. Water rates being abysmally low, enough funds are not generated for proper maintenance leading to poor quality of service. This is a vicious circle. Farmers on the other hand, who otherwise may not be averse to paying increased water charges refuse to do so unless the quality of services is first improved. It is imperative that the tariff structure is reviewed and revised with simultaneous improvement in the quality of services provided so as to restore the efficiencies.

There is an urgent need for the Paradigm shift by reversing the vicious cycle of flow water rates-low revenues-lack of funds for operation and maintenance-poor quality and unreliable water delivery service-farmers reluctance to pay higher water rates to virtuous cycle of increased water rate-higher revenue-adequate funds for operation and maintenance-good quality and reliable water delivery service farmers willingness to pay higher water rates. Assurance of good quality timely and reliable water deliveries hold the key to such a paradigm shift.

State Governments should evolve a policy for periodical rationalization and revision of water rates so that the revenue generated by the irrigation sector is able to meet the cost of operation and maintenance and realize economic returns on the investment made on irrigation projects . However, revision of water rates should go hand in hand with measures to improve the quality of services through stake holder’s participation in the management of the water resources.

Incentives & Disincentives

In this back drop, it is proposed that

a. Charging of irrigation water be done on volumetric basis,
b. Irrigation charges to be linked to reliability, timeliness, and adequacy of irrigation water supplies
c. Institution of Awards at minor/Major distributary level for implementing scientific water management Procedures
d. Providing incentives to WUAs, in the form of reduced bulk rates for water, subsidized inputs etc.
e. Creating dis-incentives for growing high water loving crops in soils and climate hat are not conducive for such crops.

3.1.18 Ensuring Environmental Protection

Surface Water Resources

India's river systems typically originate in its mountain eco-systems, and flow towards the plains and are subject to siltation from sediment loads. They are also subject to significant net water withdrawals along their course, due to agricultural, industrial, and municipal use; as well as pollution from human and animal waste, agricultural runoffs, and industrial effluents.

The direct causes of rivers degradation are, linked to several policies and regulatory regimes. These include tariff policies for irrigation systems and industrial use, which, through inadequate cost-recovery, provides incentives for overuse near the headwork's of irrigation systems and drying up of irrigation systems at the tail-ends. The result is water logging, and alkali-salinization of soil, loss in irrigation potential. Pollution loads are similarly linked to pricing policies. There is a need to review the relevant pricing policy regimes and regulatory mechanisms in terms of their likely adverse environmental impacts.

Groundwater Resources

Excessive withdrawals of groundwater in excess of annual recharge, lead to rapidly falling water levels in many areas of the country in recent decades. Pollution of groundwater occurs due to leaching of stored hazardous wastes, leaching of industrial effluents and use of agricultural chemicals, like fertilizers and pesticides. The pricing policies, free or subsidized power and diesel supply, subsidized fertilizers and chemical pesticides do not take the potential environmental impacts into account.

Wetlands

Wetlands, natural and manmade, freshwater or brackish, provide numerous ecological services. They provide habitat to aquatic flora and fauna, as well as numerous species of birds, including migratory species. Wetlands also provide freshwater for agricultural and domestic use, help groundwater recharge, and provide livelihoods to fisher-folk. They may also comprise an important resource for sustainable tourism and recreation. The density of birds, in particular, is an accurate indication of the ecological health of a particular wetland. Several wetlands in India have sufficiently unique ecological character as to merit international recognition as RAMSAR Sites.

Wetlands are under threat from drainage and conversion for agriculture and human settlements, besides pollution. This happens because public authorities or individuals having jurisdiction over wetlands derive little revenues from them, while the alternative use may result in windfall financial gains to them. However, in many cases, the economic values of wetlands' environmental services may significantly exceed the value from alternative use.

Strategies and Measures Required:

- ***Strategy i. Meeting Environmental Flow Requirements***

- Water requirements of terrestrial eco system and the flow requirements of the aquatic ecosystem shall be considered in assessing the minimum flow requirements
- While Environmental flow requirements need to be recognised as valued , different species and tradeoffs as preferred by the society between environment and other uses(Food, people) need to be developed.

- ***Strategy ii. Environmental Management of River Systems***

- Promote integrated approaches to management of river basins by the concerned river authorities, considering upstream and downstream inflows and withdrawals by season, pollution loads and natural regeneration capacities, to ensure maintenance of adequate flows and adherence to water quality standards throughout their course in all seasons.

- Consider and mitigate the adverse impacts on river flora and fauna, and the resulting change in the resource base for livelihoods, of multipurpose river valley projects, power plants, and industries.

- Consider mandating the installation of water saving closets and taps in the building byelaws of urban centers.

- ***Strategy iii. Prevention of Pollution to Groundwater Bodies***

- Assess impacts on groundwater levels of electricity tariffs and pricing of diesel,
- Promote efficient water use techniques, such as sprinkler or drip irrigation, among farmers.
- Provide necessary pricing, inputs and extension support to farmers to facilitate growing of feasible and remunerative alternative crops from efficient water use
- Support practices of water conservation methods for enhancing groundwater recharge ,
- Mandate rainwater harvesting in all new constructions in relevant urban areas, as well as proper design techniques for road surfaces and infrastructure to enhance groundwater recharge.
- Support R&D in cost effective techniques suitable for rural drinking water projects for removal of arsenic.,

- ***Strategy iv. Conservation of Wetlands***

- Development of a national inventory of all wetlands
- Setting up of legally enforceable regulatory mechanism for identified valuable wetlands to prevent their degradation and enhance their conservation.
- Developing conservation and prudent use strategies with participation of local communities, and other relevant stakeholders for each significant catalogued wetland and creation of public awareness,
- Practising eco-tourism strategies for identified wetlands through multi-stakeholder partnerships involving public agencies, local communities, and investors
- Ensuring environmental appraisal and impact assessment of all developmental projects on wetlands

- ***Strategy v. Mitigation of Water Pollution***

- Developing public-private partnership models for setting up and operating effluent and sewage treatment plants. Once the models are validated, progressively privatize such partnerships.
- Encouraging reuse of treated sewage and industrial wastewater before final discharge to water bodies.

- Ensuring clustering of polluting industries to facilitate setting up of common effluent treatment plants with adequate participation by local communities
- Promote R &D in development of low cost technologies for sewage treatment at different scales (Ex. East Kolkotta Wetlands project)

3.1.19 To Design Incentive Structures To Promote Artificial Recharging Of Ground Water Sources

A Scheme on "Artificial Recharge to ground water through Dug wells" has been launched by the Ministry for augmenting the ground water resources in 1180 Over- exploited/Critical/Semi-Critical areas in 7 States namely Andhra Pradesh, Maharashtra, Karnataka, Rajasthan, Tamil Nadu, Gujarat & Madhya Pradesh to provide sustainability to the dug wells. Such schemes need proactive support from all stakeholders.

The Ground Water Management and Regulation Scheme of Ministry of Water Resources is also aimed at promoting the artificial recharge on scientific lines and to evolve the innovating and efficient recharge structures in various conditions. Outcome of such schemes should be used for knowledge sharing and information and dissemination.

Ministry of Water Resources has instituted annual awards namely Bhoomijal Samvardhan Puraskars and National Water Award in the Year 2007. The award aims to encourage the Non-Governmental Organizations (NGOs) /Gram Panchayats/ Urban Local Bodies for adopting innovative practices of ground water augmentation by rainwater harvesting and artificial recharge through people's participation. Such type of awards should be instituted by state and local governments also.

Proposed Strategies:

- It is envisaged to take the Formulation of Master Plan for Artificial Recharge at district level,
- demonstrating Artificial Recharge Schemes,
- Capacity building programmes for Community/Panchayat Raj Institutions/stakeholders/welfare Associations/ NGOs by sharing knowledge and expertise,
- Public awareness campaign and information dissemination at block level in the over-exploited/critical and problematic areas of the country.
- Regulation of ground water development for better and equitable management of ground water resources, and
- Conferring the awards to the stakeholders for promotion of Artificial Recharge.

3.2 DOMESTIC & INDUSTRIAL SECTORS

EFFICIENT USE OF WATER IN CITIES AND INDUSTRY

The main supply problems facing major urban centers are the depletion of local sources and their contamination, the high costs of water impoundment and conveyance, and conflicts of interest arising among the various users over these sources. Besides these problems, cities are plagued with a high incidence of leaks and water-wasteful technologies continue to be employed. There is virtually no reuse of water, billing and rate collection systems are inefficient, rates are usually insufficient to cover supply costs and there is a general lack of social conscience.

3.2. 1. Domestic Sector

On average, 71% of a city's total water production is used in homes, 12% in industry, 15% by commercial users and 2% by the services sector. The techniques for efficient use domestic and industrial use of water can be classified as: metering, leakage reduction, tariff systems, water saving devices, regulations, reuse and cultivation of appropriate plant species, and information and education.

i. Metering

Metering required both at source level and user level. Metering at source level involves measuring the water flows impounded, conveyed and distributed. Metering at user level is to measure each user's consumption periodically in order to charge for the service. The meeting can have an influence on domestic water use, with reductions of up to 25% in areas that previously had no metering. This, however, involves high cost of capital and requires changes to the tariff structure. A strategy for the installation of meters at user level can be based on selective metering, metering by sectors and combined metering.

ii. Leakage Control

Leakage constitutes a major part of losses in drinking water systems: leaks in purification plants, distribution networks and home outlets leading to wrong estimates, unauthorized outlets and unrecorded volumes consumed by municipal services such as the watering of public gardens or fire hydrants. Leaks in the supply network may be visible or concealed; they first rise up through the soil or pavement, the latter are not visible and flow into the drainage system or aquifer. Leakage reduction through detection and repairs can save water up to 9%, but costs can be higher than that of water saved.

iii. Tariff

Water costs are largely subsidized by governments, but it has become increasingly difficult to continue with such financing schedules, and it is now a question of establishing rate policies that emphasize greater user involvement. If users are charged appropriately for water services, consumption becomes more efficient, since the amount of water used tends to diminish. Thus can be an effective tool to control wasteful use of water and effect water savings up to 10%, but needs to enroll user's cooperation through well designed tariff structure.

iv. Water saving Techniques

Water saving devices can help save water up to 10 % but are expensive and need cooperation of users.

Toilets : Traditional toilets use between 16 and 20 liters per flush, which means an average consumption of 80-100 liters daily per inhabitant; water-efficient toilets using only 6 liters per flush can reduce that figure to 30 liters a day per inhabitant. Other types of toilets go to the extreme of not even using water, such as biological toilets or incinerators, which degrade fecal matter in deposits situated below the toilet and turn it into fertilizer.

Showers: The discharge from showers should not exceed 10 l/min. This can be accomplished by using new shower-head designs or flow reducers.

Basin and sink faucets: Flow reduction in these fixtures is achieved by using aerators. An aerator can reduce flow by as much as 6%.

Washing machines and Dish washers: There are basically two types of washing machines: front loaders and tub machines (top loaders); the first type can be more efficient than the second type. Further, the efficient washing machines have reduced water consumption by up to 24% in comparison with traditional models.

Indoor leak detection: A great deal of water is lost in homes through leaks in pipes, plumbing fixtures and toilets.

The real solution is the manufacture of leak-proof fittings

Garden watering: The best way of saving water in gardening is to observe appropriate garden watering practices. The best time to water is between 4 and 8 a.m. or 8 p.m. and midnight.

Adoption of native Plants: The plants that make the most efficient use of water in any region are native ones. Growing these crops effects considerable savings in water..

Car washing: One of the most wasteful ways of using water is washing down cars with a hose. It is recommended using wet cloth and to patronize public car wash services that reuse water.

Swimming pools: It is hardly ever necessary to change the water in a swimming pool. It can always be clarified by using portable equipment and the appropriate chemicals. The other factors that cause waste in swimming pools are seepage and evaporation.

Pressure reducers: In areas of high pressure, the use of pressure-reduction valves is recommended, as these can produce savings of up to 10%. Table below gives some examples of efficient water use methods.

Regulations & restrictions

Regulations have good water saving potential (up to 20%) but require cooperation of the users.

Reuse and recycling of water can effect water savings up to 25%. However, acceptance by users is a major problem..

User education

Mass awareness programmes serve to save water substantially and requires well planned and coordinated efforts by Govt. Agencies.

Strategies For Domestic Sector

i. Mandatory guidelines for recycling and reuse on the lines of those proposed by the Ministry of Environment and Forests and the Central Pollution Control Board.,

ii. Provision of incentives for adopting water saving devices, Creation of knowledge bank on efficient ,low cost methods of

i. Reclaiming waste water and recommending best practices to various classes of end users,

ii. information generation on socio-economic and environmental impacts of reuse of recycled waste water, and

iii. raising awareness of waste water recycling and reuse at all levels of uses (villages, districts, states etc.,) through training programmes, exhibitions, extension activities, media coverage etc.

3.2.2 Industrial Sector

There is considerable s scope for using water more efficiently in industry. Machinery, industrial processes and related support services require large quantities of water which can be reduced significantly by introducing water efficient technology. Industrial water use can be grouped into three main categories: heat transfer, power generation and use in processes. The main water efficiency actions in industry are recycling, reuse, and reduction of consumption; two basic activities are necessary in all three cases: measuring the amount and monitoring the quality of the water.

Metering is the most basic activity for any efficient-use program in the industrial sector. In processes, equipment, irrigation areas, dipping, etc. metering helps to program a better use of water and to motivate employees to play an active role in saving water.

i. Reduction of consumption

It is possible to optimize processes, improve operations or modify the equipment or the attitude of users. Industries have adjacent areas (gardens, sanitary services, etc.) in which significant reductions can be achieved, for example by putting in plants native to the area in which the industry is located, using efficient watering equipment, watering at night, etc. In washrooms and toilets, repairing leaks and the use of flow reducers in water-efficient toilets and showers will aid in reducing industrial water consumption.

ii. Regulations

In general, regulations to improve water use efficiency are of a restrictive nature and have an impact on water savings; they may be of short or long duration, or applicable only during periods of shortage; in the latter case they normally require very strict surveillance and should therefore only be applied when really necessary.

Strategies For Industrial Sector

i. To incorporate appropriate modifications in the National water Policy directions to include integration of safe use of treated waste water in irrigation
ii. To adopt an integrated approach for planning & management of source waters through various level intersectorial groups concerned with both quantitative and qualitative aspects of water, If need be the already existing institutional and legal arrangements may be revisited
iii. To adopt mandatory guidelines for recycling and reuse on the lines of hose proposed by the ministry of environment and Forests an the Central Pollution Control Board,
iv. To Provide incentives (tax relief, excise exemption, etc.,) for industries and commercial establishments to encourage recycling and reuse,
iv. To Revise price structure to encourage industries and commercial establishments to use less water per unit of production, and
v. To Fix differential rates of pollution cess.

CHAPTER 4. ACTION PLAN FOR IMPLEMENTATION DURING XI AND XII FIVE YEAR PLANS

PLAN OF ACTION AND TIMELINESS

The implementation period of the Mission would be eight years starting from the F.Y. 2009-2010 and the completion would be in the F.Y. 2016-17. First year of the Mission would be utilised in setting up of the state Water Resources Regulatory Authorities and formulation of State Water Resources Policies. Sensitization of the staff of concerned Departments, Capacity building of staff and stake holders and actual field implementation will be taken up from the second year onwards.

4.1 ACTION PLANS - IRRIGATION SECTOR

I. INFRASTRUCTURAL UP GRADATION / RENOVATION

A. SURFACE WATER IRRIGATION

1. A State Level Water Management Programme may be taken up:
   - (i) To perform periodically the Evaluation of Performance of the Irrigation Projects, Benchmarking and Water Auditing of the Irrigation Projects.
   - (ii) To identify and reduce bottlenecks through performance review of the existing projects to bring back the canal systems to their designed standards
   - (iii) To continue schemes on Micro irrigation
   - (iv) To take up Extension, renovation, and modernization (ERM) of existing major & medium and minor irrigation projects including reclamation of saline and waterlogged areas
   - (v) To improve performance of canal system through selective lining
   - (vi) Early completion of ongoing Major and Medium Projects

2. A State Level Programme for use of Modern/Micro-irrigation techniques may be taken up:
   - (i) To tie up with Industries for their support in developing the low cost Modern / Micro-irrigation equipments with region specific.
   - (ii) R&D efforts in economizing micro irrigation systems in collaboration with Industries
   - (iii) To facilitate the application of Modern / Micro-irrigation techniques viz. Sprinkler irrigation, drip irrigation, deficit irrigation etc.

Time Frame For Undertaking The Action Plan Starting From 2009-2010:

Action Plan 1(i): - **(First Two years) 2009-11**

Action Plan 1(ii) : - **(Three Years to follow Action Plan 1 (i))2009-12**

Action Plan 1(iii) : **- (Three Years to follow Action Plan 1 (i)) 2009-12**

Action Plan 1(iv): **- (Over XI th Plan & XII th Plan Period) 2009- 20017**

Action Plan 1(v) : **- (Over the first Two Years after Action Plan 1 (iii)) 2009-11**

Action Plan 2(i): - **(First One year) 2009-10**

Action Plan 2(ii): - **(First Two Years) 2009-11**

Action Plan 2(iii), **- (First Three Years) 2009-12**

Resource Requirement

Action Plan 1:

All the approved major, medium irrigation projects under construction in the states and all the approved major, medium irrigation projects coming under the special category viz. in (a) drought-prone areas, (b) tribal areas, (c) States with lower irrigation development as compared to National average and (d) districts identified under PM's package for agrarian distress should be provided fund support under the AIBP. The State Govt. may come-up with the proposals to achieve the enshrined objectives of increased efficiency by the 20%.

Action Plan 2:

For adoption of micro irrigation techniques and R& D efforts, the fund for providing subsidy support should be provided by 50:50 bases by the centre and states.

Additional requirement of funds is given in Annexure-2

B. GROUNDWATER IRRIGATION

1. To Promote Artificial Recharge Of Ground Water For Augmentation And ustainability Of Water Sources

The action plans for promotion of artificial recharge to ground water is proposed as follows:

I. Formulation and Implementation of Master Plan for artificial recharge at district level for the country in association with central and state ground water agencies.

II. Construction of demonstrative artificial recharge schemes in the Over-Exploited/Critical/Drought affected/Poor quality/Coastal/Scarcity areas.

III. Capacity building for Community/Panchayat Raj Institutions/Stakeholders/Welfare Associations/NGOs, VOs etc. strength Water Management Training programmes at Block level in the Over-Exploited/Critical/Drought affected/Poor quality/Coastal/ Scarcity areas.

IV. Mass Awareness Campaign for raising the awareness levels of common public and community in Over-Exploited/Critical/Drought affected/Poor quality/Coastal/Scarcity areas in the domain of ground water management of the country.

V. Notification of Over-Exploited and Critical blocks/areas for management of water resources.

vi. Conferring the National Water Award and Bhoomijal Samvardhan Puraskars.

Time Frame For Undertaking The Action Plans Starting From 2009-10

Action Plan I –	Formulation in 2009-10 and Implementation in remaining years of XIth Plan & XIIth Plan.
Action Plan II –	75 blocks in 2009-12 of XIth Plan and proposed to cover remaining of 839 Critical blocks in 5 years during XIIth Plan (2012- 2017)
Action Plan III –	XI th Plan period (up to 20011-12) and continue in the XIIth Plan period Up to 2016-17..
Action Plan IV –	XI th Plan period (up to 20011-12) and continue in the XIIth Plan period Up to 2016-17..
Action Plan V –	Notification of OE/Critical areas during XIth Plan & XIIth Plan
Action Plan VI –	Conferring the National Water Award and Bhoomijal Samvardhan Puraskars during XIth Plan & XIIth Plan (up to 2016-17)

Resource Requirement

For Action Plans I to V: Additional funds to the tune of Rs. 357.3 Crores is required to be provided under state Plan Outlays**.**

For Action plan vi. Additional funds to the tune of Rs. 8.7 Crores is required to be provided under state Plan Outlays

II. INSTITUTIONAL REFORMS

A. SURFACE WATER IRRIGATION

1. To formulate and adopt State Water Policy in consonance with National Water Policy, 2002 by the each states/UTs.

2. To Set up of State Water Resources Regulatory Authorities by the each state/UT:

   (i) To regulate water resources within the state
   (ii) To facilitate and ensure judicious, equitable and sustainable allocation/distribution of water and its utilization
   (iii) To fix bulk tariff for use of water for agriculture, industries, drinking water and other uses for full recovery of O&M cost of the projects
   (iv) To carry out water audit and budgeting
   (v) To clear new projects after ensuring their development as per the integrated State Water Plan, in conformity with statutory and other obligations of interstate entitlement, and also viable from the hydrologic, economic, environmental
   (vi) To identify the Water Users Associations (WUAs) for management, installing measuring devices, calculation of entitlement, fixation of rotational programme and other related issues

3. A State Level Joint Panel may be set up in integrated manner by establishing appropriate linkages with Govts, Non-Govt. agencies and WUAs:

   (i) To manage the multidimensional facets involving improvement of physical infrastructure operation, agronomic practices of water, methods and techniques for optimizing the yields, other research needs, socio-economic and environmental concerns, weather forecast & irrigation needs by the crop weather watch group etc.
   (ii) To study and recommend on ground water recharge and its uses in conjunction with surface water.
   (iii) To study water logging, salinity and alkalinity problems and suggest measures for improvements

4. To promote Water Users Associations for all the irrigation potential created.

Time frame for Undertaking The Action Plans

Action Plan 1 & 2.

Formulation and adoption of State Water Policies and setting up of the State Water Resources Regulatory Authorities by the respective states – (Within one year from the date of adoption National Mission (should be up to the end of the year 2009-2010 in the 11th Five Year Plan.)

Action Plan 3.

Setting up of State Level Joint Panel by establishing appropriate linkages with Govt, Non-Govt. agencies and WUAs – (Within one year from the date of adoption National Mission (should be up to the end of the year 2009-2010 in the 11th Five Year Plan. The WUAs could be considered in the panel soon after the completion of projects in respect of all aspects enshrined under infrastructural augmentation).

Action Plan 4
It is proposed to complete this activity in two years. (2009-11)

Resource Requirement

The fund support for above action plan should be generated by the State Governments concerned with their resources. Additional fund requirement is given in Annexure-2 .

B. GROUNDWATER IRRIGATION

1. Strengthening of CGWB up to district level and State Ground Water Organisations up to block level.
2. To set up State Ground Water Authority for ground water regulation.

Time Frame for Undertaking the Action Plans

Action Plans-1&2 2010-11 & 2011-12

Resource Requirement
Additional Fund requirement is given in Annexure-2

IV. ADMINISTRATIVE REFORMS

A. SURFACE WATER IRRIGATION

1. To restructure the Water Resources Departments to bridge the knowledge gap in planning, development and management of water resources in sustainable manner.

2. To formulate a training and career propagation policy to the water resources personnel, professional bodies and WUAs

3. To strengthen the WALMIs for facilitating training and technical support to the water resources personnel, professional bodies and WUAs

4. To constitute a group of technical experts for technology forecasting in the water resources sector

5. To set up a joint committee in collaboration with all water user sectors to create mass awareness about the need for conservation of water and its optimal utilization and to reduce wastages of water during their utilization.

Timeframe For Undertaking The Action Plan

Action Plan 1, 2 & 3.

First Two Years(2009-11)

Action Plan 4 & 5.

First One Year (1009-10)

Resource Requirement

The fund support for above action plan should be generated by the State Governments concerned with their resources. The central assistance could be on strengthening of WALMIs and mass awareness programmes on 50:50 bases with the assistance of the State Governments concerned. Additional fund requirement is shown in Annexure-2.

B. GROUND WATER IRRIGATION

- To fix the appropriate tariff for water / electricity usages.

- To finance the construction of recharge structures by private sector.
- To ensure Private Public Partnership for artificial recharge to ground water.

Timeframe For Undertaking The Action Plans 2010-11& 2011-12

Resource Requirement

- The state government may come up to implement the Master Plan for Artificial Recharge to achieve the objective of artificial recharge to ground water including providing the land for construction of recharge structure. Centre - State Shares for fund sharing should be 50:50 basis.
- Additional fund requirement for Capacity Building of ground water organizations on artificial recharge techniques, exchange and coordination of advancement in the technology of artificial recharge, and for sensitizing the stakeholders for conservation in efficient use of water resources is shown in Annexure-2.

The additional fund requirement during 11th Five Year Plan is shown in Annexure-2.

4.2 ENHANCEMENT OF FUND ALLOCATION DURING 11th FIVE YEAR PLAN AND ALLOCATION OF FUND IN 12th FIVE YEAR PLAN

The additional fund requirement during 11th Five Year Plan and in the 12th Five year Plan is shown in Annexure-2.

4.3 DOMESTIC & INDUSTRIAL SECTORS

Action Plans:

(i) plumbing codes (include labeling of plumbing fixtures)
(ii) Set up Water efficiency labeling regulations (for appliances)in the lines of Bureau of Energy Regulation
(iii) Incorporate water efficiency initiatives into government policy and regulatory structures
(iv) Integrate water efficiency criteria into infrastructure assistance programmes including incentives for water efficiency planning
(v) Develop a generic water efficiency plan outline as a guide for municipalities/PRIs/Water Supply Boards and Departments
(vi) Develop municipal water efficiency plans to promote the following actions to be taken at municipal levels
(vii) Identifying and reducing unaccounted through water audits and leakage control programs
(viii) Introducing mandatory metering and moving towards universal metering.

(ix) Undertaking audit and retrofit programs for commercial, industrial, educational and residential facilities
(x) Coordinate development of generic public education and awareness strategy
(xi) Concerned Departments draft water use efficiency public education programs
(xii) Organize events and conferences for initiating public, stakeholder and school information and education programs in support of water efficiency.
(xiii) Priority funding for water efficiency R&D activities
(xiv) Sponsor and encourage trade shows to showcase country water efficient products and technologies

The time frame and additional funding requirements separately for the remaining period of the XI th Plan and the XII th Plan are indicated as shown in Annexure-2.

Chapter 5. MONITORING & EVALUATION

5.1 MEASURES REQUIRED FOR PERIODIC MONITORING AND EVALUATING THE ACTIONS

5.1.1 Irrigation Sector

surface Water Irrigation

The periodic monitoring and evaluation of the projects will be carried out by the regional field offices of CWC as per the norms being followed by the CWC.

Ground Water Irrigation

The periodic monitoring and evaluation of the ground water related schemes will be carried out by the Regional Offices of Central Ground Water Board and State Ground Water Organisations

5.1.2 DOMESTIC & INDUSTRIAL SECTORS

Periodic monitoring and valuation shall be carried out by the Ministry of Urban development, Ministry of Industry and Ministry of rural Development.

Annexure -1 Agriculture and crop water use in India

Annexure – 2 Action Plan of Technical activities (Pl. see attached file)

Annexure – 3 Constitution of the Subcommittee on Efficient Use of Water For Various Purposes

Annexure-1

Agriculture and crop water use in India (Provided by ADG (WM), ICAR)

The intended service from water in agriculture is the creation of favourable water regime for crop and animal production systems. Hence agricultural water management signifies those methods, systems and techniques of water conservation, remediation, development, application and use that provide a socially and environmentally favourable level of water regime to agricultural production system at the least economic cost. As the agricultural production programmes are distributed area-wise under varying conditions of rainfall, climate, soil and topography, agricultural water management is site-specific; hence, appropriate water-management technologies should be developed and adopted to suit the location specific needs. Appropriate water management is select and adoption of the right solutions to meet the agricultural water needs in a particular environment.

The research on irrigation water management should contribute in generating environment-friendly technology of water conservation, removal, development, application and utilization to bring more areas under production by creating favourable water regime to enhance crop production. Hence the research should aim to develop new knowledge and technology for(i) effective development, management, and conservation of on-farm water resources for its sustained availability and utilization,(ii) significant reduction in the use of irrigation water per unit irrigated area, (iii) removal of excess water from agricultural lands, (iv) development of sustainable cropping system in relation to the availability of water, (v) devising multiple uses of water in agricultural production programmes to enhance water productivity, (vi) reuse of poor quality municipal, industrial, agricultural and other waste waters, and (vii) avoiding/reversing the contaminations and further degradation of soil and water resources. So far only applied research has formed the core of research activities to develop solutions to various irrigation water-management problems to enhance crop productivity. The results are presented crop wise.

Rice is cultivated on diverse land forms (uplands, medium lands and lowlands) under varied agro climatic and hydrologic conditions. The plant grows well below sea level to 2000 metres above MSL and under water-limiting rain fed conditions to moderately submerged and deep water conditions. In several canal-irrigated tracts farmers primarily grow rice during wet season. Usually the upland and medium land rice fields are diked at some submerged edaphic environment and for providing protection to the crop from short-spell droughts. In lowlands the height of dikes is quite small, as these fields get continuous supply of water from upper lands. This review dwells up on different aspects of (i) soil tillage for plant establishment and efficient water use, (ii) optimum water regime, and (iii) rainwater storage in rice fields.

Optimum Water Regime-shallow versus deep submergence

Generally, the farmers have a tendency to apply higher depth of irrigation water (about 10 to 15 cm) to partially overcome the effect of uncertainty in the availability of water and to reduce the labour requirement. Higher depth of ponded water increases the rate of percolation owing to higher hydraulic head and reduces tiller formation by way of submergence of tiller forming parts.

A review of results on intermittent submergence has shown that in kharif rice the intermittent ponding saves substantial amount of irrigation water without compromising the yield. The intermittent period (number of days after the disappearance of water) varies from 1 to 5 days depending upon the rainfall pattern, depth of water table and soil texture.

Some of the research finding by ICAR area as follows:

Wheat

The approach of scheduling irrigation at IWCPE ratio was tested and compared with the existing practices at several other centers and was found superior. The optimum ratio for scheduling irrigation to wheat differed at different centers. At Bikramganj, the optimum IW/CPE ratio for irrigating wheat was 0.90.

Maize

Maize is one of the important crops of India. This has been achieved by extensive use of improved technologies, comprising high-yielding varieties, fertilizers and irrigation. The irrigated area under maize has increased. Development of irrigation facilities enabled the farmers to grow the crop in rabi as well as summer in addition to traditional season of kharif with better yields. The average yield of rabi crop in the eastern states is about 4.0 –6.0 t/ha. Maize is essentially a warm and humid weather crop and grows mostly in kharif whereas due to the favourable weather conditions it grows in kharif and rabi as well.

Studies on irrigation scheduling on the basis of different IW/CPE ratio have been conducted in India by applying 6 cm irrigation depth. Maximum yield was at 1.0 –1.2 ratio.

Sugarcane

Sugarcane is the major source of sugar in the country. Scheduling irrigation to sugarcane based on climatological approach was conducted at Chiplima and Pusa, which showed that maximum yield was at 1.0 –1.2 IW/CPE ratio.

Pigeionpea (arhar)

The results of experiments involving irrigation at critical growth stages have shown that the main kharif crop responded up to two irrigations (6-7 cm each) at pre-flowering/flowering and pod-development stages for significantly higher production of 1.78 t/ha at Faizabad. However, irrigation at pod development stage resulted 14% increase to yield over treatment (1.42 t/ha) as recorded at Faizabad.

Gram

Gram has been found to respond to irrigations provided at branching, flowering and pod formation stages at Navsari where it yielded 2.01 t/ha which is superior to two irrigations provided at any two stages (1.62 to 1.72 t/ha). One irrigation applied at pod formation stage yielded 9.5% more than the watering at branching (2.01 t/ha) at Delhi whereas at Kota the flowering stage was found more responsive to irrigation, which yielded 19.3% more than watering at branching stage (2.02 t/ha)

Lentil (masoor)

Lentil is an important crop of winter season and is grown throughout the eastern region. It is mainly grown on low-lying marginal lands that are subjected to inundation. Lentil is normally cultivated as a rainfed crop, but it responds favourably to one or two irrigations depending upon rainfall and initial soil moisture storage in the profile. At Madhipura, three irrigations (6 cm each) at vegetative, flowering and pod formation stages gave highest yield (1.32 t/ha) Based on meteorological approach, the crop responded up to IW/CPE = 0.8 at Pusa (15 cm irrigation and 1.66 t/ha yield).

Rapeseed and Mustard

Rapeseed and mustard (yellow sarson, brown sarson and toria) together form the second most important oilseed crops of eastern India. Studies on irrigation scheduling based on critical growth stages have shown that mustard requires only one irrigation of 6-7 cm applied at vegetative growth stage (3-4 weeks after sowing at Bikramganj) and 0.6 at Kharagpur (16 cm). The good crop response to irrigation has also been observed at IW/CPE ratio of 0.8 at Pusa ponded water.

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Annexure- 2

Plan of Technical Activities, time targets and financial outlays for "Efficient Use of Water for Various Purposes"-

IRRIGATION SECTOR *

I. INFRASTRUCTURAL UP GRADATION /RENOVATION

(Collaborating Institutions/Organisation: MOWR & State Irrigation Departments)

A. State Plan Outlay (Rs. in Crore)

S.No.	Activity	Action Plan	Time Target	Additional Fund Requirement	
				XIth Plan	XIIth Plan
1.	Special repairs of existing Irrigation System @ 20% of O&M charges as per norms recommended for 13th Finance Commission of Rs. 1500/- per ha for the **years 2009-10, 2010-11** for 34.42 million ha (potential utilized) and as per norms of Rs. 750/- per ha for 7.93 million ha (major & medium irrigation potential unutilized)	4.1.I. A (i) and (ii)	XIth Plan & XII th Plan	1810	4550
2.	Special repairs of existing Irrigation System @ 20% of 2/3 of O&M charges as per norms recommended for 13th Finance Commission of Rs. 1500/- per ha(i.e. Rs.1000/-) for the **years 2009-10, 2010-11** for 60.42 million ha (minor irrigation potential utilized & unutilized)		XIth Plan & XII thPlan	1000	2500
3.	Scheme on Micro Irrigation (Sprinkler & Drip irrigation)	4.1.I. A. 2 (i),(ii),& (iii)	XIth Plan & XIIth plan	1000	2500
4.	ERM of old projects up to end of 5th plan(24.7 million ha. Of major & medium Projects) + Pre independence irrigation potential (22.6 m.ha.) = 47.3 million .ha needs attention. Of this, to take up 2million ha. in the XIth plan and 5 million ha. in the XIIth plan @ Rs. 30,000/ha. (Based on the average cost per ha. based on DPR s of ERM works of major& Medium irrigation projects)	4.1.I. A. 1 (iv)	XIth Plan & XIIth plan	6000	15000

5.	To improve the performance of canal system through selective lining for an estimated 20% of existing irrigation systems (other than those areas taken up in item 4 above) of extent of 2.million ha. in the XI plan and 5 million ha. in the XII plan @ Rs.9000/- (Based on DPRs of selective lining in major& medium irrigation projects)	4.1.I. A. 1 (v)	XIth Plan & XIIth plan	1800	4500
6	ERM of minor irrigation projects to the extent of 2million ha in the XIth plan and 5 million ha. in the XIIth plan, @ Rs.50,000 per ha. (Based on DPRs of ERM works of minor irrigation projects)	4.1.I. A. 1 (iv)	XIth Plan & XIIth plan	1000	5000
7	CADWM projects- scheme on R&M works and correction of conveyance deficiencies @ of Rs.6000 per ha. for 0.10 million ha.	4.1.I. A.1 (iv)	XIth Plan & XIIth plan	60	150
8	CADWM projects- scheme on R&M works and reclamation of waterlogged, saline and alkaline lands, @ Rs 15, 000 per ha. for 0.11 million ha.	4.1.I. A.1 (iv)	XIth Plan & XIIth plan	165	500

SUB TOTAL Rs. Crore 12,835 34,700

B. Centre Plan Outlay (Rs. Crore)

S.No.	**Activity**	**Action Plan**	**Duration**	**Additional Fund Requirement**	
				XIth plan	**XIIth Plan**
1	CAD WM Projects @10% enhancement of provision of 10000 cr. For XIth plan & @ 2200 cr. per year for the XIIth plan	4.1.I. A.1 (iv)	XIth Plan & XIIth plan	400	11000
2	Early completion of on-going major & medium irrigation projects under AIBP	4.1.I. A.1 (vi)	XIth Plan & XIIth plan	No Additional Fund	No Additional Fund

SUB TOTAL 400 1100

II. INSTITUTIONAL REFORMS

A. State Plan Outlay (Rs. Crore)

S.No.	Activity	Action Plan	Duration	Additional Fund Requirement	
				XIth plan	XIIth Plan
1.	Setting up of State Water Resources Regulatory Authorities for all States @Rs. 2 Cr. per state	4.1.II.A Items 1, 2&3	XI th Plan & XIIth Plan	60	300
2.	Establishment of state level joint panels to mange irrigation crops and other management issues @Rs.1 Cr. Per state	4.1.II.A Item 3	- Do	30	150
3.	Promoting WUA s @Rs.10 per ha. For 102.77 m.ha potential created	4.1.II.A Item 4	- Do -	105	525
		SUB TOTAL	**Rs. crore**	**195**	**975**

B. Centre Plan Outlay (Rs. Crore) Nil

III. ADMINISTRATIVE REFORMS

A. State Plan Outlay (Rs. Crore)

S.No.	Activity	Action Plan	Duration	Additional Fund Requirement	
				XI Plan	XII Plan
1.	Restructuring of State Water Resources Departments and Strengthening of WALMIs for facilitating training & technical support to the water resources personnel ,professional bodies, stake holders , WUAs etc., @Rs. 2 Cr. Per Institute	4.1.III.A Items 1, 2 & 3	XI th Plan	40	50
.	Constitution of groups of Technical Experts for Technology forecasting in Water Resources @ Rs1 Cr. per State	4.1.III.A Item 4	- Do -	30	40

3.	To Set up joint committees in collaboration with of all stake holders (WUAs, etc.,) to create mass awareness about the need to conserve water and its optimal use r@ Rs.1 Cr. Per state	4.1.III.A Item 5	- Do-	30	40

SUB TOTAL Rs Cr. 100. 130

B. Centre Plan Outlay (Rs. Crore) - Nil

Total Enhanced Outlay for the XI th Plan & XII th Plan

		XI th Plan	XII th Plan
State Plan	**– Rs.**	**12,130 Crore**	**Rs. 35,805 Crore**
Centre Plan	**-**	**NIL**	

Source: IP (South) Directorate, CWC, MOWR

4. WATER HARVESTING & ARTIFICIAL RECHARGE OF GROUNDWATER

1. State Plan Outlay (Rs. in Crore)

Objective	Action Plan	Duration	Addl. Fund requirement		Collaborating Institution Organisations
			XI th Plan	XII th Plan	
1. Rain Water Harvesting and Artificial Recharge Planning & demonstration &Demonstration	4.1.B.1(i) & (ii)	2 Years (XI th Plan) 5 years (XII th plan)	-	-	CGWB CGWB and State Ground Water organisations
2. Capacity Building	**4.1.B.1(iii)**	XI th plan (remaining period) & XII th plan	8.2	47	CGWB and State Ground Water organisations

3. Creation of mass awareness	**4.1.B.1(iv)**	XI th plan (remaining period) & XII th plan	124	1373	CGWB and State Ground Water &Other organisations NGOs, and VOs
4. Notification of Over-Exploited and Critical blocks	**4.1.B.1(v)**	XI th plan (remaining period) & XII th plan	-	-	CGWB and State Ground Water &Other organis
5. Awards and Bhoomijal Samvardhan Puruskars	**4.1.B.1(vi)**	XI th plan & XII th plan a b c	 - 60 165	 - 100 275	CGWB and State Ground Water &Other organisations

SUB TOTAL Rs. Cr. 357.2 1795

2. Centre Plan Outlay (Rs. in Crore) - for XI th & XII th Plan

Objective	Action Plan	Duration	Addl. Fund requirement		Collaborating Institution/ Organizations
			XI th Plan	XII th Plan	
1. Rain Water Harvesting and Artificial Recharge Planning & demonstration	**4.1.B.1(i)** & (ii)	2 Years (XI th Plan) 5 years (XII th plan)	-	200	CGWB CGWB and State Ground Water organizations

2. Capacity Building	**4.1.B.1(iii) (480 blocks)**	XI th plan (remaining period) & XII th plan	1.8	3.0	CGWB and State Ground Water organizations
3. Creation of mass awareness	**4.1.B.1(iv) (480 blocks)**	XI th plan (remaining period) & XII th plan	1.0	2.0	CGWB and State Ground Water &Other organisations NGOs,and VOs
4. Notification of Over-Exploited and Critical blocks	**4.1.B.1(v)**	XI th plan (remaining period) & XII th plan	1	9	CGWB and State Ground Water &Other organisations
5. Awards and Bhoomijal Samvardhan Puruskars	**4.1.B.1(vi)**) Conferring the awards for adopting the best practices of Rain water Harvesting & Artificial Recharge	XI th plan & XII th plan a b c	5 - -	9 - -	CGWB and State Ground Water &Other organisations
	Sub Total		8.8	223.0	

Total Outlays:

	XI th Plan	XII th Plan	Total
Centre Plan R. Crore	**8.8**	**223.0**	**231.8**
State Plan Rs. Crore	**357.2**	**1795.0**	**2152.2**
Total (State+ Centre) Rs. Crore	**366.0**	**2018.0**	**2384.0**

(# Source: CGWB Communication

Total Additional Fund Requirement for Irrigation Sector

	XI th Plan	XII Plan
State Outlay (Rs. Crore)	**13,130.0**	**35,805.0**
Centre Plan Outlay(Rs. Crore)	**8.8**	**223.0**
TOTAL (Rs.Crore)	**13,138.8**	**36,028.0**

B. DOMESTIC & INDUSTRIAL WATER SUPPLY SECTORS @

1. State plan outlays (Rs. Crore)

Objective	Action Plan	Duration	Addl. Fund requirement		Collaborating Institution/ Organisations
			XIth Plan	XIIth Plan	
Enhancement of water use	4.3 (i) 4.3 (ii) 4.3 (iii)	XI Plan XI Plan XI Plan	200	-	MoUD/ MoRD/ BIS DO MoUD/ MoRD / MoEF DO
Encouraging municipal/ PRIs/ Water supply Boards&	4.3 (iv) 4.3 (v) 4.3 (vi to	XI Plan XI Plan XI Plan	-	-	Municipalities Nagar palikas PRIs
Public education and awareness (IEC/ HRD)	4.3.(x) 4.3 (xi) 4.3(xii)	XI Plan XI Plan 3 Years	400	100	MOUD MORD Do State govt. Deptt. Municipalities PRIs Do

Research and development and technology transfer	4.3.(xiii) 4.3 (xiv)	2009-2014 Once every year	40	60	CSIR Labs INDUSTRIES

@ (Source: Dy. Director, DDWS **SUB TOTAL Rs. Crore 640 160**
*Tentative estimates
(Source: Dy. Director, DDWS)

3. Central Plan (Rs. Crore) --- Nil

TOTAL ADDITIONAL FUND REQUIREMENT for all Sectors (Rs. Crore)

State plan outlay (Rs. Crore)

	XIth Plan	XIIth Plan
Irrigation Sector	**13,138.8**	**36,028.00**
Domestic & Industrial Sector	**640.0**	**160.00**
Total Rs. in crore	**13,778.8**	**36188.00**

Grand Total for XI and XII Plan for State Plan Rs. 49,966.80 crore

Annexure-3

Composition of the Sub-Committee on Efficient Use of Water for Various Purposes for National Water Mission under National Action Plan on Climate Change

S.No.	Name , Designation and address	Status
1.	Mr. N. K. Das, Additional Secretary, Ministry of Agriculture, Government of India, Krishi Bhawan, New Delhi	**Chairman**
2.	Ms. Sunita Narain, Director, Centre for Science & Environment, 41, Tugalakabad, Institutional Area, New Delhi	Member
3.	Mr. A.K.Ganju, Member (WP&P), CWC, Seva Bhawan, R.K.Pura, New Delhi.	Member
4.	Mr. H.S. Dhankar, Special Secretary – Water Resources, Govt. of Haryana, New Haryana Civil Secretariat, Sector-17, Chandigarh	Member
5.	Shri L.V. Nagarajan, Pr. Secretary, - Water Resources, R.No.306, 3rd Floor, Vikas Soudha, Dr. B.R. Ambedakar Veedhi, Bangalore.	Member
6.	Mr. A.R. Bhaisare, Regional Director, Central Ground Water Board, NH.IV, Faridabad, Haryana.	Member
7.	Dr. A.K.Singh, Deputy Director General, NRM Division, ICAR, Anusandhan Bhawan-II, IARI Campus, Pusa, New Delhi.	Member
8.	Mrs (Dr.) R. Dalwani, Director,NRCD, Ministry of Environment & Forests, (CPCB), Paryavaran Bhawan, Lodi Road, New Delhi.	Member
9.	Mr. R.S. Vundru, Special Secretary-Irrigation, Government of Haryana, Haryana Civil Secretariat, Chandigarh-2740133.	Member
10.	Mr. E.Venkataiah, Pl. Secretary(Irrigation), Govt. of Karnataka, M.S. Building, Bangalore.	Member
11.	Dr. M. Moni, Deputy Director General, NIC,CGO Complex, Lodhi Road, New Delhi 110003.	Member
12.	Mr. J.B. Ravinder, Asstt. Adviser, CPHPEO, Department of Urban Development, Mo UD, Nirman Bhawan, New Delhi.	Member
13.	Mr. Rajsekher Asstt. Adviser, Deptt. of Drinking Water Supply, MoRD, Paryavaran Bhawan, CGO Complex, Lodi Road, New Delhi.	Member
14.	Dr. Veer Pal, Commissioner, CAD, Ministry of Water Resources, Krishi Bhawan, New Delhi.	Member
15.	Mrs. Lily Mitra, Dy. Commissioner(Hort.),Department of Agriculture & Cooperation, (Horticulture Division), Krishi Bhawan, New Delhi.	Member
16.	Mr. C.M.Pandey, Deputy Commissioner (NRM), Deptt. of Agriculture & Coopn, NRM Division, Shastrii Bhawan, New Delhi	Member
17.	Dr. P.B.S.Sarma, Former PD (WTC), IARI, New Delhi	Consultant
18.	Mr. Y.K. Sharma, Director (I.P-South), as Member Convener, Central Water Commission, Sewa Bhawan, R.K.Puram, New Delhi.	Member Convener

Report of Sub-Committee

on

Basin Level Planning and Management

CONTENTS

1.0 Background

1.1 National Action Plan on Climate Change (NAPCC)

The National Action Plan on Climate Change released by the Hon'ble Prime Minister in June 2008 had laid down the principles and had identified the approach to be adopted to meet the challenges of impact of climate change and following 8 National Missions were identified:

- National Solar Mission
- National Mission for Enhanced Energy Efficiency
- National Mission on Sustainable Habitat
- **National Water Mission**
- National Mission for Sustaining the Himalayan Eco-system
- National Mission for a Green India
- National Mission for Sustainable Agriculture
- National Mission on Strategic Knowledge on Climate Change

1.2 National Water Mission

High Level Steering Committee of the **National Water Mission** under the Chairmanship of Secretary (WR) during the first meeting held on 7th August 2008, decided to prepare a comprehensive mission document detailing objectives, strategies, plan of action, timelines and monitoring and evaluation criteria would be developed and submitted to Prime Minister's Council on Climate Change by December, 2008.

To prepare a Comprehensive Mission Document in a time-bound manner, the Committee decided to constitute six Sub-Committees to examine all related aspects in respect of specific issues, of which "Basin Level Planning & Management" is one of them.

1.3 Sub-Committee on Basin level Planning & Management

The composition of the Sub-Committee on Basin Level Planning & Management is as under:

(i)	Member (Water Planning & Projects)	Chairman
(ii)	Principal Secretary, Water Resources Deptt, Orissa	Member
(iii)	Representative of Planning Commission	Member
(iv)	Representative of IIT, Roorkee	Member
(v)	Commissioner (PR)	Member
(vi)	Representative of NWDA	Co-opted Member
(vii)	Chief Engineer (BPMO), CWC	Co-opted Member
(viii)	Member-Secretary, UYRB	Co-opted Member
(ix)	Director (BP), Central Water Commission	Member-Secretary

Three Members viz. a representative from National Water Development Agency (NWDA), Chief Engineer (Basin Planning & Management Organisation), Central Water Commission & Member-Secretary, Upper Yamuna River Board (UYRB) were Co-opted as

Members of the Committee in view of their expertise with various aspects related to issues on Basin Level Planning & Management.

2.0 Objectives / Issues regarding Basin Level Planning & Management

Based on the issues highlighted in the National Action Plan on Climate Change and in the Technical document pertaining to Basin Level Planning & Management the following issues have been identified:

i) Ensure integrated water resource management helping to conserve water, minimize wastage and ensure more equitable distribution both across and within states.

ii) Ensuring more effective management of water resources.

iii) Integrated water policies to cope with variability in rainfall and river flow at the basin level.

2.1 Need for Integrated Water Resources Planning, Development & Management at river basin level

In the early stages of development, considering the needs of the then population, water resource planning was project specific and often for specific purposes only. Excepting some basins like Damodar, no plans were formulated for long range development, particularly for integrated use of water resources.

In a vast country like India with diverse topography, climate, geology and consequently hydrology, the distribution of available water resources is not uniform in various parts of the country. With the increase in the population and the tempo of development, there has been considerable increase in demand for water of desired quality for various basic and developmental purposes like drinking and municipal water supply, irrigation, thermal and hydropower generation, industrial requirement, navigation, pisci-culture, water quality and maintenance of ecology, etc. Any reduction in availability, further increase in water demands or large variability in the supplies resulting from climatic change would lead to larger water stresses.

Based on several theoretical studies reported, some of the impacts of climate change on water resources of India may include occurrence of more intense rains, changed spatial and temporal distribution of rainfall, higher runoff generation, low groundwater recharge, melting of glaciers, changes in evaporative demands and water use patterns in agricultural, domestic and industrial sectors etc. Climate change may also alter the distribution and quality of India's natural resources and adversely affect the ecological sustainability of India's development path. The rise of temperature, as a result of climate change is directly related to the processes such as evaporation, transpiration, condensation, etc. involved in the hydrologic cycle, which in turn impacts the temporal and spatial characteristics of water resource availability and their quality. Under the climate change situation, water allocation conflicts, within individual users, within users of different classes, within interest groups of the different types of uses, (including the use and non-use), amongst States of India, and amongst co-basin Nations, may all become more acute.

As the water availability in India varies both in space and time, some river basins have much larger water availability, as compared to their area or population, some other basins have comparatively much lesser water availability. Considering the situation, inter-basin transfers had also been recognized as an important tool for increasing usable water. National Perspective Plan for water transfers was drawn up and necessary studies to finalize the Plan are being conducted by NWDA. Strategies like inter-basin / intra-basin water transfers would have to be considered with added gravity and may have to be implemented expeditiously.

It is also stressed that non-development of water storage projects is not a viable or available option; due to the large temporal variations in river flows in Indian monsoonal climate. It is imperative that conservation, recycle, reuse of precious water and proper treatment of waste water must be given serious attention for sustainability. The available utilizable water resources would be inadequate to meet the future water demand of all the sectors. The situation can be salvaged by making concerted efforts to achieve higher standards of efficiency in water use in all sectors of use. There are also several agencies in the field of water resources development and management. It is necessary to analyze fast emerging scenario in water sector and strategies to ensure integrated water resources development and management.

A comprehensive strategic planning for integrated use of our water resources has, therefore, become an urgent necessity. The need for such planning has been highlighted in the past by Irrigation Commission, Irrigation Ministers' Conference, etc. and also enunciated in the National Water Policy. The National Water Policy recognises the river basin as the basic hydrological unit for water resources planning and recommends setting up of appropriate river basin organisations for the planned development and management of a river basin /sub-basins as a whole.

All the above aspects bring to light the necessity of having some implementing and decision making mechanism for river basin development in the country which may consider and adopt an optimal model most suitable to the basin. Appropriate institutional mechanisms at State as well as at Central govt. level need to be established for the integrated, optimum and holistic development and management of water resources.

3.0 Strategy of Integrated Water Resource Planning, Development & Management

Integrated Water Resources Planning, Development & Management basically involves the rational and optimum conservation & protection, equitable allocation & distribution, and prudent utilization of the available water resources within the framework of socio-economic-environmental considerations by involving the stakeholders in an atmosphere of co-operative participation. This necessitates a paradigm shift towards basin planning approach from the project-centric approach to meet the future water demand of all the sectors and adapt/ mitigate the affects of climate change.

India's aspirations for meeting continued socio-economic development and environmental sustainability calls for fundamental and urgent solutions through the formulation of a comprehensive, integrated, multi-disciplinary and multi-sectoral approach for planning, development and management of water resources. To achieve the objectives/

issues as mentioned, it is extremely important to adopt the strategy of integrated water resources planning, development and management at river basin level.

4.0 Action Plan for Basin Planning & Management

For optimal utilization of available water, there is need to formulate projects within the framework of overall basin/sub-basin plan. River basin development and management involves issues of multi-disciplinary nature. All the above aspects bring to light the necessity of having some implementing and decision making mechanism for river basin development in the country which may consider and adopt an optimal model most suitable to the basin. Appropriate institutional mechanisms at State as well as at Central govt. level need to be established for the integrated, optimum and holistic development and management of water resources.

Therefore, the action plan to implement the integrated water resources planning, development and management at river basin level effectively and in holistic manner appropriate multi-disciplinary basin / sub-basin organizations at state level and at central level, should be set up. Simultaneously because of a paradigm shift towards basin planning approach, to meet the growing future water demands of all the sectors, and for mitigating the affects of climate change, strengthening/ reorientation of the States water related Departments as well as Central apex department dealing in water resources (CWC) is required to be done.

Accordingly the action plan containing strengthening / reorganization of States and Central departments and setting up of the multi-disciplinary organizations at state and Central level is suggested. Some actions have already been initiated in recent past. The restructuring of CWC has already been proposed and studies have already been carried out by different organizations. The state governments of Orissa and Tamil Nadu have already constituted the state level SRBO.

4.1 Strengthening / Reorganization of Water related Departments of States for data collection / compilation

It is widely felt that present system/ arrangements for data collection/ compilation are not wholly satisfactory and that different sets of data are maintained and given by different agencies. There is less uniformity in the terms and definitions, and methodology adopted in collection and compilation of water related data. The information relating to basin data is often dispersed, heterogeneous and incomplete. It should be comparable and adaptive to the pre-requisites for objective decision making. A standardized information system for the basin with complete, reliable, representative and easily accessible database is vital.

The inadequacy of data leads to costly planning errors and mismanagement. Exchange of data with and between basin states can clear misgivings among them. Uniform codes are also to be evolved for facilitating data aggregation and processing. A data bank and information system is to be maintained for each river basin. Therefore, for development and management of water resources, availability and accountability of information / data is the basic requirement.

Apart from data regarding water availability and actual water use, it would be necessary to include comprehensive and reasonably reliable projections of future demands. Information on natural catastrophes like floods and droughts, their extremes and frequency, demographic pattern, social and economic changes, education and employment, changes in land use pattern, development of industries, types of industries, pollution and environmental problems related to water resources development or otherwise can help management of river basin directly.

Broadly the basin information system should contain the basin features, basin resources, resources utilization, accounting of water resources which incorporates the availability as well as utilization of water etc. The major components of each of these for integrated Planning and management in a river basin are as detailed below:

Basin features

Basin features mainly covers the basin settings, physiography & river system, climate characteristics, geology, soil characteristics and communication.

Basin settings include:

- Basin boundaries with latitude and longitude
- Area covered as compared to geographical area of the state / country
- State-wise distribution of drainage areas (%)
- Physical and economic sub-regions of the country

Physiography and river system mainly covers:

- Various ranges and ridges, glaciers and lakes, sub-basins and tributaries
- Topographical data and site map
- Catchment details and drainage areas of the sub-basins
- Hydrological data (stream flow, sediment flow etc.)
- Natural disaster events for floods and droughts including mitigation measures, drainage congestion problems, embankments etc.

The climate characteristics include:

- Climate – Cold / Hot / Dry
- Rainfall – Mean annual, seasonal, weighted average rainfall in various sub-basins – standard deviations and variations during different periods and in areas sensitive to climate change such as low rainfall areas; Himalayan region (above permanent snow line, and glaciated areas) and Himalayan region (seasonal snow areas). There should be better raingauge data collection network through automated sensors etc.
- Temperature – Mean annual, maximum, minimum, maximum and average monthly temperature in various parts of basins and sub-basins
- Evaporation & evapo-transpiration
- Humidity, wind velocity, solar radiation etc.

Geology includes:

- Stratigraphic classification of geological formations

- Geological characteristics including seismic data of the region

Soil characteristics mainly covers:
- Principal soil types and their location / distribution and effect of rainfall on soil formation
- Behavior under irrigation conditions and drainage characteristics

The communication features of the basin will cover information on air, rail and road transportation including existing, ongoing and contemplated.

Basin resources data

The basin resources cover land, water, minerals, forests and demography

Land
- Gross area
- Land Use pattern including area under different types of forests, culturable area
- (cultivated and un-cultivated), total cropped area, area sown more than once
- Gross and net irrigated area

Water
- Surface water
  - ➢ Average annual run-off of the basin and its method of determination
  - ➢ 50, 75, 90 and 100 % dependable yields of the basin, sub-basins and tributaries
  - ➢ Historical and estimated floods
  - ➢ Virgin flow
  - ➢ Surface water potential and quality

- Ground Water
  - ➢ Hydrological characteristics of aquifers
  - ➢ Estimation of available / utilizable resources and present utilization
  - ➢ Areas identified / suitable for further exploitation
  - ➢ Recharge statistics

Minerals, forests and demography
- Minerals in the basin with statewise location, state of exploitation and other implications
- Type of forests, their distribution and exploitation
- Types of flora and fauna in the basin
- Demographic data (population, profession, education etc.) including urban and rural distribution, group by age, social, economic and ethnic classification
- Variation of density of population and rate of increase / decrease of population

Resource utilization /requirement data

The water utilization will cover multi-sectoral water utilization and also the future requirement

Water Supply

- Present source of water supply for urban centre / rural population and utilization
- Identification of additional sources of supply

Agriculture & Drainage

- General grouping pattern of irrigated areas and agriculture practices
- Change in cropping pattern, crop rotation and expected yield
- Irrigation practices, their limitations and management
- Irrigation facilities from various sources and areas irrigated by each source
- Crop water requirement for irrigation, surplus or deficit
- Identification of strategy / source to make up deficit
- Existing / proposed surface drainage system, drainage of irrigable area and sanitary problem

Power generation

- Existing including non-conventional sources, power supply position, projected demand and demand centres for base and peaking power
- Proposals for hydropower and associated consumptive water requirements
- Proposals and need of water for additional power generation using fossil fuel

Ecology

- Present and future eco-system and requirement of water to sustain – EIA & EMP

Industry

- Industrial potential – space, finance, raw material, power, market, export potential etc.
- Existing /proposed agro industries and other industries
- Estimated water utilization and sources of supply

Navigation, recreation, fishery etc.

- Present proposed development and alternative modes
- Maximum capacity of boats, barges etc. and water requirements
- Water requirement and quality for various purposes like recreation, fishery etc.

Future requirement

- Projected needs of water supply
- Needs for food security
- Water for energy, ecology, industry, navigation and other uses

Accounting of basin water resources

The accounting of water resources will take into account the periodic dependable availability and quality of water for various uses and also the distribution of available surface and ground water. The total availability will depict the reachwise water resources as well as the overall water resources scenario. The present and the projected water utilization for multi-sectoral uses like domestic, irrigation, hydro-power, ecology, industries, navigation and other uses also forms the part of the accounting of water resources. Water accounting also needs to incorporate the water losses like evaporation, percolation, leakage etc. and the return flows.

Data on various constraints

The constraints mainly cover legal (constitutional provisions in respect of agriculture, power, industry, transport etc; protection of riparian / established water rights and uses; submergence and sharing of costs and benefits), technical (co-ordination between conflicting requirements; inter-agency cooperation) and environmental (preservation of cultural heritage; Environmental Impact Assessment and Environmental Management Plan). The environmental aspects of the restraints assume bigger significance in the light of the possible climate change

The climate change phenomenon may have direct effect on most of the above parameters that can ultimately affect / alter the basin characteristics in general and may profoundly influence the agricultural, domestic as well as the ecological demands in the basin.

Therefore, by carrying out the above function of data collection / compilation and *from the point-of-view of mitigating various challenges in water sector effectively, including climate change*, it is necessary that the state water resources department with co-operation of all major water user agencies be strengthened / reoriented to act as a nodal agency for maintaining the data bank and information system, keep the data updated as well as measures to improve mechanism for data sharing among different user agencies.

National Water Policy- 2002 at the outset has also elaborated in a separate section the kind of information system required for water sector. The policy proposes a standardized national information system with a network of data banks and data bases, integrating and strengthening the existing Central and State level agencies and improving the quality of data and the processing capabilities. Continued use of a state-of-the-art information technology is also envisaged in the policy in the entire gamut of activities comprising collection, maintenance, analysis, projection, forecasting and exchange of information / data among various agencies. As a major initial step in realizing the key aspects of the information system envisioned by the Water Policy, the scheme on Water Resources Information System proposes to establish databases and data banks at the national and State level . Watershed maps using satellite images & other information on GIS platform are to hosted for visual display of spatial information laid over watershed maps for pictorial understanding by planners and managers involved in water resources development. There is no alternative system available at present that can provide comprehensive core information on water resources at basin level.

4.2 Setting up of State level multi-disciplinary basin / sub-basin Organisations (SRBOs)

Once the reliable data collection mechanism is established, resources planning for water is to be done for a drainage basin as a whole or for a sub-basin falling within the hydrological unit. All individual developmental projects and proposals should be formulated by the States and considered within the framework of a overall plan for a basin or sub-basin, for optimum/ equitable utilization of water resources.

The State level organizations should undertake planning, development & management of the water resources of the basin / sub-basin as hydrological unit, within their administrative boundary, keeping in view the confines of statutory and other obligations of interstate entitlements.

The basin/sub-basin development plans including water balance studies, creation of water resources infrastructure projects, conjunctive development of surface and ground water, multi-sectoral water resource allocation, sector-wise water use management, flood management, water quality management, R&D etc. should be suitably drawn up by state which is briefly described below:

Water balance:

- Comparison of multi-sectoral demands
- Surpluses and shortages during various periods in various reaches

The water balance studies will help for equitable distribution of water to mitigate the inter-regional imbalances in water availability through inter-basin transfer of water and also on the intra-basin transfer within the administrative boundary of the states.

Water resource infrastructure projects:

- The identified storage sites be prioritized and new projects be taken up in a phased manner keeping in view the minimizing of regional imbalances and development of drought / flood prone areas. While formulating the new projects due consideration be given so that good storage sites are not lost to Run-of-the-River (RoR) schemes.

- Special efforts be made to investigate and formulate projects either in, or for the benefit of, areas inhabited by tribal or other specially disadvantaged groups such as socially weak, scheduled castes and scheduled tribes. In other areas also, project planning to pay special attention to the needs of scheduled castes and scheduled tribes and other weaker sections of the society. The economic evaluation of projects benefiting such disadvantaged sections also needs to take these factors into account.

- Studies need to be taken up on the feasibility of increasing the existing storages by raising the height of the dam or by providing gated spillway in small & minor dams, waste weirs etc. Construction of carryover storages need to be encouraged. Consideration may also be made for changing the reliability criteria regarding water availability.

- Implementation of the current programme of renovation and restoration of water bodies with changed focus needs to be taken up.

The Sub-Committee report on surface water management further elaborates on the various aspects of enhancing the storages for mitigating the unpredictability of climate change.

Conjunctive development of surface and ground water

Under the climate change scenario, the conjunctive use of surface and ground water will play a crucial role as a mitigatory measure since climate change may lead to situation of water level rise in some areas and water level decline in other areas. Following measures need to be adopted in the light of the above:

- Evolving of a suitable plan for controlling the problem of rising water levels by adopting the technique of conjunctive use of surface and ground water, and proper drainage

- Preparing sector / block wise plans for development of ground water resource in conjunction with surface water

- Testing of the sustainability of the irrigation / cropping pattern with respect to conjunctive use of water resources and suggesting improvements for future developments

- Evaluating the economic aspect of groundwater development plan with respect to cost benefits ratio, internal rate of return and pay back period

Further details elaborating the findings of the feasibility studies for conjunctive utilization of surface and ground water in some of the major irrigation commands are incorporated in the report of the sub-committee on ground water management.

Multi-sectoral water resource allocation

The spatial & temporal variations in water availability, the rising water demand and the climate change phenomenon can accentuate the unpredictability in the availability of water resources. This calls for a systematic conflict management plan for equitable allocations using flexible water allocation priorities, taking into account the socio-economic-environmental needs. Decision Support Systems can be applied to reveal strategies for managing and allocating scarce resources to their highest and best use by providing better insight into the physical and conceptual interconnections in the basin It is therefore extremely important to develop the Decision Support System based on system engineering concepts for ensuring the priority-based water allocation among multi-sectoral uses taking into consideration the surface and ground water availability and the inter-sectoral and inter-regional trade-offs and policy options for basin management..

Water-use management - Sector wise

It is necessary to prepare the sectoral management plans for optimizing the water use in a river basin for deriving maximum benefits by improving the water use efficiency in each sector. The management plans for various sectors will vary basin-wise and some of the important areas that need to be addressed are highlighted below. These are suitably covered in the reports of the sub-committees on Efficient Use of Water for Various Purposes' and 'Domestic & Industrial Water Management'.

Irrigation

Considerable effort needs to be focused for improving the efficiency in water resource system especially in the irrigation system which is the major water consuming sector. The National Commission has assumed that the irrigation efficiency will gradually increase to 60% from the present level of 35 to 40 %. Some of the action areas to be pursued aggressively include:

- State level water management program should be taken up for evaluation of the performance of the selected irrigation projects, preparation of annual water auditing of the irrigation projects including water stored or diverted, losses, reuse of lost waters for identification and reduction of the bottlenecks to bring back the systems to desired standards

- Programmes for minimizing inadvertent evaporation from agricultural fields between crops, wet soil between crop rows in irrigated fields needs to be taken up. This may include conserving moisture though mulches and plastic sheets and reducing gap between kharif harvesting and rabi sowing.

- Changing cropping patterns towards low water use crops for appropriate water management in drought–prone areas.
- Involvement of stakeholders through Participatory Irrigation Management (PIM) and facilitating the expeditious creation of Water Users' Associations.

- Sufficient funds for operation and maintenance work to be provided for modernization of irrigation system and performance improvement. Water regulatory authorities in the States in the lines of Maharashtra Water Resources Regulatory Authority can be established.

Domestic & Industrial

Some of the actions that are needed to be adopted for efficient management of water resources at basin level in domestic & industrial sectors are as follows:

- Pre and post evaluation of existing artificial recharge initiatives to assess effect on ground water table on a watershed level.

- Inclusion of wastewater reclamation as a supply augmentation measure and to provide incentives (tax rebates, excise exemptions etc.) for industries and commercial establishments meeting 50% (say) of their water requirements from reclaimed sources

- Raising awareness on potential of wastewater reclamation and reuse at village, state and national levels.

- A baseline of water use efficiency in industries can be developed through comprehensive water audit. National / international benchmarks for water consumption and water reuse should be fixed and achieved within a specified time frame. This should be done on a priority for water intensive industries, especially the 17 highly polluting sectors in the CPCB "red category".

- Revising water tariff based on cost recovery principle considering the aspects such as willingness to pay; higher incremental tariff; tariff reduction based on scale of adoption of water harvesting; tariff based on scarcity value /opportunity cost; revised and restructured tariff as a measure to encourage industries to use less water per unit production ("industrial water productivity" concept).

- Promotion of rooftop rainwater harvesting activities including identification of incentives for adopting and sustaining the same.

Details on the actions discussed above are covered in the reports of the sub-committees on Efficient Use of Water for Various Purposes' and 'Domestic & Industrial Water Management'.

Flood management

The weather experts have predicted that climate change may intensify the hydrologic cycle; more intense rainfall may occur in fewer spells; the floods may become more intense and frequent. Therefore, considerable attention must be given to flood management. Some of the action that need to be taken up are as follows:

- Linking the digital elevation models for low lying areas with hydraulic models to understand flood situations under different floods
- Build capacity of linking storm surge models, tidal hydraulic models and flood flow models
- Improvements in urban storm water drainage

Water quality management

Protection of quality of freshwater is integral to sustainable development and therefore very important in the context of integrated water resource planning, development and management. Some of the action that need to be taken up are as follows:

- Setting up water quality models for each major river and aquifer
- Enhancing the capacity of the institutional and legal mechanism to take action by 'Polluter Pays Principle'.
- Allow attractive financial packages combined with penalties to users / defaulters to build and operate modern effluent treatment plants and recirculation arrangements in order to reduce penalties.
- Encouraging direct use of partially treated domestic effluents in irrigating non-food crops.

The report of the Sub-Committee on surface water management covers more details on the above areas.

Research & Development

Since the impending climate change can evoke wide ranging variability in availability of water resources, significant thrust needs to be accorded on the Research & Development plans for more effective distribution and management of water resources.

- A State level programme for Research & Development for i) application of modern techniques may be taken up with industries for their support in developing the low cost Modern / Micro-irrigation equipments with region specific and facilitation of the application of Modern / Micro-irrigation techniques viz. Sprinkler irrigation, drip irrigation, deficit irrigation etc., ii) development of crops which require minimum water and can sustain poor quality saline water, biological control of drainage congestion in waterlogged areas, iii) improving energy efficiency of water pumps used for irrigation etc., and iv) cost effective desalination of seawater /brackish water particularly for water scarce coastal areas.

- Development of a combined unsteady flow hydraulics-cum-sediment transport model capable of depicting rive erosion in each flood event for use in river management works though R&D effort.

Keeping In view of the above, it is important to set up State level multi-disciplinary organization for a basin or a sub-basin having representatives from stake holder departments and public. These State level river basin organizations (SRBOs) should perform broadly the following functions:

a) Creation of information system including databank of all the data (collected from various sources) for integrated water resources planning & management

b) Development of the comprehensive technological tools based on the state of the art computer technology, for preparation of basin / sub-basin plans

c) To study the variability in the hydro-meteorological parameters such as temperature, rainfall etc. region / basin / sub-basin wise keeping in view the effect of climatological changes for optimum utilization of water

d) Based on the above studies, identification of water short / surplus regions in the basin / sub-basin and their quantification and assess future scenarios with changes in demand, land use etc., due to climate change

e) Preparation of river basin / sub-basin plans including intra / inter basin water transfers and climate change scenario and formulation of various policies for effective management and optimum utilization of water

f) Prioritization and initiation of newly identified water resources projects in respect of climate change

In this regard it may be mentioned here that Orissa and Tamil Nadu have

already constituted state level RBOs.

The Orissa Government through a resolution dated 26.02.2007 has already approved the concept of a multi-disciplinary organization i.e. River Basin Organisation (RBO) to plan and monitor (oversee) all water related activities in river basins. The structure of RBO is two-tier with a Board and a Council. The board is a professional body with responsibility to plan development of water resources in the basin and the Council is a body of stake holders to deliberate on the action plans put up by the Board and accord necessary approval. The Chief Engineer / Basin Manager of the Basin is the Member Secretary of the Council and also the Board. The Member Secretary have one RBO cell to provide technical and other inputs to the Board.

Govt. of Tamil Nadu vide Govt. Order dated 12.01.2001 has constituted Palar and Tamiraparani River Basin Management & Development Boards. Hon'ble Water Resources Minister of the State is the Chairman of these two Boards. Basin Management Committees have also been constituted to assist and take decisions on behalf of the Basin Management & Development Board. Hon'ble Water Resources Minister of Govt. of Tamil Nadu is the Chairman of these two Committees also. Chief Engineer, Water Resource Organisation is the Member Secretary for the Basin Management & Development Board and Basin Management Committee Chief Engineer, Central Water Commission has been made as Member of the River Basin Management & Development Board. The Basin Management Committee is supported by a Technical Secretariat at Chennai, as common facility for both the Basins.

A brief on these state level SRBO are placed at Annex -I and Annex -II respectively.

4.3 Creation of inter-state River Basin Organisations (RBO)

In India most of the river basins are inter-state in nature. Therefore, there is competition/ conflict for river water not only between the various uses within a State but also between riparian states. The Irrigation Commission, 1972 recommended that the river basin plans must be prepared if the water resources of the country are to be developed to the best advantage. The above necessitated for establishment of inter-state River Basin Organisations (RBO) for proper development and management of the water resources at the river basin level.

The main objective of RBO would be the preparation/finalisation of the integrated master plans for the basin as a whole for sustainable development of the water resources. These plans will also consider the prioritization and initiation of newly identified water resources projects in respect of climate change. The water sharing amongst the co-basin states would continue to be decided through inter-state agreements between the co-basin states or the Tribunal Awards. However, RBOs can provide a platform for discussions among co-basin states. Therefore, the objectives of the setting up of the River Basin Organisations are:

1. Preparation of the comprehensive and integrated basin plan for sustainable development of available resources to derive optimum benefits; and

2. Integrated planning, development and management of water resources with active participation of the stakeholders

For the planned development of river basins as a whole, the River Boards Act was passed by the parliament in year 1956 for preparation of water resources development schemes and for advising the States on the regulation and other aspects. The Act provides formation of river boards with the consent of States but no such board under the Act could be constituted due to several reasons. For effective planning, development & management within a basin, it is necessary to evolve an appropriate model of RBO for a basin which may be effective in addressing the issues within the specific basin.

It has been proposed to set up two RBO during the XIth Five Year Plan for Mahanadi and Godavari river basins. The proposed RBO be chaired by an officer of the rank of Higher Administrative Grade officer of CWC in respective river basins or as per decision of MoWR. The members of the RBO may consist of the Principal Secretary (Water Resources) of the co-basin states and other members as appointed by MoWR from other disciplines . Subsequently RBO are proposed to be set up in five more major river basins in the XII th Five year plan.

The Central Government and the concerned State Governments to provide necessary funds to the RBO for the discharge of its functions. 80% of the expenditure may be borne by the Central Government and the remaining 20% of the expenditure may be borne by all the concerned Co-basin States equally irrespective of the area of the basin falling within a State.

The powers and functions of the proposed RBOs may be as under:

1. The RBO may be empowered to perform all or any of the following functions, namely:

(a) advising the Governments interested on any matter concerning the regulation or development of river basin and in particular, advising them in relation to the co-ordination of their activities with a view to resolve conflicts among them and to achieve maximum results in respect of the measures under-taken by them in the river basin for the purpose of:

i) conservation, control and optimum utilisation of water resources of the inter-State river including transfer of surplus flood water to other river basin;
ii) promotion and operation of schemes for irrigation, water supply or drainage;
iii) promotion and operation of schemes for development of hydroelectric power;
iv) promotion and operation of schemes for flood control & management,
(v) promotion and operation of schemes for controlling water logging and salinity aspects including assessment of causes and suggestion of remedial measures,
vi) promotion and operation of schemes for lean flow estimation and forecasting;
vii) promotion and operation of schemes for modernization of existing projects;
viii) promotion and operation of schemes for drought aspects;
ix) promotion and control of navigation;
x) promotion of afforestation and control of soil erosion;
xi) prevention of pollution of the waters;

xii) such other matters as may be prescribed.

2. (i) The RBO may, from time to time, prepare schemes, including multipurpose schemes, not inconsistent with its functions as specified, for the purpose of regulating or developing river basin within its area of operation. After preparing any such scheme, the RBO shall consult the Governments interested and the Central Government in respect of the scheme and after considering their suggestions, if any, the RBO may confirm, modify or reject the scheme. The scheme as confirmed or modified shall thereupon become final and shall be called the approved scheme, and advising the Governments interested to undertake measures for executing the schemes prepared by it.

(ii) allocating among the Governments interested the costs of executing any scheme prepared by the RBO and of maintaining any works undertaken in the execution of the scheme;

(iii) watching the progress of the measures undertaken by the Governments interested;

(iv) any other matter which is supplemental, incidental or consequential to any of the above functions

3. The Central Government, after consultation with the Governments interested, may by notification in the official Gazette, empower the RBO to perform all or such of the above functions as may be specified in the notification.

4. For the purpose of efficiently performing its functions RBO may, within its area of operation,-

a) acquire, hold and dispose of such property, both movable and immovable, as it deems necessary;
b) undertake such preliminary investigation or surveys or the other measures as it deems necessary;
c) inspect or cause to be inspected any works undertaken by any Government interested concerning the regulation or development of river basin;
d) conduct and co-ordinate research on various aspects of the conservation, regulation or utilization of water resources, such as water power generation, irrigation, navigation, flood control & management, soil conservation, modernization of existing projects, water logging & salinity, drought aspects, land use and connected structural and design features;
e) collect such topographical, meteorological, hydrological and sub-soil water data as it deems necessary;
f) publish statistics or other information relating to the various aspects of the regulation or development of river basin;
g) require any Government interested to furnish such information as the RBO may require in relation to:
   (i) the measures undertaken by that Government for the regulation or development of river basin;
   (ii) the topographical, meteorological, hydrological and sub-soil water data;
   (iii) such other matters as may be prescribed

5. The RBO may, with the previous approval of the Central Government, by notification in the Gazette of India, make regulations for:

a) regulating the meetings of the RBO and the procedure for conducting business there at;
b) regulating the manner in which, and the purpose for which, advisory committees may be appointed;
c) regulating the manner in which and the purposes for which persons may be associated with the RBO;
d) determining the terms and conditions of service of the members of advisory committees, of persons associated with the RBO and of all officers appointed by the RBO.

6. The RBO shall prepare, in such form and at such time each year as may be prescribed, an annual report giving a true and full account of its activities during the previous year and copies thereof shall be forwarded to the Central Government and the Government interested; and the Central Government shall cause every such report to be laid before both Houses of Parliament.

4.4 Strengthening / Re-Organisation of Central Water Commission

4.4.1 The Central Water Commission (CWC), an apex technical Organisation in the field of water resources, functions as an attached office of the Ministry of Water Resources. During the course of institutional changes and increased emphasis on water resources planning, development and management in the planning process, the CWC has evolved into a body of expertise in various facets of development and management of surface water resources. It serves as a specialized organisation providing adequate support to the states in the above areas. CWC is charged with the general responsibility of initiating, coordinating in consultation with the Central and State Governments concerned, the schemes for control, conservation and utilization of water resources throughout the country for the purpose of flood control, irrigation, navigation and water power generation and if required, also undertake the construction and execution of such schemes.

In its present setup, CWC is headed by a Chairman assisted by three Members each heading a technical wing, namely, Designs and Research (D&R), Water Planning and Projects (WP&P) and River Management (RM). Members are assisted by officers of the rank of Chief Engineers, Directors/Superintending Engineers, Deputy Directors/Executive Engineers and Assistant Directors/Assistant Executive Engineers in that order and other engineering and non-engineering officers and supporting staff in the discharge of their duties. The Human Resources Management is looked after by a Chief Engineer. The CWC was reorganized with setting up of 13 basin wise regional offices at Bangalore, Bhopal, Bhubaneshwar, Chandigarh, Coimbatore, Delhi, Gandhinagar, Hyderabad, Lucknow, Nagpur, Patna, Shillong & Siliguri, besides the National Water Academy at Pune for training in- service Engineers.

Some of the major functions of CWC are collection and analysis of hydrological and hydro-meteorological data, flood forecasting and assistance to state governments in flood management, techno-economic appraisal of projects, monitoring of projects and projects receiving central assistance, planning and design of river valley project, surveys, investigations and preparation of detailed project reports, studies on environmental and socio-economic issues, studies related to irrigation planning and water management, performance evaluation of completed projects, basin planning management, water resources assessment, hydrological studies, assistance in resolution of inter-state water disputes, construction equipment planning, preparation of guidelines and studies on dam safety, research and development, standardization of engineering practices, reservoir regulation studies, reservoir sedimentation studies, morphological studies of rivers, coastal erosion, surface water quality monitoring, training and capacity building, international co-operation in water sector

With the competing demands on the scarce water resources the basin-wise/ state-wise riparian claims over water have been on the increase and it is becoming increasingly necessary for an impartial agency like CWC to verify the river water flow data, assist river water tribunals and other similar bodies in adopting criteria based on equity and efficiency considerations and evolve policies and strategies that are equitable and at the same time optimal from the national point of view. Thus CWC with its vast expertise on diverse fields in water resources planning, development and management will have an immense role in the future for:

a) Developing a legal and techno-managerial framework of river basin wise planning and development of water resources with an appropriate hydrological unit as a base.

b) Playing more decisive role in facilitating Inter-state River water sharing, planning, investigation, design, appraisal and monitoring of water resources projects.

c) Assisting / advising the River Basin Organisations (RBOs) and the State River Basin Organisations in various aspects related to preparation of comprehensive river basin master plan, investigation works & design aspects related to formulation of schemes, river management, flood forecasting, integrated operation of reservoirs, water quality aspects, etc.

d) Maintaining close co-ordination in activities between the Central and State Governments elated to water resources planning, development & management.

Various committees, expert bodies etc. have given suggestions / recommendations from time to time on the restructuring / strengthening of functioning of CWC like the National Commission for Integrated Water Resources Development Plan, the Implementation Cell of Ministry of Water Resources, Administrative Staff College of India etc. Keeping in view these recommendations and also the provisions of National Water Policy, CWC is proposed to be restructured to undertake the functions and responsibilities to meet the emerging challenges in the water sector.

The present river basin wise regional offices of CWC (13 Nos.) headed by an officer of Senior Administrative Grade are proposed to be upgraded and reorganized, depending upon the size of the river basins, to be headed by an officer of Higher Administrative Grade. These regional offices are to establish close liaison with the concerned State Govts, departments, etc. so as to have full knowledge of all activities in the water resources in the

State and work as a link between the State Govt., River Basin Organisations, This reorganized set up of CWC will create required synergy between all agencies involved in the water resources development in the States so as to fulfill the objectives of Integrated water resources planning, development and management. The seven regions / basins and their location identified are:

1. Indus and Yamuna Basin, Delhi
2. Ganga Basin, Patna
3. Brahmaputra Basin, Guwahati
4. Narmada & Tapi, Bhopal
5. Mahanadi & Eastern Rivers, Bhubneshwar
6. Krishna & Godavari, Hyderabad
7. Cauvery & Southern Rivers, Coimbatore

The main functions of the proposed set up would be:

- Creation of online databank at regional office and access to databanks of state and CWC (HQ) though information system. The existing "Development of Water Resources Information System" scheme will provide support to this activity.
- To provide advisory support towards preparation of river basin / sub-basin plans at State level
- To prepare comprehensive rive basin plan combining the basin / sub-basin level plans prepared by the States

4.4.2 Capacity building measures for CWC and State Government in service engineers may also be taken in the context of Integrated water resources planning, development & management. For this the National Water Academy, CWC at Pune is proposed to be appropriately strengthened in two stages and upgraded to be headed by an officer of Higher Administrative Grade.

4.5 Updating the National Water Policy necessitated due to changed climatic scenario

As the various river basins / States differ from each other in various aspects, their response to climate change phenomenon would be different. Therefore proper analysis of the impact of climate change on water resources may be dependant on various studies having inter-linkages among different sectors**.** Some of the studies that can be undertaken may include:

(i) Trend analysis of temperature and prediction for different scenarios with degree of confidence;
(ii) Prediction for meteorological extreme events, including heavy one-day or short period rainfall and localised cloud burst;
(iii) Temporal shift of precipitation;
(iv) Trend analysis of precipitation and prediction for different scenarios with degree of confidence;

(v) Analysis of river flows on 10-daily basis after including extractions by the projects in the basin and return flows and likely future scenarios;
(vi) Different what-if analysis scenarios need to be generated for predicted combinations of rise in temperature and change in precipitation for the water resources facilities in the basin for optimizing the operation of the same;
(vii) Snowmelt characteristics and glacier retreat;
(viii) Sub-basin-wise averaging of water equivalent of glacier melt runoff studies are needed for considering mitigation measures;
(ix) Effect of de-glaciation on sedimentation for the water resources facilities in the basin;
(x) Inventory of glacial lakes and their vulnerability for outburst due to increase in temperature;
(xi) Effect on irrigation water requirement and other consumptive uses; effect on hydropower projects; effect on water quality; and effect on groundwater resources.

In a nutshell, emphasis needs to be laid on assessment of likely future changes due to climate change with regards to meteorological parameters (temperature, precipitation etc.), hydrological parameters (river flow analysis, ground water availability), what-if analysis scenarios for predicted combinations of rise in temperature and change in precipitation for the water resources availability and facilities including their operation, future changes in multi-sectoral utilization & demand, evaporation characteristics, Snowmelt characteristics & glacier retreat and its effect on river flows etc.

The results of the above studies will help to a large extent in firming up the possible impacts of climate change on water resources scenario and in updating the National Water Policy in consultation with the States to ensure basin level management strategies to deal with variability in rainfall and river flow due to climate change.

The proposed **Action Plan statement** containing the objective, strategies, action points, timelines, financial requirements and the collaborating institutions is given in the following pages.

Proposed Action Plan - Sub-Committee of Basin Level Planning & Management

Objective	Strategies	Proposed Action Plans	Duration	Financial Requirements	Collaborating Institutions/ Organisations
I. National Water Mission to ensure integrated water resource management helping to conserve water, minimize wastage and ensure more equitable distribution both across and within states. II. Ensuring more effective management of water resources, III. Integrated water policies to cope with variability in rainfall	Integrated Planning and Management of Water Resources for sustainable development for river basins.	**I.** Strengthening / Reorganization of Water related Departments of the States for data collection / compilation of all water related data using modern Information technology, keeping the climate change scenario in view	One year	To be met from State funds	Water related Departments of States
		II. Setting up of State level multi-disciplinary, basin / sub-basin wise organizations having representatives from stake holder departments. and public to perform following functions:	By 2010	The expenses of State RBOs will be met from the budget of Department of Water Resources	Water related Departments of States and all stakeholders
		a. Creation of information system including databank of all the data (collected from various sources) for integrated water resources planning & management	By 2011		
		b. Development of the comprehensive technological tools based on the state of the art computer technology, for preparation of basin / sub-basin plans	By 2011		
		c. To study the variability in the hydro-meteorological parameters	By 2011		

variability in rainfall and river flow at the basin level.		such as temperature, rainfall etc. region / basin / sub-basin wise keeping in view the effect of climatological changes for optimum utilization of water resources and to carry out comprehensive water balance studies d. Based on above studies, identification of water short/ surplus regions in the basin / sub-basin and their quantification and assess future scenarios with changes in demand, land use etc. due to climate change e. Preparation of River basin/ sub-basin plans including intra / inter basin water transfers and climate change scenario and formulation of various policies for effective management and optimum utilization of water f. Prioritization and initiation of newly identified water resources projects in respect of climate change **(Orissa & Tamil Nadu have constituted state level RBOs)** **III.** Creation of Inter-State River Basin Organisations (RBOs)	 By 2012 By 2012 By 2017 By XI Five	Rs 49 Crore	Concerned States, MoWR / CWC

		a. The MoWR has proposed to set up two RBOs / River Boards in the XIth Plan under the River Board Act, 1956 for comprehensive and integrated approach in planning, development & management of water resources of the basin. To begin with, Mahanadi and Godavari basins have been selected for setting up of the RBOs and the proposals need to be expedited.	Year Plan		
		b. Subsequently RBOs to be set up in five more river basins	XII Five Year Plan	Rs 125 Crore	Concerned States, MoWR / CWC
		IV. Strengthening / Re-organisation of Central Water Commission field units			
		A. The present river basin wise regional offices of CWC (13 Nos.) headed by an officer of Senior Administrative Grade are proposed to be upgraded and reorganized, depending upon the size of the river basins, to be headed by an officer of Higher Administrative Grade. These regional offices are to establish close liaison with the concerned State Govts, departments, etc. so as to have full knowledge of all	By XI Five Year Plan	Rs 40 Crore per year	MoWR / CWC

		activities in the water resources in the State and work as a link between the State Govt., River Basin Organisations, This reorganized set up of CWC will create required synergy between all agencies involved in the water resources development in the States so as to fulfill the objectives of Integrated water resources planning, development and management. The seven regions / basins and their location identified are: 8. Indus and Yamuna Basin, Delhi 9. Ganga Basin, Patna 10. Brahmaputra Basin, Guwahati 11. Narmada & Tapi, Bhopal 12. Mahanadi & Eastern Rivers, Bhubneshwar 13. Krishna & Godavari, Hyderabad 14. Cauvery & Southern Rivers, Coimbatore Main functions of the proposed set up are: a. Creation of online databank at regional office and access to databanks of state and CWC (HQ) through information system. The existing "Development of Water Resources Information System" scheme will provide support to			

		this activity. b. To provide Advisory support towards Preparation of River basin/ sub-basin plans at State level. c. To prepare comprehensive river basin plan combining the basin / sub-basin level plans prepared by the States B. Capacity building for in service engineers of Central and State Govt. Organisations			
		Capacity building measures for CWC and State Government in-service engineers may also be taken in the context of Integrated Water Resources Development and Management. For this the National Water Academy at Pune is proposed to be appropriately strengthened in two stages and upgraded to be headed by an officer of Higher Administrative Grade.	Stage – I During XI Five Year Plan Stage – II (During XII Five Year Plan)	Rs 10 crore Rs 20 Crore	MoWR / CWC MoWR / CWC
		V. Updating the National Water Policy necessitated due to changed climatic scenario to mitigate the likely impacts due to climate change the existing National	By 2012	----	MoWR / CWC, States

		Water Policy may be updated to cope with variability in rainfall and river flow at basin level.			

Annex-I

Note on Palar and Tamiraparani River Basin Management & Development Boards Tamil Nadu

The abstract of order issued by Government of Tamil Nadu is as reproduced below:

1. National Water Policy as well as State Water Policy of Tamil Nadu emphasize the need for development and management of water resources with a river basin as an integral unit. To implement this important element of the National as well State Water Policy, the government have received suggestions for integrated planning, monitoring, management and development of water and land resources with the active involvement of stakeholders of each river basin. Integrated development of water and land resources will lead to socially and environmentally sustainable development of the resources in the basin which would improve the livelihood of the basin citizens. It has been suggested that River Basin Management and Development Boards may be set up initially in Palar and Tambaraparani basins to manage these activities in the basins.

2. The basins have distinct characteristics. The Palar basin is less developed in terms of agriculture and industry than the Tambaraparani basin. Palar has greater pollution problems associated with tanneries. In addition, it has a ground water barrier contributing to water quality problems. The Tambaraparani basin has a distinct wet area where hydropower is being generated. Both the basins have a sizeable delta region with associated salinity intrusion problems. Irrigated agriculture is practiced in both the basins. Storages in the Palar basin have been mobilized through a number of tanks. Some of these tanks are system tanks, these are fed by diversion of flows from the main river in addition to the yield of their own local small sub-catchments. Similar tanks exist in the Tambaraparani basin as well. In addition, there is a storage reservoir at Papanasam where hydropower generation is being carried out. Due to the existence of this reservoir and the 'wet' zone, water is available for agriculture almost throughout the year, which has encouraged farmers to go for water intensive crops. Uncontrolled expansion of water-intensive crop areas contributes to severe water stress in the basin. Urban conglomerations together with a ship-building industry at the mouth of the basin are imposing additional inter-sectoral demands on the basin. Therefore, even though water is available in reasonable quantity and quality, the Tambaraparani basin is coming out as a severely stressed basin. Groundwater extraction is taking place in both the basins with about 16% of the blocks in Palar having been declared Dark and only 5% of the blocks in Tambaraparani having been declared Dark. As groundwater quality also is affected by tanneries there is an urgent need to tackle ground water exploitation issues in the Palar basin. Given these diverse issues to be considered, it is essential that an integrated basin management approach is taken in these two basins on a pilot basis. The Government have examined the suggestion of Constituting Basin Management and Development Boards and have accepted it in principle. The Government however, decided to form Palar and Tambaraparani River Basin Management and Development Boards only for the water based activities to begin with.

3. The **River Basin Management and Development Boards** will have the following Members:

Hon'ble Minister in-charge of water resources	Chairman
Development Commissioner	Member
Secretary, Finance Department	Member
Secretary in-charge of water resources	Member
Secretary, Agriculture	Member
Secretary, MAWS	Member
Secretary, Rural Development	Member
Secretary, Industries	Member
Secretary, Environment and Forests	Member
All MPs representing the Constituencies in the river basin	Members
All MLAs representing the constituencies in the river basin	Members
All Panchayat Union Chairmen	Members
All Municipal Chairmen	Members
District Panchayat Presidents of the concerned districts	Members
Presidents of Distributory Level Committee of Water Users' Association	Members
District Collectors of concerned districts	Members
One representative each of the following departments (i) Agriculture (ii) Horticulture (iii) Forest (iv) Environment/ Pollution control (v) Agricultural engineering (vi) Fisheries (vii) Animal Husbandry (viii) Public Health (ix) TWAD Bd. (x) Industries	Members
Chief Engineer, Water Resources Organisation	Member-Secretary
Superintending Engineers, Water Resources Organisation Circles in the area	Members
Superintending Engineers, Tank Modernisation of Water Resources organization	Members

Superintending Engineers, (Plan formulation) Water Resources Organisation	Member
3 representatives of industries	Members
3 representatives of NGOs and eminent persons in the area	Members
Chief Engineer, Central Water Commission	Member

4. The above Board would meet twice in a year or more frequently, if required. The powers and responsibilities of the Board will be:

- To approve the perspective and annual plan of various activities in the basin prepared by the Basin Management Committee.

- To approve the annual budget

- To give general guidelines for implementation of various schemes related to water resources in the basin.

5. The following activities would be coordinated by the Board in so far as the sustainable use of water is concerned:

- Irrigation
- Agriculture
- Horticulture
- Coil conservation
- Environment and Pollution Control
- Domestic water supply
- Fisheries
- Water supply to cattle
- Water supply to industries
- Water supply to power generation
- Watershed Development
- Wasteland Development
- Forests
- Recreation and Tourism
- Public Health

6. The Government also constitute the **Basin management Committee** to take all decisions regarding the development and management of the water resources in the basin. The composition of the Basin Management Committee would be as follows:

Hon'ble Minister in-charge of water resources	Chairman
Development Commissioner	Member
Secretary in-charge of water resources	Member

Secretary, Finance or his representative	Member
Secretary, Agriculture	Member
Secretary, MAWS	Member
Secretary, Rural Development	Member
Secretary, Industries	Member
Secretary, Environment and Forests	Member
Chief Engineer, Water Resources Organisation	Member-Secretary
2 MPs to be nominated by Government	Members
2 MLAs to be nominated by Government	Members
Collectors of concerned districts	Members
District Panchayat Presidents from the basin area	Members
3 representatives of Water Users Associations	Members
One eminent person in the area	Member
One representative of NGO	Member

7. This Basin Management Committee would take all decisions on behalf of the Basin Management and Development Board, prepare the perspective Plan, Annual Plan and Budget including allocation of water among competing demands and to approve all the schemes with regard to the development and management of water resources in the following areas :

(a) Irrigation
(b) Soil conservation
(c) Domestic Water Supply
(d) Water Supply and Sewage Schemes of Municipalities
(e) All other uses of water resources in the basin.

In due course the function of the existing water utilization committee would be taken over by the Basin Management Committee in these two basins.

8. The above Basin Management Committee would have full powers to make perspective plan and the annual plan for the activities mentioned in Para 7 above in the basin area, to approve the schemes relating to them in principle and to periodically review the progress of the schemes. The approval of the detailed schemes including financial approval and its implementation will continue to be undertaken by the concerned line Departments. Line Departments would, however, not approve any new scheme related to use of water resources which has not been approved in principle by the Basin Management Committee.

9. The Basin Management Committee would be supported by a **Technical Secretariat** located in Chennai as a common facility for both the Basins. The core group in the secretariat would comprise:

Basin Modeler
GIS Specialist
Sociologist
Environmental specialist
Economist
Hydrologist
Water Technologist
WRO Engineer
Hydrogeologist
Watershed Manager
Training Specialist
Information specialist
Administrative Personnel

The **Technical Secretariat** Officers can attend the meetings of the Board and the Committee as special invitees as decided by the Basin Management and Development Board and Basin Management Committee.

10. The **Technical Secretarial** will have full time employees. These personnel can be employed on deputation basis from Government departments or Autonomous Bodies. They can also be employed on consultancy basis. All expenses on the Technical Secretariat, Basin Management Committees and Basin Management and Development Boards will be borne under WRCP.

The above order issued with the concurrence of Finance Department of State dated 3.1.2001.

Annex- II

Note on River Basin Organisation in Orissa

Scarcity of water is becoming a global issue and India is no exception to it. The situation in Orissa is a little more favourable than in many other Indian States. However it is high time the State put its water resources management on a sustainable track. In the post independence era, till early nineties irrigation development concentrated on expanding the area covered by water delivery systems. But the National Water Policy 2002 as well as the State Water Policy give utmost importance to Water Resources Planning, Institutional mechanism to support it and water allocation priorities along with other provisions. The National and State Water Policy has clearly indicated that Water Resources Planning should be under taken considering the river basin as a unit and institutional mechanism appropriate to river basin planning should be established taking into account all water uses including irrigation. Accordingly the State Water Plan has been formulated with an aim to conceptualize Integrated Water Resources Management (IWRM), which is defined as "a process which promotes the coordinated development and management of water, land and related resources in order to achieve economic and social welfare objectives using participating and equity criteria but without compromising the sustainability of natural ecosystems". The institutional integration and convergence of different uses of water has been felt necessary at different levels of governance and administration.

Basing on the above, Government of Orissa vide Resolution no. 5788/Irr-I-WB-4/06/ WR dated 26.2.2007 have approved the concept of a multi-disciplinary organization i.e. River Basin Organisation (RBO) to plan and monitor (oversee) all water related activities in river basins.

The structure of RBO will be a two-tier one with a Board and a Council. The board will be a professional body with responsibility to plan development of water resources in the basin and the Council will be a body of stake holders to deliberate on the action plans put up by the Board and accord necessary approval. The Chief Engineer and Basin Manager of the Basin will be the Member Secretary of the Council and also the Board. The Member Secretary will have one RBO cell to provide technical and other inputs to the Board.

The detailed arrangement of RBO indicating the structure, functions and power is mentioned below:

River Basin Organisation

1.0 The Organisation

River basins have been recognized as the basic unit in water planning increasing demand on water resulting scarcity has forced us to adopt Integrated Water Resources

Management as the basic objective of water planning. All water related activities in river basin are to be planned and over seen by one single multi-disciplinary organization i.e River Basin Organisation (RBO).

2.0 Structure of RBO

There will be a two-tier arrangement for RBO a Board and a Council. The Board will be a professional body, which will be responsible to plan development of water resources in the basin. It will consist of the professionals in water related activities within a particular River Basin/ Sub-Basin.

The Council will be a body of stake holders in the water sector in the basin. The council will deliberate on the action plans and projects put up by the Board and accord necessary approval. The council may also require the Board to study different aspects and problems relating to water within the basin and come up with various solutions.

The composition of RBO may be as under :

I. Council:

The Council shall comprise of stakeholders in water sector with a maximum of 25 members.

Chairman: Minister/Minister of State, Water Resources for large basins.
For smaller basin chairman may be nominated by Deptt. Of W.R.

Members

- Members of Parliament (Lok Sabha) of the basin area.
- Member of Legislative Assembly of the basin area.
- Chair persons of Zilla Parishads.
- RDC
- District Collectors.
- 2 NGOs working within the basin on water sector to be nominated by Govt. in Department of Water Resources
- 4 Presidents of Apex Societies/ Distributory Committees formed under the Pani Panchayat Act to be selected by govt. in Deptt. Of Water Resources for a period of two years in rotation.

Special Invitees:

- District level officers of the Line Department will be special Invitees.

Member Secretary: Chief Engineer & Basin Manger of the Basin.

II. **Board:** The composition of the Board may be as under.

Chairman - Principal Secretary/ Secretary of Water Resources for large basins. For small basins an officer of suitable rank may be nominated by Deptt. of WR.

Members - (One officer in the rank of S.E./ Depty Director from the following Organisations working under the jurisdiction of the basin).

Public Health
R.W.S.S.
Minor Irrigation
GWSI
Agriculture
Water Shed Mission
O.S.P.C.B.
Hydrology
Lift Irrigation
Industries
Fisheries
Energy
Revenue & D.M

Member Secretary - Chief Engineer & Basin Manager of the Basin.

RBO Cell : The Member Secretary will have an RBO Cell which shall provide technical and other inputs to the Board for discharging its functions and powers and to ensure the implementation of the decisions.

The Cell will function in the office of Chief Engineer & Basin Manager of the Basin. The staffing will be as follows :

1. Executive Engineer – 1
2. Assistant Engineer – 2
3. Junior Engineer – 1
4. Steno-cum-Junior Clerk – 1
5. Peon- 2

3.0 Functions and Power of River Basin Organisations:

3.1 Functions:

(a) The objective of RBO is to ensure Integrated Water Resources Management (IWRM) in the basin. RBO is an organization of all stakeholders department in the basin and will bring in coordination of their activities with a view to resolving conflicts and avoid duplication among them for achieving maximum results in respect of the measures undertaken by them.

(b) In order to achieve the above objective the RBO shall within one year or its formation prepare ten years perspective action plans for

i. Conservation, management and optimum utilization of water resources of the rivers and ground water for drinking water supply, irrigation, drainage, hydroelectric power, industrial water supply, flood control, navigation, pisciculture etc.

ii. Promotion of afforestation and control of soil erosion for the catchment of river to prevent sedimentation of reservoirs and recharge ground water.

iii. Prevention of pollution of the surface and ground water of the basin.

iv. Mitigation and prevention of drought.

v. Development of crop plan for irrigation projects and for rain fed area.

vi. and such other matters as may be prescribed.

The member of the Board shall consult and take into the account the policies, schemes and guidelines of the concerned Departments in Government. The perspective plans prepared by the RBOs shall be approved by WRB and shall be the blue print of development of water resources in the basin.

(c) The RBO will finalise allocation of water to various stake holders in the basin for approval by the Water Resources Board.

(d) The disputes relating to water among the various stakeholders within the basin will be resolved by the RBO.

(e) All new projects in the water related activities including afforestation and soil conservation to be taken up by any Department in the basin will have to be placed before the RBO and its comments taken into considerations before Administrative approval is accorded to the Projects.

(f) The State Water Resources Board is the highest organization in the State for policy and principles on water development. Orissa Water Planning Organisation (OWPO) functions as its secretariat and is responsible for preparation and updating of the basin plans of the State. The OWPO shall submit the draft Basin Plans, when prepared, to the RBO and modify the draft as per comments of RBO before putting up to WRB for approval.

(g) The RBO may perform such other matter which is supplemental, incidental or consequential to any of the above functions as may be decided by Government from time to time.

3.2 Power

For the purpose of efficiently performing its functions every RBO may within its area of operation may

(a) Cause to be inspected any work undertaken in the basin by any Department.
(b) Collect such topographical, meteorological, hydrological, agronomical and sub-soil water data as it deems necessary.

(c) Cause any Deptt. To furnish such information as the RBO may require in relation to its functions.

(d) Any other matter as may be necessary to perform the functions effectively.

4.0 Funding

There will be no separate funding from the Govt. to carry out development works in the basin. The line departments will execute the projects/ activities as provided in their budget. The expenses of the RBO will be met from the budget of Deptt. of W.R.

Proposed Action Plan - Sub-Committee of Basin Level Planning & Management

Objective	Strategies	Proposed Action Plans	Duration	Financial Requirements	Collaborating Institutions/ Organisations
I. National Water Mission to ensure integrated water resource management helping to conserve water, minimize wastage and ensure more equitable distribution both across and within states. II. Ensuring more effective management of water resources, III. Integrated water policies to cope with variability in rainfall and river flow at the basin level.	Integrated Planning and Management of Water Resources for sustainable development for river basins.	**I.** Strengthening / Reorganization of Water related Departments of the States for data collection / compilation of all water related data using modern Information technology, keeping the climate change scenario in view	One year	To be met from State funds	Water related Departments of States
		II. Setting up of State level multi-disciplinary, basin / sub-basin wise organizations having representatives from stake holder departments. and public to perform following functions:	By 2010	The expenses of State RBOs will be met from the budget of Department of Water Resources	Water related Departments of States and all stakeholders
		a. Creation of information system including databank of all the data (collected from various sources) for integrated water resources planning & management	By 2011		
		b. Development of the comprehensive technological tools based on the state of the art computer technology, for preparation of basin / sub-basin plans	By 2011		
		c. To study the variability in the hydro-meteorological parameters such as temperature, rainfall etc. region / basin / sub-basin wise keeping in view the effect of climatological changes for optimum utilization of water resources and to carry out comprehensive water balance studies	By 2011		