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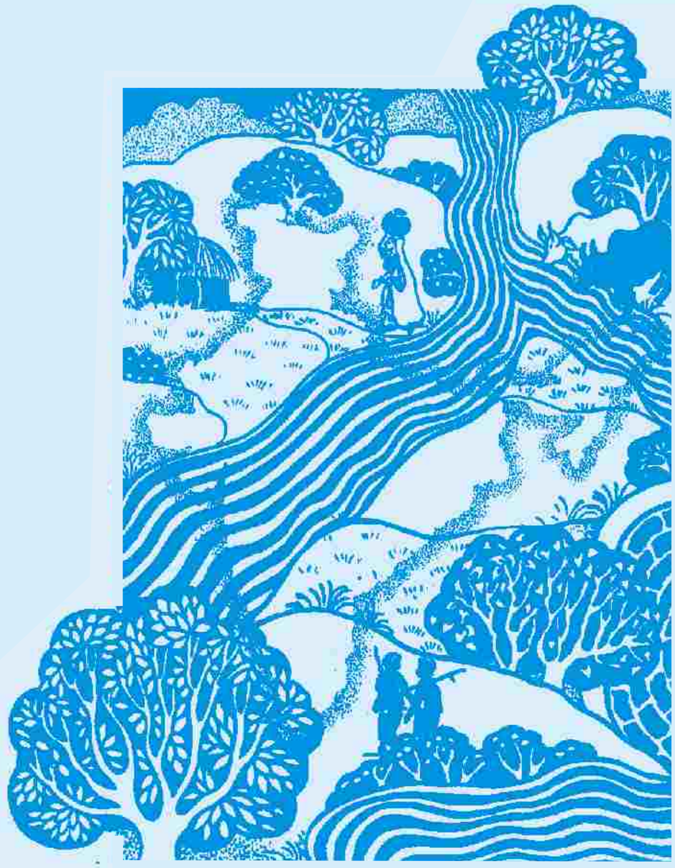

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Comment

India Inc. 2050
Potential Deviations from 'Business-As-Usual'

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and
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Comment on:

Report of the National Commission for Integrated Water Resource Development (NCIWRD)

The debate on India's ambitious interlinking project has become polarized. Instead of helping the nation to think, analyze and form a rational viewpoint, it has turned into a shouting match, devoid of scientific analysis.

The proponents insist that thousands of highly qualified engineer-days have been invested in studying the feasibility of the links. But, the analysis is not available in public domain. The opponents argue that the project is a conspiracy to hide the past inefficiencies of the irrigation bureaucracy. And yet, the alternatives proposed by them to India's impending water challenge also seem far from concrete.

This ITP Comment takes a close look at the NCIWRD report, which has repeatedly been cited as the basis for interlinking planning and outlines a framework for 'Water Future' research which will help in raising the level of this important national debate by helping develop a refined, textured and nuanced understanding of 'India's Water Challenge 2050'.

India Inc. 2050: Potential Deviations from 'Business-As-Usual'[1]

Research Comment on Report of the National Commission on Integrated Water Resources Development (NCIWRD) Titled: "Integrated Water Resource Development: a Plan for Action"

Introduction

The Government of India's (GoI) ambitious National River Linking Project (NRLP) will form a gigantic south Asian water grid which will handle 178 billion cubic metres (BCM) of inter-basin water transfer every year. In doing so, it will, build 12,500 Kms of canals; generate 35 giga-watts of hydropower; and add 35 million ha (mha) to India's irrigated areas at a projected cost of US$ 120 billion. Arguably, this is one of the largest infrastructure projects ever undertaken anywhere in the world and it will, directly or indirectly, influence the lives of over a billion people.

The (now disbanded) high powered Task Force, set up with the mandate of planning and implementing the project, repeatedly cited projections made by the National Commission for Integrated Water Resource Development (NCIWRD, 1999) about increased irrigated area required to feed the growing population as the key justification for NRLP. However, for an investment that would annually take away one percent of India's GDP, the Commission's analyses need verification and examination from a variety of angles.

In this paper, we take a hard look at the methodology and assumptions employed by the Commission in view of some recent developments and outline potential deviations from the Commission's estimates. Our intention is not to criticize the work of the learned Commission but rather to suggest ways and means of extending and refining the analysis initiated by it.

NCIWRD's Methods and Assumptions

The Commission uses a 'building-blocks' approach to estimate the total water requirement for three years: 2010, 2025 and 2050. Water requirement for each important use is estimated, under a set of specific assumptions, and then all uses are added up to obtain national-level water requirement figures. We briefly discuss here the methods, assumptions, and results obtained for each use.

Water Provision for Irrigation

For estimating agriculture water use, projected requirement has been broken down into four key determining variables: [1] requirement for food production; [2] requirement for non-food production; [3] water use efficiency; and [4] land productivity.

The key assumption in estimating irrigation requirement for food production has been that India will continue its policy of maintaining self-sufficiency in food production. The Commission also assumes that the present ratio of area under food and non-food production (70:30 for irrigated areas; 66:34 for un-irrigated areas) will remain constant. Interestingly, a comparison of projections made under a special study by Ravi (1998) for the Commission with those by Bhalla

[1]The research covered by this IWMI-Tata *Comment* was carried out with generous support from Sir Ratan Tata Trust, Mumbai under IWMI-Tata Water Policy Program. The research paper can be downloaded from the IWMI-Tata Website http://www.iwmi.org/iwmi-tata.

This ITP *Comment* is based on the full paper titled "India 2025/2050: The Emerging Agenda for Water Future Research" by the same authors. (Verma and Phansalkar 2004) The paper can be requested by writing to s.verma@cgiar.org.

BOX 1: SETTING THE STAGE - INDIA'S WATER RESOURCES [2]

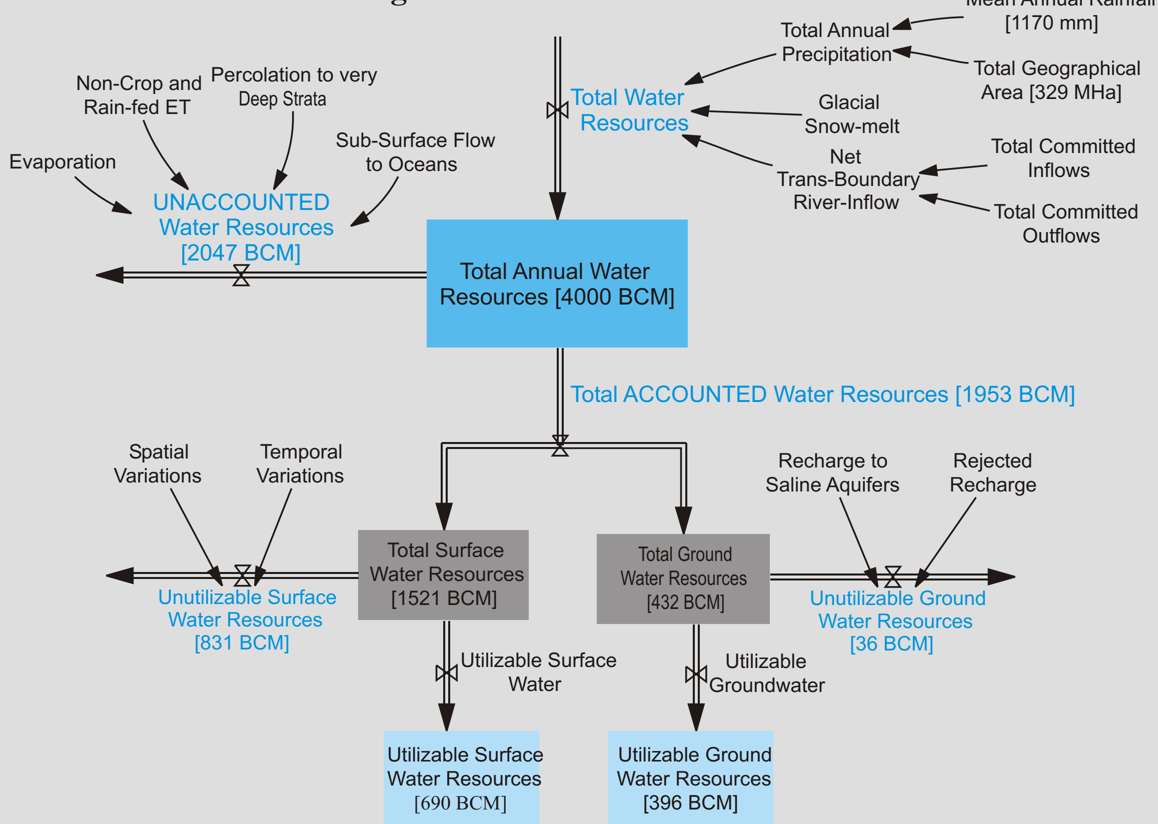
How much water do we have? How much of it is currently being used? How far can it be stretched further? Ironically, even the best estimates on these basic questions are often confusing, inaccurate or inconsistent. In this section, we try and address these questions in a simple and coherent manner to provide the reader a backdrop for NCIWRD's estimates.

India's total annual water resources are estimated as the sum of total precipitation, net transboundary inflows, and total glacial snow-melt. Roughly, these have been estimated at around 4000 BCM. Of these 4000 BCM, less than half (1953 BCM) is accounted for. The rest (2047 BCM) constitutes what may be called the 'unaccounted' water resources of India. This 'unaccounted' water is primarily used up in natural processes which may be looked at as "deductions-at-source". Roughly half the total annual water we receive is used as evaporation (from natural and man made water resources) to maintain humidity; taken up by trees, shrubs and other non-agriculture vegetation; used up by rain-fed crops; gets recharged and stored in deep aquifers from where extraction is technically and/or economically infeasible; and flows below the surface towards the oceans to maintain a critical hydraulic pressure which prevents saline sea water from entering our groundwater aquifers.

Out of the accounted 1953 BCM, only about 1086 BCM is actually usable. This second deduction is because of the spacio-temporal variations in its availability. The Ganga-Brahmaputra-Meghna (GBM) basin, which covers 33 percent of the land area, accounts for more than 60 percent of the India's water resources. Similarly, catchments of west flowing river basins, which cover for only 3 percent of the land area, account for 11 percent of water resources. Thus, 71 percent of India's water resources are available to only 36 percent of the area (at a comfortable 24 BCM/mha) while the rest 64 percent area gets the remaining 29 percent of the water resources (at 5 BCM/mha). Moreover, about 80 percent of the Himalayan river flows and 90 percent of the Peninsular river flows occur during the four monsoon months. While some of this gets used 'online', the remaining needs to be stored 'offline' for use in the remaining eight months.

After taking into account these variations, the utilizable water resources of the country add up to 1086 BCM; of which 690 BCM is the utilizable surface water potential and 396 BCM is the utilizable groundwater potential (See Figure 1). In a nutshell, if we look at the hydrological cycle as a system, ***the purpose of all water resource development interventions (large or small) is to use the water (at least once and as many times as possible) from the time is falls as rain to the time it flows into the oceans and comes back in the form of rain in the next cycle through the creation of 'artificial delays'***. Unless such delays are introduced in the hydrological cycle, our capacity to utilize water resources will be significantly diminished.

Figure 1: India's Water Resources



[2]All figures quoted in this box are with reference to the NCIWRD (1999) report. The authors would like to acknowledge the help of Mr. Chetan Pandit, IWRS, Delhi for clarifying the basic concepts of water resources to us through an 'E-Mail Crash Course on Water Resources'. Acknowledgements are also due to Dr. Christopher Scott, Principal Scientist and Regional Director, IWMI, South Asia.

Table 1: Water Requirement for Irrigation: 2010, 2025, 2050 (All Figures in BCM)

VARIABLE	REMARKS AND ASSUMPTIONS	UNITS	2010	2025	2050
Population	Low Growth Scenario (UN 1995)	Million	1156.60	1286.30	1345.90
	High Growth Scenario (Visaria & Visaria)	Million	1146.00	1333.00	1581.00
Urbanization	Low Growth Scenario	%	32	37	48
	High Growth Scenario	%	34	45	61
Per Capita Food Demand	@ 4.5% Expenditure Growth	Kg/Cap/Yr.	194	218	284
Food PLUS Demand	**Low Growth Scenario**	**MT**	**245**	**308**	**420**
	High Growth Scenario	**MT**	**247**	**320**	**494**
Net Sown Area	Marginal Increase	Mha	143	144	145
% Gross Irrigated Area	Low Growth Scenario	%	40	45	52
	High Growth Scenario	%	41	48	63
Cropping Intensity	20% Growth Assumed over 50 years	%	135	140-142	150-160
% Food Crops	Rainfed Areas (No Change)	%	66	66	66
	Irrigated Areas (No Change)	%	70	70	70
Food Crop Yields	Rainfed Areas (Modest Increase)	T/Ha	1.10	1.25	1.50
	Irrigated Areas (Modest Increase)	T/Ha	3.00	3.50	4.00
Food PLUS Production	**Low Growth Scenario**	**MT**	**246**	**307**	**422**
	High Growth Scenario	**MT**	**249**	**322**	**494**
Irrigation Efficiency	Surface Water Irrigation	%	40	50	60
	Ground Water Irrigation	%	70	72	75
Gross Irrigation Requirement [GIR]	Surface Water Irrigation [NIR = 0.36]		0.91	0.73	0.61
	Ground Water Irrigation [NIR = 0.36]		0.52	0.51	0.49
SW Dependence	Growing Dependence on SW Assumed	%	47	49-51	54.3
Total Water Required	**Low Growth Scenario**	**BCM**	**543**	**561**	**628**
	High Growth Scenario	**BCM**	**557**	**611**	**807**

Source: Adapted from various tables in the NCIWRD Report

and Hazel (1998) shows that even at 5 percent growth rate of expenditure, the food and feed demand projected by the former is less than that estimated by the latter. Moreover, Bhalla and Hazel estimate that 42 percent of India's population will be living in urban areas as early as 2020. Ravi's prognosis, however, estimates a much lower proportion of urban population for the same time period and has generated three scenarios of food demand under 4 percent, 4.5 percent and 5 percent growth rates in expenditure. The Commission has accepted the projections made by Ravi with the assumption of 4.5 percent growth in expenditure to estimate its food and feed demand. Based on these assumptions, the Commission has calculated the total water requirement for irrigation in 2010, 2025 and 2050 under low and high population growth scenarios as shown in Table 1.

Water Provision For Domestic Use

The Commission has reviewed various norms suggested for water requirement for human use and has suggested a target of providing 220 litres per capita per day (LPCD) for urban areas and 150 LPCD for rural areas by 2050. On the basis of these targets, it has estimated the water requirement for domestic use under high and low population growth scenarios. It has further assumed that roughly 55-60 percent of the water requirement for domestic use will be met from surface water sources. The total bovine water requirement for 2010, 2025 and 2050 has been estimated assuming a half percent annual growth rate of bovine population and water requirement of 18-30 LPCD (Table 2).

Table 2: Estimation of Domestic and Municipal Use and Bovine Requirements

Population Type	2010	2025	2050
Targets for Domestic and Municipal Use (LPCD)			
Class I Cities	220	220	220
All Other Urban Areas	150	165	220
Rural Areas	55	70	150
Low and High Projections (BCM)	42-43	55-62	90-111
% from Surface Sources (approx.)	55	57	60
Bovine Water Requirements (BCM)	4.8	5.2	5.9

Source: Adapted from tables 3.26 and 3.27, NCIWRD Report

Water Provision for Industries

The Commission, by its own admission, is very tentative about its projections for water use in industries. It notes that there is a serious dearth of information and analysis on both present water requirement and future growth of industries in India. In such a scenario, it uses data available with the Central Pollution Control Board (CPCB) and the classification of industries into 17 sub-sectors done by the Planning Commission to arrive at its estimates. The estimates for the years 2010, 2025 and 2050 are 37, 67, and 81-103 BCM respectively. These estimates are based on a 'sliding scale' with the lower estimate of 81 BCM arrived at by assuming significant breakthroughs in development and adoption of water saving technologies for industrial production. It has further assumed that 70 percent of these requirements will be met from surface water sources.

Water Provisions for All Other Needs

In addition to the above, the Commission has estimated water requirement for power generation, development for inland navigation, compensating evaporation losses from reservoirs, floods and environment and ecology. We briefly enumerate these below:

Power Generation: While recognizing the growing importance of non-thermal sources, specifically hydel power, the Commission contends that, in view of the economies in power generation from coal and the high initial investment and long gestation period in the construction of hydel schemes, thermal power will continue to be the mainstay of India's power sector in the foreseeable future. Based on estimates collected from various sources for thermal power and by using lump-sum provisions based on 9 percent annual growth assumption for hydel power, it has used a water requirement norm of 0.001 BCM/100 MW power generation capacity. Based on this ballpark number and projections about India's growing power generation capacities, the Commission has arrived at its final results (Table 3).

Table 3: Water Requirement for Power Development: 2010, 2025 and 2050 (BCM)

Category	Norm for Water Requirement (0.001 BCM/100MW)					
	2010		2025		2050	
	Low	High	Low	High	Low	Hig
Thermal	2.81	3.43	7.85	9.59	28.71	35.07
Hydropower*	15.00	15.00	22.00	22.00	30.00	30.00
Nuclear	0.29	0.36	1.13	1.38	3.68	4.50
Solar/Wind	0.00	0.00	0.01	0.01	0.04	0.04
Gas-based	0.02	0.02	0.06	0.07	0.18	0.22
TOTAL	**18.10**	**18.80**	**31.10**	**33.10**	**62.60**	**69.80**

* Lump-sum based on 9 percent annual growth assumption
Source: Adapted from table 3.28, NCIWRD Report

Development of Inland Navigation: Of the 900 billion ton-km per annum total inland cargo, only one billion is currently moved by inland water-way transport. The flow requirements in water channels are mostly expected to be met by seasonal flows in various river systems and canals. However, in the event of damming of entire river flow, some water would need to be released from upstream reservoirs for keeping the waterways navigable, especially during the lean season. In view of this, the Commission has projected 7, 10 and 15 BCM surface water requirement for 2010, 2025 and 2050 respectively for navigational purposes.

Compensating Evaporation Losses: Evaporation losses from reservoirs are generally quantified in terms of percentage of reservoir capacity and are estimated as 20 percent of total withdrawals. However, such calculations would require accurate withdrawal data for all reservoirs. In the absence of such data, the Commission has adopted an alternative method based on live storage capacity. It has estimated national average values of evaporation losses from reservoirs as 15 percent of live storage capacities for major and medium irrigation reservoirs and 25 percent for minor irrigation reservoirs (Table 4).

Table 4: Estimates of Evaporation Losses (2010, 2025 and 2050)

Particulars	1997	2010	2025	2050
Live Capacity (Major Storage)	173.73	211.44	249.15	381.50
Evaporation (@ 15%)	26.10	31.70	37.40	57.20
Live Capacity (Minor Storage)	34.70	42.30	49.80	76.30
Evaporation (@ 25%)	8.70	10.60	12.50	19.10
Total Evaporation Loss (rounded-off)	**35.00**	**42.00**	**50.00**	**76.00**

Source: Adapted from table 3.29, NCIWRD Report

Floods: The Commission makes a case for setting aside some water capacity for moderating the releases from dams in the event of high floods. However, it concludes that such situations are 'casual' in nature, and therefore no provision has been made for such purpose.

Environment and Ecology: The Report talks at length about the poor state of the environment in the country citing references to indiscriminate depletion of forest cover. It mentions that India's forests can 'sustainably' provide only about 0.041 km^3 of fuelwood every year compared to the current demand of 0.240 km^3. Further, it adds that industrial wood requirements are more than twice the current silvicultural productivity, and that while the carrying capacity of forests is only 31 million cattle-heads, currently about 90 million of them graze in forests. The report, however, concludes that since most of the water requirements for afforestation would be met from precipitation and soil moisture (green water), there is no need for any specific earmarking for this purpose. It also takes note of the alarming levels of river pollution, giving examples of cities such as Delhi, which produces nearly 2 billion litres of sewage, most of which is dumped into the Yamuna river without any treatment. It points out that treatment of such sewage from Delhi alone would require about 3 BCM of fresh water to restore the quality of water to a safe limit. And yet, at the end, it makes a token provision of 5, 10 and 20 BCM for water for floods, environment, and ecology for 2010, 2025 and 2050 respectively.

Total Water Requirement

Based on all the assumptions and projections above, the Commission has estimated total water requirement under low and high demand scenarios as 694-710, 784- 843 and 973-1180 BCM for 2010, 2025 and 2050 respectively (Table 5).

POTENTIAL DEVIATIONS

The Report presents a rare case when issues of such diverse nature, and requiring such diverse expertise, have all been dealt together and therefore makes a compelling reading for any concerned individual. Having said that, we believe that the estimates represent ultra-conservative 'Business-As-Usual' scenarios which, among other things, fail to take into account two things: [1] coping mechanisms of the people and demand responses to policy triggers; and [2] technological and social breakthroughs on the horizon. Several autonomous and induced changes which will profoundly influence the course of India's food-agricultural sector over the coming 50 years do not find a place in the data and projections made by the NCIWRD (at least in the part available in the public domain). We discuss some such potential deviations here.

India's Demography 2050

The Commission reviewed some of the existing estimates (Table 6) and chose, for reasons not clearly specified, to follow the Visaria and Visaria

Table 5: Total Water Requirement: 2010, 2025 and 2050 (BCM)

Uses of Water	1997-98	Scenario	2010	2025	2050	%SW*
Agriculture Use	524	High	557	611	807	57-61
		Low	543	561	628	
Domestic and Municipal Uses	30	High	43	62	111	53-59
		Low	42	55	90	
Industrial Uses	30	High	37	67	108	70-71
		Low	37	67	81	
Power Generation	9	High	19	33	70	77-81
		Low	18	31	63	
Development of Inland Navigation	-	High	7	10	15	100
		Low	7	10	15	
Compensating Evaporation Losses	36	High	42	50	76	100
		Low	42	50	76	
Floods, Environment and Ecology	-	High	5	10	20	100
		Low	5	10	20	
GRAND TOTAL	**629**	**High**	**710**	**843**	**1180**	**63-65**
		Low	**694**	**784**	**973**	

*Proportion of requirement proposed to be met from surface water sources
Source: Adapted from Table 3.30, NCIWRD Report

estimate as 'high variant' and the United Nation's 1994 estimate as 'low variant'. Interestingly even the UN has, since then, revised its own estimates and their latest (2002) projections for India in 2050 are 5-8 percent lower than those in 1994.

There is a strong case, therefore, that the reality in 2050 might significantly deviate from the Commission's estimates. One of the reasons for such a deviation could be the potential impact of HIV/AIDS which most population projections in India have so far ignored. Back in 1999, when the Commission was preparing its estimates, the GoI had not officially recognized the emerging threat of HIV/AIDS. Today, not only has the reality perhaps some-what exacerbated, the GoI too has admitted that there are more than 5 million HIV/AIDS affected persons in the country[3].

Table 6: Projections of India's Population Growth

Reference	All India population (in million)				
	2000	2010	2020	2025	2050
Natarajan (1993)	1020.50	1183.10	1301.00		
United Nations (1994)					
[a] Low Variant	1013.50	1156.60	1249.70	1286.30	1345.90
[b] Middle Variant	1022.00	1189.00	1327.10	1392.00	1640.00
[c] High Variant	1030.50	1221.70	1406.10	1501.50	1980.00
Registrar General (1996)	997.00	1162.00			
Visaria and Visaria (1996)	995.00	1146.00		1333.00	1581.00
United Nations (2002)					
[a] Low Variant	1016.94	1145.90	1236.09	1265.61	1241.56
[b] Middle Variant	1016.94	1173.81	1312.21	1369.28	1531.44
[c] High Variant	1016.94	1201.71	1388.48	1474.48	1870.06

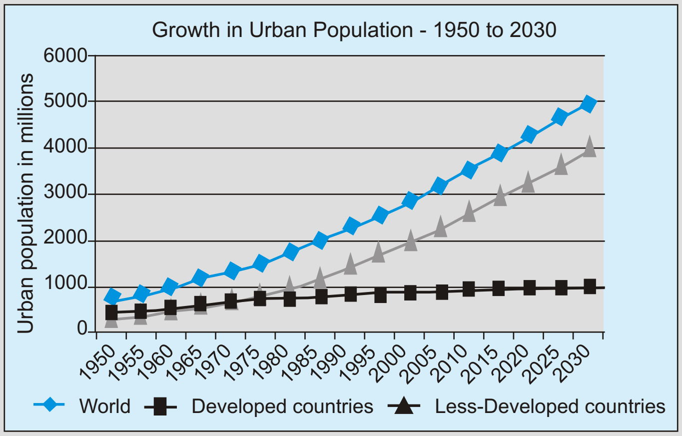
Source: NCIWRD (1999); UN (2002)

[3] Health Minister's reply to a question raised in Parliament on August 18 2004.

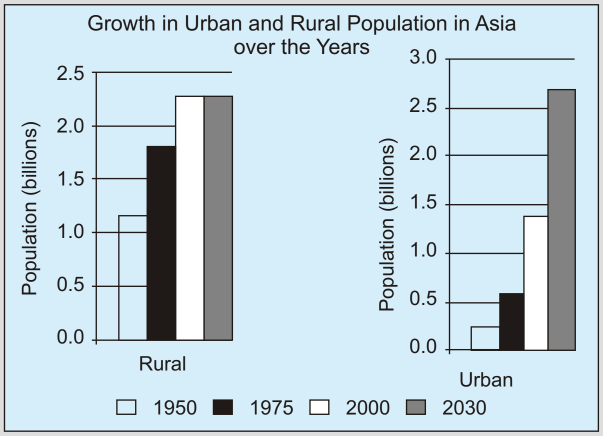
BOX 2: WATER RESOURCE PLANNING IN THE 'URBAN CENTURY'

Even as the share of agriculture in the GDP of developing countries is continuously falling, majority of their populations continue to depend on agriculture. This has meant that the water intensity of rural livelihoods has remained high and much of the planning for water resources has remained significantly agriculture-centric. However, recent trends in urbanization indicate that this is going to change sharply over the next half-century. Based on an analysis of the United Nation's latest demographic projections (UN 2002), Mohan and Dasgupta (2004) assert that the 21st century is going to be the 'Asian urban century' (Figure 2).

Figure 2: Asia in the 'Urban Century'



Source : UN 2002; Mohan and Dasgupta (2004)



Source: UN, 2002; Mohan and Dasgupta (2004)

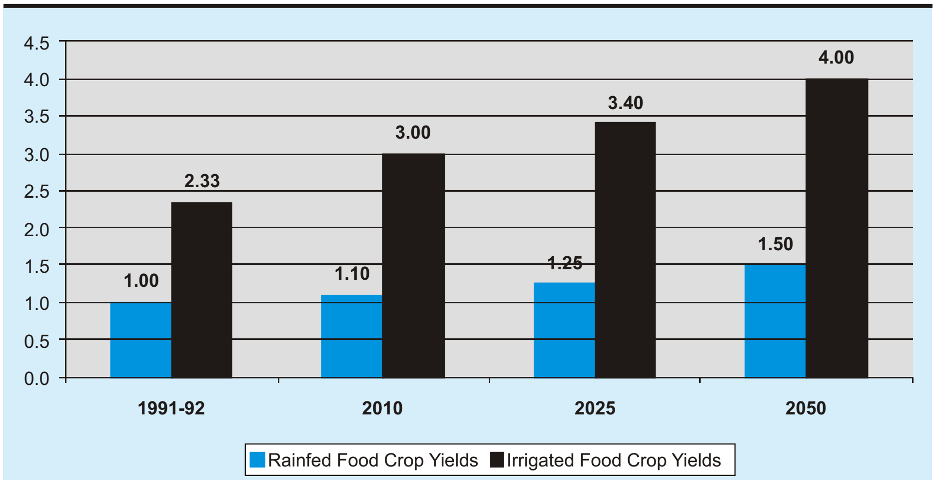
For India, this would imply that, by 2030, more than 40 percent of her population will live in urban settings resulting in a further intensification of the already evident conflicts between towns and their hinterland for water. While urban water requirements total up to a small share in total fresh water use, and will perhaps continue to remain that way, year after year, knee-jerk policy action is taken to avert urban water crises. These annual bouts of crises and the fact that numerous irrigation systems are today unable to serve rural areas as their water gets diverted to cities illustrates that the growing needs of urban centres were not adequately considered at the time of planning the irrigation systems. Scenarios of urban water needs, which are backed by policy priority, much higher ability to pay, and often a stronger political pull, therefore must be developed and built into the planning process.

Dyson and Hanchate (2000) are among the few who have attempted with and without AIDS projections. They argue that because the disease has a very long incubation period, population known to be suffering from AIDS at any point of time represents only the tip of the iceberg. Further, they assert that while the effect in India might not be as dramatic as in some African countries such as South Africa, to make no allowance for its impact is no longer tenable. India must be looked at as a continent (like Africa) where there might be pockets (like South Africa and Botswana) which will be severely affected by the epidemic as well as pockets (like north Africa) where the level of infection will be low. Even in such large and diverse populations, the impact of HIV/AIDS on mortality rates and life expectancy can be significant. Between 1980 and 2005, it is believed that Africa's life expectancy will remain constant at around 51 years. However, in a 'without AIDS' scenario, it would have been roughly 5 years higher (UN 1999a; 1999b). In the light of the above, a closer re-examination of India's demography in 2050 is in order.

Liberalization and Food Crop Preferences

Changes currently underway in the international trade policy environment and India's policy response to these will have wide-ranging consequences for the agriculture sector and for food security in the short and long term. Along with China, India is one of the biggest players in the world food market; not by virtue of the size of their current trade, but on account of the potential havoc these countries can create by entering the world food market either as significant importers or exporters. If either of them decide to export or import in large numbers,

Figure 3: Projected Yield Growth by NCIWRD



Data Source: NCIWRD (1999)

world food prices could soar or crash in no time. With liberalization in trade (as a result of WTO/GATT), such situations will bring different incentives and signals to the Indian farmer. If world food prices are lower than the costs of production in India (if say, China adopts a food-export policy), free trade and Chinese farmers could potentially crowd Indian farmers away from food-farming.

Three things will determine farmers' preference for food crops: [1] India and China's foray into the world food market and the resultant impact on food prices.; [2] degree of freedom and liberalization (conversely, support and protection) in international food trade; and [3] farm-level food surplus/deficit (it is not uncommon to see farmers being averse to buying food for self consumption). While most people tend to agree that India will not give up its food self-sufficiency policy, individual farmers' decision to produce food crops will depend on price signals and market surplus/deficit conditions operating at the micro and meso level.

Productivity and Efficiency of Water Use

The Commission has assumed very modest increase in the productivity of irrigated and rainfed food farming systems (Figure 3). If these assumptions hold, and given that total cropped area is unlikely to increase significantly, India would certainly need much more land under irrigation to feed the growing population. However, certain recent and potential future developments incline us to rethink.

Drip irrigation technologies promise 30-70 percent improvement in water-use efficiency, besides offering significantly higher yields and several other benefits. However, ever since they were first introduced (some three decades ago), area under drip irrigation has expanded rather sluggishly from 1500 ha in 1985 to a little over 70,000 ha in 1992 and rapid growth has only been seen in recent years as the area spread to 2,25,000 ha in 1998; still miniscule compared to an estimated potential of 10.50 million ha. Despite active promotion by a growing private irrigation equipment industry and subsidies (up to 90 percent) offered by the government, the appeal of these technologies has remained confined to "gentlemen farmers" (Shah and Keller, 2002). Recent research suggests that when faced with groundwater stress, the same farmers who have rejected the capital intensive subsidized drip systems have innovated and embraced low-cost grassroots innovations such as *Pepsee* drips[4] which act as stepping-stone technologies. How quickly and to what scale will these technologies expand? What would be the net impact of 'More Crop per Drop'?

The impact of GM technologies, which for obvious reasons was not taken into account, could be another significant factor. So far, much of the debate on GM technologies in India has been concentrated around Bt cotton rather than food crops. How the GM revolution can change the paradigms of food security needs to be studied in detail. Will future technologies offer seed varieties

[4]*Pepsee* systems are low cost substitutes for drip irrigation systems made up of low density polythene ranging from 65 to 130 microns. At less than half the price of conventional drip systems, this grassroots innovation promises comparable results and has become very popular among cotton farmers in the Maikaal region of central India (See Verma *et al*., 2004).

which will produce much more food grain for the same amount of water? What could be the implications of such technologies for the poor and for under-developed and developing countries? What kind of global system of governance will evolve to govern the GM revolution? Will intellectual property rights (IPRs) and patents play a big role in determining dominance in the global food business? What would all this mean for India?

Then, there are certain 'horizon' technologies like system of rice intensification (SRI) which promise to improve water use efficiency. SRI is drawing attention world-wide as a compact of paddy cultivation practices that boost paddy yield while reducing water use and cost of cultivation. Developed after over two decades of experimentation in Madagascar, under conditions not very different from those in India, SRI promises significant increase in rice yields without the introduction of new varieties of HYV seeds or increase in external chemical inputs and, most importantly, *with much reduced water use*. This technology has been successfully tried with farmers in Sri Lanka, Tamil Nadu, Karnataka and Andhra Pradesh and by PRADAN with poor farmers in Purulia. In regions where paddy cultivation is central to rural livelihood systems, such as tribal Orissa, Jharkhand and Chattisgarh, SRI holds out a big promise that needs to be vigorously explored. Though there is little empirical data on SRI in India, data from other countries suggests it might become the mainstream practice in the years to come and could well be the 'next-big-thing' in rice cultivation. In Madagascar, average paddy yields among adopter farmers rose from 2 to 8 tons/ha. Is the promise offered by SRI too good to be true? Can such high yields be sustained in the long-run without affecting soil fertility?

Performance of India's Surface Irrigation Systems

The efficiency levels at which surface irrigation systems work in most parts of the country does not require great elaboration. The Commission has projected that India's surface irrigation systems will work at 40, 50 and 60 percent efficiency levels in 2010, 2025 and 2050 respectively. How these incredible efficiency gains will be achieved is mostly left to the readers' imagination. The Commission has suggested that *"all state irrigation acts have to be amended to incorporate provision for the formation of farmers' bodies"*. It then proceeds to review performance of user managed irrigation systems in nine major states and concludes that their performance is far from satisfactory. Irrespective of the above, it hails the fact that over 25,000 water users' associations (WUAs), covering 5.8 mha, have been created in various states.

Initiating a program for user management of irrigation systems or the mere formation of irrigation communities will not automatically lead to improved efficiency in surface irrigation systems. One school of thought argues that even when successful, participatory irrigation management (PIM) can only help improve distribution efficiency (DE), which, in any case, is only a small part of the overall efficiency (E)[5]. Proponents of this school argue that the main culprit in poor efficiencies is poor 'Main System Management'. Factors such as lower water availability, untimely and unreliable supply, lower storage capacity and higher conveyance losses vis-à-vis those assumed at the planning stage, are responsible for poor efficiencies. The pertinent questions, therefore, are: what kind of efficiency improvements (CE or DE or AE) can we achieve by 2050; how, how much, and at what cost? To

[5]According to the International Commission on Irrigation and Drainage (ICID),
Overall Efficiency (E) = CE * DE * AE where,
CE = Volume of water delivered to the distribution system / Volume of water delivered at the canal head;
DE = Volume of water delivered to the field / Volume of water drawn from the distribution system;
AE = Volume of water made available to crops / Volume of water drawn at the field head.

BOX 3: INDIA'S PUBLIC IRRIGATION SYSTEMS

The Planning Commission contends that a mere 10 percent increase in the efficiency of the existing irrigation infrastructure would lead to 14 million additional hectares of agricultural land getting water. In a series of exchanges between noted water sector stalwarts Ramaswamy R. Iyer and Radha Singh, in the Economic and Political Weekly (EPW), the latter remarked (Singh 2003) :

> "Conceding that the efficiencies of our water systems, especially irrigation, must be improved, the efficiencies within the major and medium sector (irrigation) are around 40 per cent, while in the minor and groundwater sectors it is above 60 per cent. With a delta of 0.95 m, total water use in major and medium irrigation sectors would be 37 mha × 0.95 = 351 BCM. Improvements in efficiencies within this sector would render an additional availability of approximately 52 BCM which, though significant, is hardly enough to counter the widespread scarcity prevalent in numerous basins of our country."

It is not clear as to how the figure of 52 BCM has been arrived at. If 351 BCM is taken to be a correct estimate, and assuming that surface irrigation projects do operate at 40 percent efficiency level (which is the level that the Commission projects India's surface irrigation projects will achieve by 2010), it would mean that the amount of water which actually reaches the farmers' fields would be 351*0.40 = 140.40 BCM. Assuming that no additional surface irrigation projects are commissioned, with improvement in efficiency from 40 percent to 60 percent, this should change to 351*0.60 = 210.60 BCM. The additional availability, therefore, can be calculated as 210.60 - 140.40 = 70.20 BCM. Again using the Commission's own assumptions of water required to grow food grains, this additional 18.20 BCM water (which we just now discovered!, 70.20-52) would amount to an additional food production of roughly 12 million tons!

what extent will PIM or Irrigation Management Transfer (IMT) salvage India's public irrigation systems? Is there a need to think of and experiment with alternative strategies and institutional arrangements for vitalizing this important sector?

Ecological and Environmental Water Needs

Ecological and environmental water needs is perhaps the most intriguing topic in the entire report. The report begins by making a strong case for ecological and environmental water needs but falls short of making any real estimates of the requirements and of making any worthwhile allocations. We strongly believe that the token provisions made by the Commission greatly undermine the issue and need to be revisited. We discuss the issue of forests to illustrate what all might go wrong in these estimates.

As mentioned earlier (See Box 1), more than 50 percent of India's total water resources are un-accounted i.e. we do not fully understand how this water gets used. We do know that a part of this water is taken up by forests and other non-agricultural vegetation including grasslands and shrubs. While hardly anyone would want to suggest a policy to deplete forests to expand our utilizable water resource, if our forests continue to deplete and degrade as they have in the recent past, perhaps much more of this water will be available for alternate uses, though at huge ecological costs. If, on the other hand, effective forest protection policies and laws coupled with efforts towards large scale afforestation are going to move the country towards the universally preferred norm of 33 percent forest cover (from the existing ~20 percent), much less water might actually remain utilizable. The Commission's projections conveniently assume away any additional allocation for afforestation efforts citing that such requirements would be met by natural precipitation (green water). However, the fact that green and blue water are interlinked, that blue water is basically the residual left after all green water requirements are met, and that degree of green water use might impact total blue water availability itself is ignored.

While the importance of forests can hardly be overemphasized, there is a striving for better understanding of the relationship between forests and water in order to give forests their due place in water resource planning. Our argument here is not for or against forests but that water requirements of forests, and other ecological and environmental needs, must be given their due share in water resource planning.

Water Requirements vs. Water Demand

The Commission's estimates of 'water demand' are built on the basis of normative standards set down by competent agencies. For example, it's estimates of domestic and municipal water demand are based on the 220 LPCD and 150 LPCD norms. In the case of irrigation water demand, it uses 'Delta' figures for various crops. However, in our opinion, these can hardly be termed as 'demand'. Demand is defined as the desire to possess a commodity or make use of a service, backed by the ability to purchase it. In other words, it is the amount of a commodity or service that people are ready to buy for a given price. The Commission's approach ignores the impact of two key variables on demand: [1] price at which the water is supplied; and [2] the quality of the supply.

Costs (both tangible and transaction), quality of water and quality of supply are all likely to deviate the actual demand from the normative requirements. Price and scarcity also prompt people to make adjustments in their cropping pattern and cropping systems (shift to less water intensive crops; adoption of water saving irrigation practices or technologies).

India's experience with using price as a lever for influencing water use has not been very encouraging. The price at which use-rate becomes equal to the zero-waste level is invariably too high to be imposed in a political system such as ours. The neo-classical assumption of price acting as the best allocator does not therefore automatically work. Recent evidence of farmers extracting free power in several Indian states illustrates this point. Shah *et al.* (2003) suggest that, instead, an intelligent supply schedule which delivers just the right quantity of power (for agriculture), at the precise time when it is needed, would make both farmers and the electricity boards better off. Thus, efficient use is proposed to be effected not by price but by intelligent supply management. A refined and practical prognosis of future water demand must, therefore, account for two critical variables: [1] water demand (and not requirement) as a function of price, availability and supply quality; and [2] coping mechanisms and consumption patterns of users under conditions of surplus and scarcity.

Relative Dependence on Surface and Ground Water

To us, there seems to be a distinct 'surface water bias' in the Commission's estimates. The Commission assumes that surface water will be used to meet 57-61 percent agricultural; 53-59 percent domestic and municipal, 70-71 percent industrial, 77-81 percent power generation and 100 percent of all other requirements. Recent studies, however, indicate that groundwater might already be contributing much more than is commonly understood. While the Commission estimates that total groundwater use in 2010 will only be around 230 BCM, recent estimates of groundwater use today already exceed this number. The Central Ground Water Board's (CGWB 1995) estimates suggest that groundwater provision for domestic, industrial and other non-agricultural uses totals to 71 BCM. Together with estimate for groundwater use in agriculture by Shah *et al* 2003 (210 BCM), total groundwater use in India would already be close to 280 BCM.

Evidence from the 54^{th} round of NSSO survey also seems to support this. In a survey of nearly 80,000 households across more than 5,000 villages, 80 percent of the rural households reported that they self-supplied their domestic water needs. A significant proportion of these households can be expected to be relying heavily on groundwater, the largest source of self-supply. Data from a recent ITP study (Londhe *et al* 2004) in six A class cities (Indore, Nagpur, Jaipur, Ahmedabad, Bangalore and Chennai) notes that in three of these, the contribution of groundwater towards meeting the domestic and municipal water requirements of the city ranges between 72 percent and 99 percent. Several of them also have a thriving tanker water economy, supplying anywhere between 14-55 million litres per day (MLD) with annual revenues ranging between Rs.

0.11 and 1 billion. This informal water economy depends entirely on groundwater extraction from peri-urban areas. These findings tend to suggest that the relative shares of surface and groundwater need to be revised.

The Emerging Agenda for 'Water Future' Research

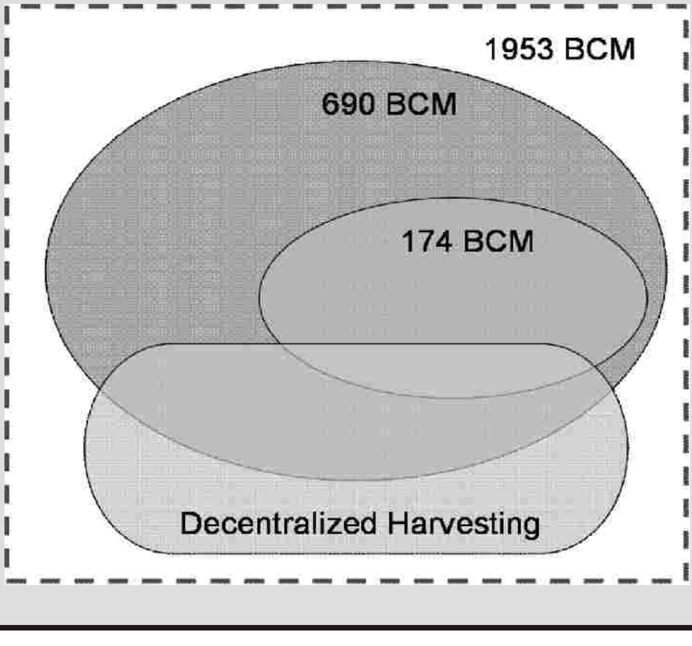
While the conservative estimates of the Commission paint quite a grim picture of India's water future, it must be granted that if no corrective action is taken, no forward planning done, nothing done to change the wasteful and inequitable use of water, the situation could well be like the one depicted by it. However, the broad statement of the demand and supply as done by the Commission indicates only a canvass; the actual picture will emerge only with people responding to the crisis as they see it emerging. The report thus offers a good base, a beginning point, which needs to be worked and built upon, rather than accepting it as the last word. The authors of the report too were, perhaps, quite aware of some of the inherent drawbacks which might have been imminent owing to paucity of available data and analyses. That is why even the report itself does not shy away from categorically stating that:

BOX 4: WHICH WATER GETS HARVESTED BY 'DECENTRALIZED RAIN WATER HARVESTING AND GROUNDWATER RECHARGE'?

Decentralized rain water harvesting and groundwater recharge movements have become a contentious issue in India. Four instances readily come to mind. The Rajasthan government took strong exception to Tarun Bharat Sangh's *Laava ka Baas* dam, arguing that it was basically capturing the water which would normally have flowed down to Bharatpur. Similarly, there has been some controversy about the Karnataka government's move to de-silt tanks in the Cauvery Basin as removing the silt from the tanks increases their capture capacity which, in turn, affects flows downstream. There are also reports about how “indiscriminate” rain water harvesting in the upper catchment is preventing the Jayakwadi reservoir in Maharashtra from filling. Even in Saurashtra; home to what is perhaps the largest people's movement of its kind in the world; doubts have been raised that the popular water harvesting and ground water recharge movement might have affected the storage in reservoirs downstream.

As the battle of wits between the 'bare-foot' and the 'suited-booted' engineers assumes alarming proportions, it is critical to make an objective assessment of the potential of such practices and to determine how much these can contribute towards meeting India's water challenge in 2050. The first question, of course, is which water do these movements harvest? If the water captured and harvested by these movements is part of the 2047 BCM which was anyway 'un-accounted', such conflicts should not arise. If we assume that the capture is from the 1953 BCM 'accounted' water, then, can decentralized water harvesting and recharge contribute to increasing the utilizable surface water potential beyond 690 BCM? If only a maximum of 174 of the 1869 BCM of water is so far stored in large, medium and minor dams (existing storage capacity), one would tend to believe that there's lots of scope for decentralized structures to capture more, provided they are sited at the right places and are not built to capture the same water which would have been captured downstream anyway. What can we do to ensure this? Answers to these questions can also significantly change our prognosis of India 2050.

Figure 4: Decentralized Water Harvesting: Which Water, Where?



"…These estimates should be treated basically as approximations…It would be desirable to review these estimates regularly, say, at the interval of 5-10 years."

One of the windfalls of the recent debate on inter-linking of rivers has been a heightened interest among the scientific community in projections about India's water future. Perhaps prompted by the estimates made by NCIWRD, there have been some attempts at the arguably difficult exercise of predicting the future. Irrespective of whether the river linking plan finally gets implemented or not, we believe that it provides an excellent opportunity for India to review its preparedness for meeting the challenge ahead. Admittedly, our analysis raises more questions than we attempted to answer but we hope that this will trigger a studied debate on this very important theme.

Table 7 presents a summary of the discussion above as well as a mixed-bag of other research themes worth pursuing which are elaborated in the full paper (See Box 4).

Table 7: The Emerging Agenda for 'Water Future' Research

THEME	STUDIES	ISSUES
Rethinking Water Availability and Demand	Evading Deductions at Source…Can we? Should we?	Adding 'Accounted' Water; Forest-Water Linkages; Non-Crop ET (Evapo-Transpiration); Sea-Water Intrusion
	Whicht Water Gets Harvested by 'Decentralized Rain Water Harvesting and Groundwater Recharge'?	Upstream-Downstream Conflicts; Riparian Rights; Potential of Decentralized Water Harvesting
	Desalination Plants: How much freshwater can they add (and at what cost)?	Potential of Desalination for meeting urban water requirements; Cost of Desalination
	Re-use of Wastewater for Agriculture: Boon or Bane?	Wastewater Use in Agriculture; Direct and Indirect Health Implications of Wastewater Irrigation
	Will Requirements Expand to Fill Free Supply?	Requirement-Demand Gaps; Pricing of Water; Quality of Water Supply; Coping Mechanisms
Demographic Projections	Incorporating the possible impact of HIV/AIDS	With and Without, High and Low HIV/AIDS Projections
	Regional Variations, Structure and Habitat of India's Population	Regional Variations; Changes in Structure; Habitat; Dependence Ratios; Rural-Rural and Rural-Urban Migration
Rate, Pattern and Structure of India's Economic Growth	Growth in India's GDP, Per Capita Income and Expenditure.	Degree of Formalization of India's Water Sector; Disposable Incomes and Water Demand
	Sectoral and Regional Variations in India's Economic Growth	Industrial Growth and Water Demand; Subsistence vs. Market Oriented Agriculture; Soft-Water and Hard-Water Development Models
	Rural Livelihoods and Occupation Patterns in 2050	Growth of and Employment in Rural Non-Farm Sector; Water Intensity of Rural Livelihoods
Food Security, Liberalization and Modernization of Indian Agriculture	Impact of World Food Trade on India's Food Security	WTO/GATT; India's Food Self Sufficiency Policy; Chinese Food Policy; World Food Prices
	Impact of GM Technology	Characteristics of Future Seed Varieties; Governance of Global GM Revolution
Efficiency and Productivity of Agriculture Water Use	Physical and Institutional Efficiency of Surface Water Systems	PIM/IMT; Alternate Institutional Arrangements; CE-DE-AE
	More Crop per Drop	Micro Irrigation; Horizon Technologies like SRI
	Engineering Food grain Productivity Gains in Less-Favoured Regions	Productivity of Rain-fed Agriculture; food productivity in Tribal central India
	Future Sources of Growth in India's Water Sources	Relative Importance of/ Dependence on Surface water or Ground water
Factoring in Changes in India's Macro Hydrology	Climate Change and its Impact on Future Water Availability and Demand	Climate Change Impact on Evaporation, ET, Run-off, Rainfall, Agricultural Productivity, Glacial Melting
	Environmental Impacts of Intensive Groundwater Use	Fluoride and Arsenic Contamination of Groundwater

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IWMI-Tata Water Policy Program

The IWMI-Tata Water Policy Program was launched in 2000 with the support of Sir Ratan Tata Trust, Mumbai. The program presents new perspectives and practical solutions derived from the wealth of research done in India on water resource management. Its objective is to help policy makers at the central, state and local levels address their water challenges – in areas such as sustainable groundwater management, water scarcity, and rural poverty – by translating research findings into practical policy recommendations.

Through this program, IWMI collaborates with a range of partners across India to identify, analyse and document relevant water-management approaches and current practices. These practices are assessed and synthesised for maximum policy impact in the series on Water Policy Research Highlights and IWMI-Tata Comments.

The policy program's website promotes the exchange of knowledge on water-resources management, within the research community and between researchers and policy makers in India.

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