Some Critical issues on Groundwater in India

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For almost all the water needs of the country, groundwater is by far the most important water resource.

- Worldwide, according to a UNEP study (Groundwater its susceptibility to degradation, 2003), over 2 B people depend on aquifers for their drinking water.
- 40 per cent of the world's food is produced by irrigated agriculture that relies largely on groundwater.
- Groundwater constitutes about 95 per cent of the freshwater on our planet (discounting that locked in the polar ice caps), making it fundamental to human life and economic development.

Characteristics By its very nature, groundwater has some important characteristics:

- It is almost universally available, with variation in levels, quality and quantity
- It is a common property resource as no single person or organization can own it.
- However, the way it is used, it has become a totally private property. According to current regime and legal situation, those who own the land have total freedom to use as much groundwater as required.
- There is a dynamic equilibrium between rainwater, surface water bodies including ponds, wetlands, lakes, rivers, tanks and groundwater. Forests and trees also are part of this system as both forests and trees play crucial role in groundwater recharge.
- Many aquifers are also able to offer natural protection from contamination, so untreated groundwater is usually cleaner and safer than its untreated surface water equivalent;
- groundwater is relatively easy and cheap to use. It can be brought on-stream progressively with little capital outlay and boreholes can often be drilled close to where the water supply is needed;
- It is a resource that is organisationally easy to develop; individuals can construct, operate and control their own supply, often on their own land.
- According to UNEP report, in 1990-93, India had world's highest land under irrigation, at 50.1 m ha, which consumed 460 BCM water, of which 41% came from surface water and 53% from groundwater.
- In India, the land irrigated by surface water has doubled between 1950 and 1985, but the area irrigated from aquifers has increased by 113 time
- Aquifers serve the important function in the hydrological cycle of storing and subsequently releasing water. The water thus discharged from aquifer storage fulfils two major roles. First, it can benefit the environment by naturally maintaining and sustaining river flow, springs and wetlands. Secondly, it can provide a valuable water supply to meet the growing demand for water for drinking and domestic use, crop irrigation and industry. The reconciliation of
- These different roles is a major task for those concerned with sustainable use of the Earth's water resources. In any parts, where rainfall is scarce, groundwater may be the only source of freshwater available and is, as a consequence, often heavily exploited.

HOW GROUNDWATER OCCURS

Groundwater is part of the Earth's water or hydrological cycle. When rain falls, a part infiltrates the soil and the remainder evaporates or runs off into rivers. The roots of plants will take up a proportion of this moisture and then lose it through transpiration to the atmosphere, but some will infiltrate more deeply, eventually accumulating above an impermeable bed, saturating available pore space and forming an underground reservoir. Underground strata that can both store and transmit accumulated groundwater to outlets in rivers, springs and the sea are termed aquifers.

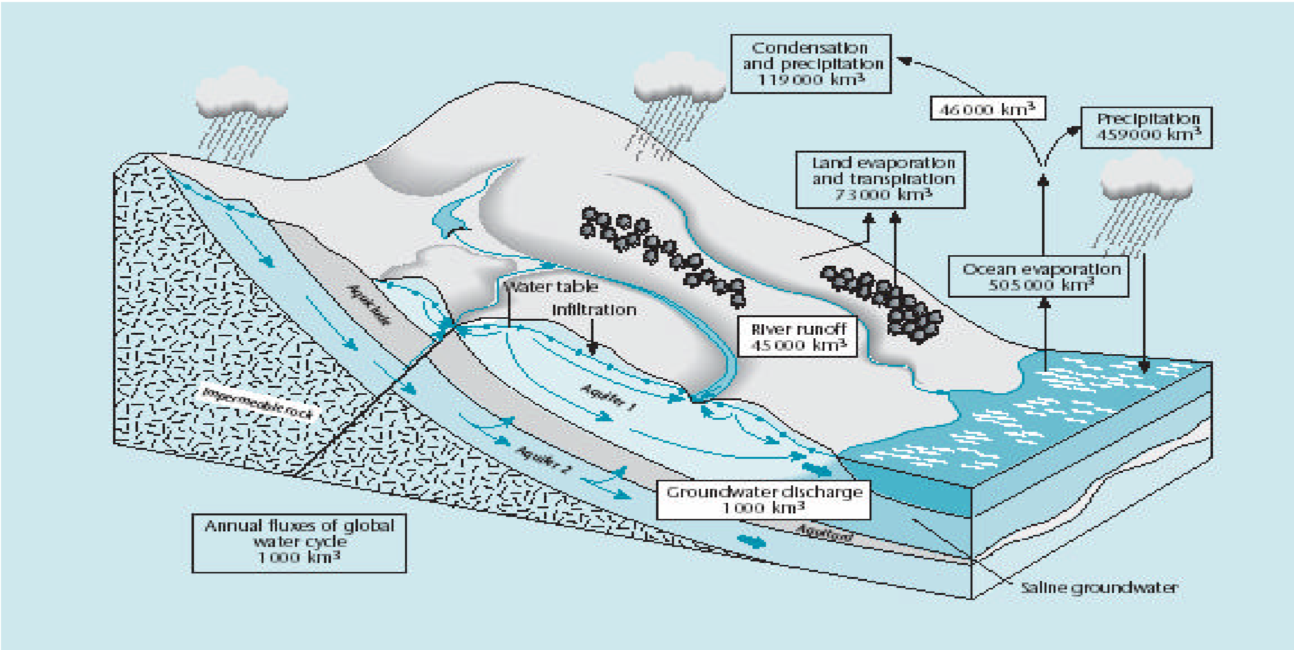


Figure A. Groundwater in the hydrological cycle.

The water table marks the level to which the ground is fully saturated (saturated zone) and reaches the surface at most rivers and all groundwater-fed lakes. Above the water table the ground is known as the unsaturated zone. The productivity of an aquifer depends on its ability to store and transmit water, and these qualities may vary (see Figure A). Unconsolidated granular sediments, such as sand or gravel contain pore space between the grains and thus the water content can exceed 30 per cent of the volume. This is reduced progressively as the proportion of finer materials such as silt or clay increases and as consolidation occurs, typically accompanied by cementation of the grains. In highly consolidated rocks groundwater is found only in fractures and rarely exceeds 1 per cent of the volume of the rock mass. However, in the case of limestones, these fractures may become enlarged, by solution and preferential flow to form fissures and caverns. Even then, the total storage is relatively small compared with unconsolidated aquifers; one result is that there is less water available to dilute contaminated water that finds its way into the system.

Groundwater systems are dynamic and water is continuously in slow motion down gradient from areas of recharge to areas of discharge. In large aquifer systems, tens or even hundreds of years may elapse in the passage of water through this subterranean part of the hydrological cycle. Such flow rates do not normally exceed a few metres per day and compare with rates of up to 1 metre per second for riverflow. Velocities can be much higher where flow is through fracture systems, dependent on factors like aperture or fracture network density. In limestones with well-developed solution or in some volcanic aquifers with extensive lava tubes or cooling cracks, velocities can be measured in km/day. Thus supplies located in different aquifers, or in different parts of the same aquifer, can tap water of widely different residence time. This is an important factor for contaminants that degrade over time and in the control of disease-causing micro-organisms such as some bacteria, viruses and protozoa. (Source: UNEP 2003)

Destruction of Groundwater Recharge Systems Direct human interventions over the years have lead to reduction in groundwater recharge. These include: deforestation, destruction of local water systems (including traditional water systems) (like ponds, tanks, lakes, wetlands and so on), stoppage of river flows by dams and even run of the river projects. Deforestation also leads to change in river flow regime in the affected area, that also affects the recharge in the given area.

- There are larger and indirect human interventions that has also affected the groundwater recharge systems, including urbanization, concretization of more and more land, the those factors that lead to global warming also contribute in reduction in groundwater levels as evapo-transpiration needs are higher when temperatures go up, leading to more groundwater use.

- Mining also leads to destruction of groundwater recharge systems in the mined areas. In fact in mining areas groundwater is many times unnecessarily pumped out so that mining becomes possible. This could be minimized and restored at least when mining in a given area is completed, but that almost never happens.
- There are some human interventions that also seemingly add to natural groundwater recharging. These include the increased recharge that happens due to canal irrigation. However, there is little credible evaluation as to how much of this happens. In any case, if groundwater recharge is the objective, than such systems are not the best options.

Legal regime Following the Supreme Court order the Union govt has created a Central Groundwater Authority, under the Environment Protection Act, 1986 "to regulate and control, management and development of ground water in the country and to issue necessary regulatory directions for this purpose". This gives this body sweeping powers, but there has been little effective action to control the use of groundwater to stop unjustified use that takes this common property away from the members of the society that share the aquifer.

- Industries and commercial interests are also exploiting this situation to the detriment of the poorer and weaker section of the society.
- Poorer people are worst affected by this situation as when aquifer levels go down, their wells go dry and they do not have the means to dig their wells deeper. So private interests are taking away the social resources from the hands of the poorer people.
- According to an answer given by Union Minister for Water resources in Lok Sabha on April 7, 2003, "So far the State Governments of Andhra Pradesh, Goa, Tamil Nadu, Kerala and Union Territory of Lakshadweep have enacted legislation on the lines of Model Bill and State Governments/Union Territories of Assam, Bihar, Haryana, Himachal Pradesh, Jammu and Kashmir, Karnataka, Maharashtra, Mizoram, Orissa, Punjab, Rajasthan, Uttar Pradesh, West Bengal, NCT of Delhi, Pondicherry and Daman & Diu have initiated action in this direction." The model bill was circulated by the Union govt in 1970, 1992 and 1996.

Groundwater in India According to the report of the National Commission on Integrated Water Resources Development (GOI Sept 1999), the total replenishable ground water is estimated as 432 BCM. Out of this, 396 BCM is considered utilizable – 71 BCM (15%) for domestic, industrial and other uses and 325 BCM (90% of the balance) for irrigation.

The figure of 431.9 BCM is the estimate of the Working groups (constituted in 1994-5) based on large volume of hydrogeological and related data generated by CGWB and state ground water organizations. This is the sum total of the potential due to natural recharge from rainfall (342.4 BCM) and the potential due to recharge augmentation from canal irrigation system (89.5 BCM).

As noted by the World Bank (1999), the groundwater estimation methodology outlined by the Groundwater Estimation Committee in 1984 is based on water balance concepts: groundwater draft estimates are compared to groundwater recharge estimates in order to judge whether the existing draft in a development unit (block) is sustainable and to assess the scope for additional groundwater developments for irrigation. An important feature of the methodology is that neighbouring development units are assumed to be hydraulically isolated from each other, i.e. cross boundary flows are considered to be non existent.

Moreover, as the situation in any block changes over time, the recharge situation would also change. This aspect is not taken into account to update the estimates and development potential figures.

Groundwater Potential in River basins in India

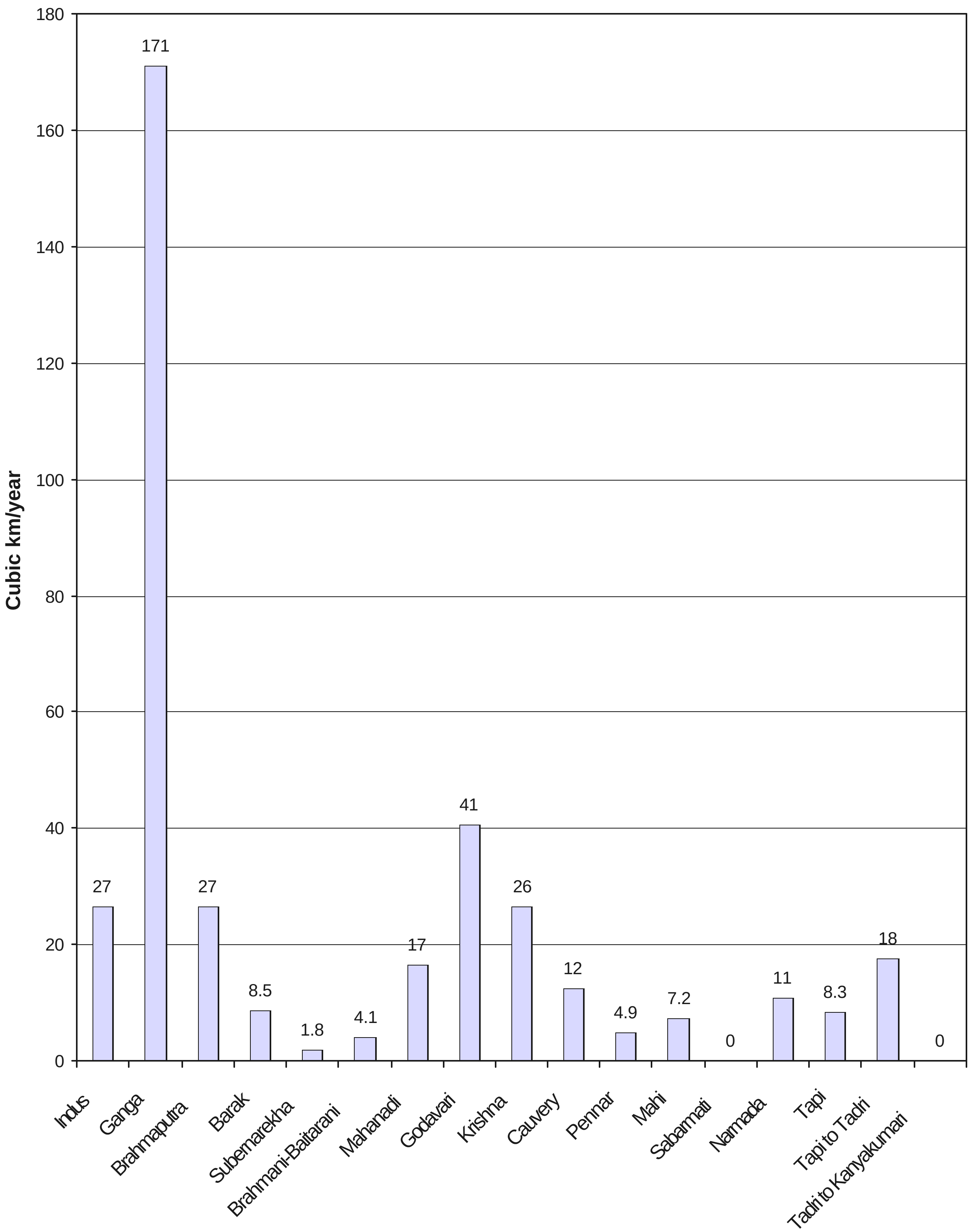


Fig. 1 Replenishable ground water run-off in the principal river basins of India

Source: RJ Rao in Journal of Indian Water Works Association, Jan-Mar 2004

Dynamic Fresh Ground Water Resource - Statewise

(BCM)

No	States	Replenishable GW From Normal Natural Recharge	Replenishable GW Due to recharge from Canal Irrigation	Total Annual Replenishable GW
1	Andhra Pradesh	20.03	15.26	35.29
2	Arunachal Pradesh	1.44	0.00	1.44
3	Assam	24.23	0.49	24.72
4	Bihar	28.31	5.21	33.52
5	Goa	0.18	0.03	0.21
6	Gujarat	16.38	4.00	20.38
7	Haryana	4.73	3.80	8.53
8	Himachal Pradesh	0.29	0.08	0.37
9	Jammu & Kashmir	2.43	2.00	4.43
10	Karnataka	14.18	2.01	16.19
11	Kerala	6.63	1.27	7.90
12	Madhya Pradesh	45.29	5.60	50.89
13	Maharashtra	33.40	4.47	37.87
14	Manipur	3.15	0.00	3.15
15	Meghalaya	0.54	0.00	0.54
16	Mizoram	Not assessed		
17	Nagaland	0.72	0.00	0.72
18	Orissa	16.49	3.52	20.01
19	Punjab	9.47	9.19	18.66
20	Rajasthan	10.98	1.72	12.70
21	Sikkim	Not assessed		
22	Tamil Nadu	18.91	7.48	26.39
23	Tripura	0.57	0.10	0.67
24	Uttar Pradesh	63.43	20.39	83.82
25	West Bengal	20.30	2.79	23.09
26	Union Territories	0.35	0.05	0.40
	Total	**342.43**	**89.46**	**431.89**

Dynamic Fresh Ground Water Resource - Basinwise (BCM)

Sl. No.	River Basin	Replenishable GW from Normal Natural Recharge	Replenishable GW Due to Recharge from Canal Irrigation	Total Replenishable GW
1	Indus	14.29	12.21	26.5
2	Ganga-Brahmaputra-Meghna Basin			
2a	Ganga sub-basin	136.47	35.1	171.57
2b	Barhmaputra sub-basin	25.72	0.83	26.55
2c	Meghna (Barak) sub-basin	8.52	0	8.52
3	Subarnarekha	1.68	0.12	1.8
4	Brahmani-Baitarani	3.35	0.7	4.05
5	Mahanadi	13.64	2.86	16.5
6	Godavari	33.48	7.12	40.6
7	Krishna	19.88	6.52	26.4
8	Pennar	4.04	0.89	4.93
9	Cauvery	8.79	3.51	12.3
10	Tapi	6.67	1.6	8.27
11	Narmada	9.38	1.42	10.8
12	Mahi	3.5	0.5	4
13	Sabarmati	2.9	0.3	3.2
14	West Flowing Rivers of Kutch and Saurashtra including Luni	9.1	2.1	11.2
15	West Flowing Rivers south of Tapi	15.55	2.15	17.7
16	East Flowing Rivers Between Mahanadi and Pennar	12.82	5.98	18.8
17	East Flowing Rivers Between Panner and Cauvery and those south of Cauvery	12.65	5.55	18.2
18	Area of North Ladakh not draining into Indus	Not Assessed		
19	Rivers draining into Bangladesh	Not Assessed		
20	Rivers draining into Myanmar	Not Assessed		
21	Drainage areas of Andaman, Nicobar and Lakshadweep Islands	Not Assessed		

Static Fresh Ground Water Resource - Statewise (BCM)

No	States	Alluvial/ Unconsolidated Rocks	Hard Rocks	Total
1	Andhra Pradesh	76	26	102
2	Assam	920	0	920
3	Bihar	2557	11	2568
4	Gujarat	92	12	104
5	Haryana	420	1	421
6	Himachal Pradesh	13	0	13
7	Jammu & Kashmir	35	0	35
8	Karnataka	0	17	17
9	Kerala	5	6	11
10	Madhya Pradesh	14	27	41
11	Maharashtra	16	22	38
12	Orissa	162	13	175
13	Punjab	910	0	910
14	Rajasthan	115	13	128
15	Tamil Nadu	98	0	98
16	Tripura	101	0	101
17	Uttar Pradesh	3470	30	3500
18	West Bengal	1625	1	1626
19	Delhi	3	0	3
20	Chandigarh	1	0	1
	Total	**10633**	**179**	**10812**

Static Fresh Ground Water Resource - Basinwise (BCM)

No	River Basin	Alluvial/ Unconsolidated Rocks	Hard Rocks	Total
1	Indus	1334.9	3.3	1338.2
2	Ganga-Brahmaputra-Meghna Basin			
2a	Ganga sub-basin	7769.1	65	7834.1
2b	Barhmaputra sub-basin	917.2	0	917.2
2c	Meghna (Barak) sub-basin	101.3	0	101.3
3	Subarnarekha	10.1	0.7	10.8
4	Brahmani-Baitarani	40.1	3.3	43.4
5	Mahanadi	108.4	11.3	119.7
6	Godavari	36	23.4	59.4
7	Krishna	13.6	22.4	36
8	Pennar	3.9	7.2	11.1
9	Cauvery	39.1	3.3	42.4
10	Tapi	4.3	3.2	7.5
11	Narmada	13.8	4.6	18.4
12	Mahi	9.7	2.9	12.6
13	Sabarmati	25.5	2.7	28.2
14	West Flowing Rivers of Kutch and Saurashtra including Luni	103.1	10.1	113.2
15	West Flowing Rivers south of Tapi	5.4	5.8	11.2
16	East Flowing Rivers Between Mahanadi and Pennar	34.4	6.9	41.3
17	East Flowing Rivers Between Panner and Cauvery and those south of Cauvery	63.1	2.9	66
18	Area of North Ladakh not draining into Indus	Not Assessed		
19	Rivers draining into Bangladesh	Not Assessed		
20	Rivers draining into Myanmar	Not Assessed		
21	Drainage areas of Andaman, Nicobar and Lakshadweep Islands	Not Assessed		
	Total	**10633.00**	**179.0**	**10812.0**

Static Fresh Groundwater Resource National Commission has reported the above data from CGWB. The estimates pertain to a depth of 450 m in alluvial terrain and 100 m in hard rock terrain. This clearly is a huge resource that remains unexploited. CGWB surveys are still ongoing, and the national commission has recommended that the investigations be completed expeditiously, particularly in drought prone areas. National Commission did not include any water from the static aquifers in its calculations for future water scenarios. Great care will have to be taken when this is exploited in some urgent situation.

ANNUAL GROUND WATER RESOURCE AND IRRIGATION POTENTIAL

(BCM)

Sl. No.	States	Total Replenishable GW	Net Utilisable GW for Irrigation	Net Draft	Net Balance GW	% GW Dev.
1.	Andhra Pradesh	35.2916	26.9981	7.0922	22.9056	23.64
2.	Arunachal Pradesh	1.4385	1.1005	-	1.2227	-
3.	Assam	24.7192	18.9102	0.9418	20.0695	4.48
4.	Bihar	33.5213	25.6439	5.4676	23.0255	19.19
5.	Goa	0.2182	0.1670	0.0154	0.1701	8.30
6.	Gujarat	20.3767	15.5881	7.1702	10.1500	41.45
7.	Haryana	8.5276	6.5236	6.0798	1.1686	83.88
8.	Himachal Pradesh	0.3660	0.2637	0.0530	0.2399	18.18
9.	Jammu & Kashmir	4.4257	3.3858	0.0500	3.7118	1.3
10.	Karnataka	16.1857	12.3821	4.3010	9.4568	31.26
11.	Kerala	7.9003	5.9281	1.0062	5.5806	15.28
12.	Madhya Pradesh	50.8892	38.9298	7.1312	36.1248	16.49
13.	Maharashtra	37.8673	22.9231	7.7403	17.7298	30.39
14.	Manipur	3.1540	2.4129	Neg	2.3810	Neg.
15.	Meghalaya	0.5397	0.4128	0.0182	0.4405	Neg.
16.	Mizoram		Not	Assessed		
17.	Nagaland	0.7240	0.5535	Neg.	0.6150	Neg.
18.	Orissa	20.0014	15.3009	1.4313	15.5699	8.42
19.	Punjab	18.6550	15.1109	15.7576	1.0322	93.85
20.	Rajasthan	12.7076	9.6418	5.4238	5.2893	50.63
21.	Sikkim		Not	Assessed		
22.	Tamil Nadu	26.3912	20.1892	13.55789	8.8748	60.44
23.	Tripura	0.6634	0.5076	0.1885	0.3754	33.43
24.	Uttar Pradesh	83.8210	64.1233	26.8354	44.4113	37.67
25.	West Bengal	23.0923	17.6653	4.7452	14.8829	24.18
	TOTAL STATES	431.4769	324.6621	115.0055	245.7300	31.88
	UNION TERRITORIES					
1.	Andaman & Nicobar		Not Assessed			
2.	Chandigarh	0.02966	--	0.02454	0.00512	--
3.	Dadar & N.Haveli	0.04220	0.0323	0.00457	0.03130	12.74
4.	Daman & Diu	0.01300	0.0099	0.00900	0.00200	--
5.	NCT Delhi	0.29154	--	0.11800	--	--
6.	Lakshadweep	0.00243	--	0.00155	0.00088	63.79
7.	Pondicherry	0.02877	0.0220	0.00595	0.01850	24.34
	TOTAL UT's	0.40760	0.0642	0.16362	0.05780	--
	GRAND TOTAL	431.8850	324.7264	115.16912	245.7878	31.92

Irrigation Development from Groundwater in India

No	States	Net utilizable GW for irrigation, mhm/ year	Weighted avg delta, m	Utilisable irrigation potential, mha	Potential created, mha	Potential utilized, mha	% of potential developed	Balance irrigation potential to be developed, m ha
1	Andhra Pradesh	2.69981	0.047-1.472	3.96008	1.77420	1.73910	44.80	2.18588
2	Arunachal Pradesh	0.11005	-	0.01800	0.00240	0.00240	13.33	0.01560
3	Assam	1.89102	1.283	0.90000	0.20680	0.15180	22.98	0.69320
4	Bihar	2.56439	0.40-0.65	4.94763	4.29180	3.81590	86.74	0.65583
5	Goa	0.01670	0.57	0.02928	0.00190	0.00170	6.49	0.02738
6	Gujarat	1.55881	0.45-0.714	2.75590	1.77890	1.69370	64.55	0.97700
7	Haryana	0.65236	0.385-0.600	1.46170	1.54490	1.49930	105.69	-0.08320
8	Himachal Pradesh	0.02637	0.385	0.06850	0.01570	0.01150	22.92	0.05280
9	Jammu & Kashmir	0.33858	0.385-0.600	0.70795	0.01160	0.01100	1.64	0.69635
10	Karnataka	1.23821	0.18-0.74	2.57281	0.78010	0.76410	30.32	1.79271
11	Kerala	0.59281	0.53-0.83	0.87925	0.14060	0.12420	15.99	0.73865
12	Madhya Pradesh	3.89298	0.4	9.73249	1.62290	1.50630	16.68	8.10959
13	Maharashtra	2.29231	0.43-1.28	3.65197	1.63630	1.58840	44.81	2.01567
14	Manipur	0.24129	0.65	0.36900	0.00060	0.00050	0.16	0.36840
15	Meghalaya	0.04128	0.65	0.06351	0.01020	0.01000	16.06	0.05331
16	Mizoram	Not assessed						
17	Nagaland	0.05535	negligible					
18	Orissa	1.53009	0.34-0.44	4.20258	0.71720	0.60070	17.07	3.48538
19	Punjab	1.51109	0.518	2.91715	3.41200	3.35300	116.96	-0.49485
20	Rajasthan	0.96418	0.457-0.600	1.77783	2.04840	2.01250	115.22	-0.27057
21	Sikkim	Not assessed						
22	Tamil Nadu	2.01892	0.37-0.93	2.83205	1.31450	1.31190	46.42	1.51755
23	Tripura	0.05076	0.63	0.08056	0.02120	0.02120	26.32	0.05936
24	Uttar Pradesh	6.41233	0.20-0.50	16.79896	22.63400	20.35800	134.73	-5.83504
25	West Bengal	1.76653	0.33-0.75	3.31794	1.85520	1.41310	55.91	1.46274
	Total States	32.46622	-	64.04514	45.8214	41.9903	71.55	18.22374
	Total Uts	0.00642	-	0.00504	0.06240	0.06180		
	Grant Total	32.47264	-	64.05018	45.88330	42.05310	71.64	18.16638
Note: + - Relates to Dadra & Nagar Haveli only								

Note: mham = 10 BCM
Source: RJ Rao, May 30, 2003 (http://wrmin.nic.in/resource/irrpot_gw.htm)

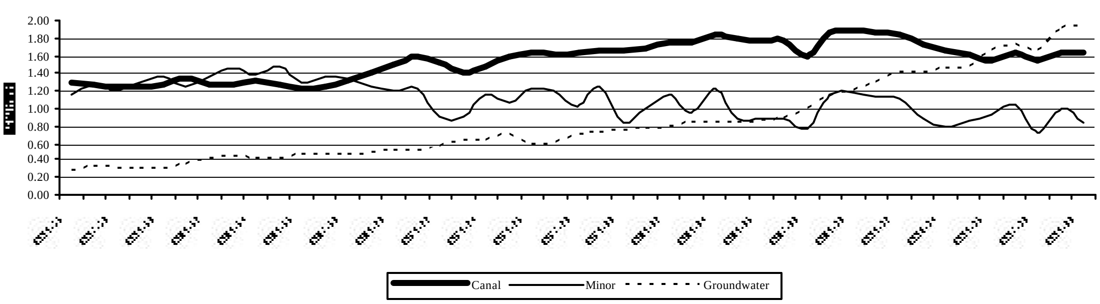


Figure: Year-wise net land irrigated by different water sources in Andhra Pradesh, India (Source: Prof R Jagadisha Rao, Oct 2003)

In Andhra Pradesh, since its inception in 1956, while the net irrigated land under major and minor works increased for some years and later decreased significantly, the net land irrigated by groundwater has increased steadily from about 0.3 m ha in 1955-56 to 1.9 m ha in 1999-2000.

Falling levels Systematic time series data of precise location and levels of groundwater there in is not easily available. CGWB has been reporting the districts that experience over 20 cm of drop in the pre monsoon groundwater levels for a certain length of years. Such data were earlier reported for 20 year series, but has recently been reported for ten year series. Though these data do not reflect the precise situation as it only reports names of districts where the drop is reported and not how much area or which blocks, we have put together the data from four sets of time series: 1982-2001, 1983-2002, 1994-2003 and 1995-2004. In the following section, the first list under each state is for the period 1982-2001 (unless otherwise specified). For subsequent series data, we have listed the districts that have been added or removed in the problem areas. The districts are included in this list if they experience a drop in GW level of over 4 meters for 20 year period or a drop of over 2 meters over a ten year period. All the information is from answers given in Parliament at various dates.

Andhra Pradesh Adilabad, Anantpur, Chittoor, East Godavari, Hyderabad, Karimnagar, Khammam, Kurnool, Mahbubnagar, Medak, Nalgonda, Nellore, Nizamabad, Prakasam, Ranga Reddy, Srikakulam, Warangal Vijayanagaram, Visakhapatnam,

Added for 1983-2002: Guntur, West Godavari
Removed for 1983-2002: Khammam

Added for 1994-2003: Cuddapah,Khammam, Krishna,
Removed for 1994-2003: Hyderabad, Karimnagar, Medak, Nizamabad, Vijayanagaram

Arunachal Pradesh (added in 1983-2002, removed for 1994-2003) East Siang

Assam Jorhat, Kamrup, Karbi-Anglong, Morigaon

Added for 1994-2003: Nagaon, Sonipur
Removed for 1994-2003: Kamrup, Karbi-Anglong, Morigaon

Bihar Gaya

Added for 1983-2002: Darbhanga, Khagaria, Samastipur

Added for 1994-2003: Nalanda
Removed for 1994-2003: Gaya, Khagaria, Samastipur

Added for 1995-2004 Bhagalpur, Munger, Muzaffarpur, East Champaran, Navada, Saharsa, Saran
Removed for 1995-2004: Darbhanga, Nalanda

Chhattisgarh Bastar, Bilaspur, Champa, Dantewada, Durg, Janjgir, Kanker, Raigarh

Added for 1994-2003: Dhamtari, Kawardha, Koriya, Mahasamund, Raipur, Rajnandgaon, Surguga

Removed for 1995-2004:Dantewada

Delhi South West, South, New Delhi, North West, West, Central

Removed in 1994-2003: West, Central

Gujarat Ahmedabad, Amreli, Banaskantha, Baroda, Bharuch, Bhavnagar, Dangs, Jamnagar, Junagadh, Kheda, Kutch, Mehsana, Panchmahal, Rajkot, Sabarkantha, Surat, Surendranagar, Valsad

Added in 1995-2004: Gandhinagar

Haryana Bhiwani, Faridabad, Fatehabad, Gurgaon, Hissar, Jind, Kaithal, Karnal, Kurukshetra, Mahendragarh, Panchkula, Panipat, Rewari, Rohtak, Sirsa, Yamunagar

Removed for 1983-2002: Fatehabad, Karnal, Rohtak, Yamunanagar

Added for 1994-2003: Ambala, Jhajjar, Sonipat

Added for 1995-2004: Ambala, Fatehabad, Karnal, Yamunanagar
Removed for 1995-2004: Panchkula

Himachal Pradesh (*added in 1995-2004*) Kangra, Kullu, Mandi, Sirmur, Solan, Una

Jharkhand Giridih, Lohardaga, Palamu

Added for 1983-2002: Gumla
Removed for 1983-2002: Giridih, Lobardaga

Added in 1994-2003: Giridih, Hazaribagh, Ranchi

Added in 1995-2004: Dhanbad, Dumka, Lohardaga, Paschim Singhbhum, Purvi Singhbhum
Removed in 1995-2004: Gumla

Jammu & Kashmir (*added in 1995-2004*) Jammu, Kathua, Rajouri, Udhampur

Karnataka Bangalore, Belary, Belgaum, Bidar, Bijapur, Chamarajanagara, Chitradurga, Davanagere, Dharwad, Gadag, Gulbarga, Hassan, Haveri, Kolar, Koppala, Mandya, Mysore, Raichur, Shimoga, Tumkur, Uttar Kannada

Removed for 1983-2002: Chamarajanagara

Added for 1994-2003: Bagalkot, Chikmagalur
Removed for 1994-2003: Bangalore, Bijapur, Chitradurga, Gadag, Gulbarga, Kolar, Mandya, Mysore, Raichur, Shimoga, Tumkur

Added for 1995-2004: Bangalore, Bijapur, Chamrajnagar, Chitradurga, Coorg, Dakshin Kannada, Gadag, Gulbarga, Kolar, Mandya, Mysore, Raichur, Shimoga, Tumkur, Uddupi

Kerala Ernakulam, Idukki, Kannur, Kasaragod, Kollam, Kottayam, Kozhikode, Thiruvananthapuram

Removed for 1983-2002: Ernakulam, Kasargod, Kottayam, Koshikode, Thiruvananthapuram

Added for 1994-2003: Thiruvananthapuram

Added for 1995-2004: Kasargod, Kottayam, Mallapuram, Palakkad

Madhya Pradesh Barwani, Betul, Bhind, Chhatarpur, Chhindwara, Damoh, Datia, Dewas, Dhar, Guna, Gwalior, Hoshangabad, Indore, Jabalpur, Katni, Khandwa, Khargone, Mandsaur, Morena, Narsinghpur, Nimach, Panna, Raisen, Ratlam, Rajgarh, Rewa, Sagar, Satna, Sehore, Shajapur, Sheopur, Shivpuri, Vidisha

Added for 1983-2002: Bhopal, Jhabua, Tikamgarh, Ujjain

Added for 1994-2003: Balaghat, East Nimar, Harda, Seoni, Shahdol
Removed for 1994-2003: Barwani, Bhopal, Narsinghpur, Panna

Added for 1995-2004: Barwani, Bhopal, Dindhori, Narsinghpur, Panna, Mandla, Seoni, Shahdol, Sidhi, Umaria

Maharashtra Ahmednagar, Akola, Amravati, Aurangabad, Beed, Bhandara, Buldhana, Chandrapur, Dhule, Gadchiroli, Jalgaon, Jalna, Kolhapur, Latur, Nagpur, Nanded, Nasik, Parbhani, Pune, Sangli, Satara, Sholapur, Thane, Wardha, Yavatmal

Added for 1983-2002: Osmanabad, Raigarh, Ratnagiri

Removed for 1983-2002: Beed

Added for 1994-2003: Beed, Gondia, Hingoli, Nandurbar, Sindudurg,
Removed for 1994-2003: Gadchiroli, Jalna, Parbhani, Osmanabad, Raigarh, Sangli, Thane

Added for 1995-2004: Gadchiroli, Jalna, Mumbai, Parbhani, Osmanabad, Raigarh, Sangli, Thane, Washim

Meghalaya (*Added for 1983-2002, removed for 1994-2003*) West Garo Hills

Orissa Angul, Balasore, Bolangir, Boudh, Cuttack, Deogarh, Dhenkanal, Gajapati, Ganjam, Kalahandi, Keonjhar, Khurda, Koraput, Mayurbanj, Malkangiri, Nayagarh, Nowrangpur, Phulbani, Sambalpur, Sundergarh, Suvarnpur/ Sonepur

Added for 1983-2002: Bargarh, Jajpur, Nawapara, Puri, Rayagada
Removed for 1983-2002: Boudh, Keonjhar

Added for 1994-2003: Jharsuguda, Kandhamal
Removed for 1994-2003: Sonepur

Added for 1995-2004: Keonjhar, Angul, Cuttack, Dhenkanal, Jajpur, Puri, Kalahandi, Phulbani
Removed for 1995-2004: Kandhamal, Bolangir, Deogarh, Gajapati, Khurda, Malkangiri, Nayagarh, Nowrangpur

Punjab Amritsar, Bhatinda, Ferozepur, Jalandhar, Kapurthala, Ludhiana, Mansa, Moga, Patiala, Ropar, Sangrur

Added in 1983-2002: Faridkot, Fatehgarh

Removed in 1994-2003: Faridkot, Jalandhar, Kapurthala, Ropar

Added in 1995-2004: Faridkot, Jalandhar, Karpurthala, Ropar, Gurdaspur, Hoshiarpur, Nawashahar

Rajasthan Ajmer, Alwar, Banswara, Baran, Barmer, Bhilwara, Bikaner, Bundi, Chittorgarh, Churu, Dausa, Dholpur, Dungarpur, Hanumangarh, Jaipur, Jalore, Jhalawar, Jhunjhunu, Jodhpur, Kota, Nagaur, Pali Rajsamand, Sirohi, Sawai Madhopur, Tonk, Udaipur

Added in 1983-2002: Ganga nagar, Karauli, Sikar,

Added in 1994-2003: Bharatpur, Jaisalmer,
Removed in 1994-2003: Ganga nagar, Banswara, Chittorgarh, Dholpur, Hanumangarh, Jalore, Jhunjhunu

Added in 1995-2004: Banswara, Chittorgarh, Dholpur, Hanumangarh, Jalore, Jhunjhunu

Tamil Nadu Coimbatore, Cuddalore, Dharampuri, Dindigul, Erode, Kancheepuram, Kanya Kumari, Madras, Namakkal, Perambalur, Pudukkottai, Sivaganga, Tanjavur, Tirunelveli, Tiruvallur, Tiruvarur Theni, Tiruvannamalai, Tuticorin

Added in 1983-2002: Karaikal, Ramanathapuram, Tiruchirappalli, Viluppuram
Removed in 1983-2002: Tanjavur, Tuticorin

Added in 1994-2003: Karur, Madurai, Salem, Vellore, Virudhunagar, Tanjavur, Tuticorin
Removed in 1994-2003: Karaikal, Chennai

Added in 1995-2004: Karaikal, Chennai, Nilgiri, Virudhanagar
Removed in 1995-2004: Pudukkottai

Tripura (*Removed in 1983-2002*) South Tripura, West Tripura

Uttar Pradesh Agra, Aligarh, Allahabad, Badaun, Banda, Ballia, Barabanki, Bareilly, Bijnor, Bulandshahar, Deoria, Etah, Etawah, Faizabad, Fatehgarh, Fetehpur, Ghaziabad, Hamirpur, Hardoi, Jalaun, Jaunpur, Jhansi, Kanpur, Lakhimur, Lalitpur, Lucknow, Mainpuri, Mathura, Mirzapur, Moradabad, Muzaffarnagar, Pratapgarh, Raebareili, Rampur, Saharanpur, Shahjahanpur, Sitapur, Sultanpur, Unnao

Added in 1983-2002: Azamgarh, Bahraich, Gonda, Meerut
Removed in 1983-2002: Bijnor

Added in 1994-2003: Kaushambi
Removed 1994-2003: Agra, Aligarh, Azamgarh, Bahraich, Badaun, Banda, Ballia, Barabanki, Bareilly, Bulandshahar, Deoria, Etah, Etawah, Faizabad, Fatehgarh, Ghaziabad, Gonda, Hamirpur, Hardoi, Jaunpur, Kanpur, Lalitpur, Mainpuri, Mathura, Meerut, Moradabad, Rampur, Saharanpur, Shahjahanpur, Sitapur, Sultanpur, Muzaffarnagar

Added in 1995-2004: Agra, Aligarh, Auraiya, Azamgarh, Meerut, Badaun, Baghpat, Ballia, Bijnor, Chandauli, Chitrakoot, Deoria, Etawah, Gautam Budh Nagar, Ghaziabad, Hamirpur, Hathras, Jaunpur, Kanpur, Kanpur Dehat, Lalitpur, Mahoba, Mathura, Saharanpur, Sitapur, Sultanpur
Removed in 1995-2004: Kaushambi, Raebareili

Uttaranchal (*Added for 1995-2004*) Dehradun, Haridwar

W Bengal Bankura, Bardhaman, Birbhum, Dakshin Dinajpur, Jalpaiguri, Kochbihar, Purulia

Added in 1983-2002: Howrah, Hugli, Mednipur, Murshidabad, N 24-Parganas, S 24-Parganas

Added in 1994-2003: Malda
Removed in 1994-2003: Dakshin Dinajpur, Jalpaiguri, Kochbihar,

Added in 1995-2004: East Medinipur, West Medinipur
Removed in 1995-2004: N 24 Parganas

Dadra & Nagar Haveli (*Added for 1995-2004*) Dadra & Nagar Haveli

Pondicherry (*Added for 1995-2004*) Pondicherry
(Answer in Rajya Sabha, March 4, 2003, July 13 2004, April 26, 2005 Lok Sabha July 5 2004)

Analysis The following table tries to capture the above data in terms of number districts that have seen consistent reduction in groundwater levels over various districts.

It is clear from the table (see next page) that the situation is much more difficult than the planning commission data given above gives. If the latest data indicates that in 368 districts the GW levels have been falling for the ten years, if we include the districts that figured at least once in the above data, then the number of problem districts go up substantially. It is true that not whole of all these districts have seen such consistent fall in GW levels, nor that the situation is uniformly worrying in all the districts. However, what this indicates is that we need clearer picture with more frequent and precise data about groundwater levels than what we are getting now.

State wise Number of districts with falling Groundwater trend

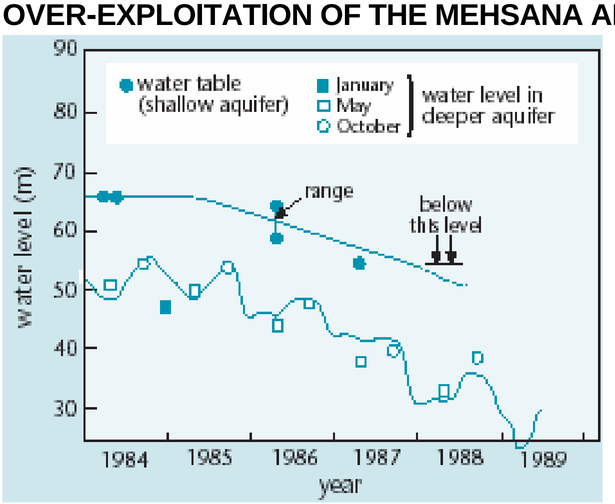
State	No of districts with GW level falling during			
	1982-2001	1983-2002	1994-2003	1995-2004
Andhra Pradesh	19	20 (+2, -1)	18 (+3, -5)	18
Arunachal Pradesh	0	1	0	0
Assam	4	4	3 (+2, -3)	3
Bihar	1	4	2 (+1, -3)	7 (+7, -2)
Chhatisgarh	8	8	15	14
Delhi	6	6	4	4
Gujarat	18	18	18	19
Haryana	16	12	15	18 (+4, -1)
Himachal Pradesh	0	0	0	6
Jharkhand	3	2 (+1, -2)	5	9 (+5, -1)
Jammu & Kashmir	0	0	0	4
Karnataka	21	20	11 (+2, -11)	26
Kerala	8	3	4	8
Madhya Pradesh	33	37	37 (+4, -4)	47
Maharashtra	25	27 (+3, -1)	25 (+5, -7)	34 (+9)
Meghalaya	0	1	0	0
Orissa	21	24 (+5, -2)	25 (+2, -1)	25 (+8, -8)
Punjab	11	13	9	16
Rajasthan	25	28	23 (+2, -7)	29
Tamil Nadu	19	21 (+4, -2)	26 (+7, -2)	28 (+3, -1)
Tripura	2	0	0	0
Uttar Pradesh	39	42 (+4, -1)	11 (+1, -32)	37 (+28, -2)
Uttaranchal	0	0	0	2
West Bengal	7	13	11 (+1, -3)	12 (+2, -1)
Dadar and N Haveli	0	0	0	1
Pondichery	0	0	0	1
TOTAL	**286**	**304**	**262**	**368**

National Commission Data National commission report (GOI 1999), quoting CGWB figures of 1995 said that the problem of overexploitation was limited to eight states as shown in table below.

State	No of blocks	Overexploited		% level of GW development
		Number	%	
Punjab	118	62	52.54	94
Haryana	108	45	41.67	84
Rajasthan	236	45	19.07	51
Tamil Nadu	384	54	14.06	61
Gujarat	218	14	6.42	42
Karnataka	175	6	3.43	31
Uttar Pradesh	895	19	2.12	38
Andhra Pradesh	309	2	0.65	24
Other states	2722	Nil	Nil	-
Total	5165	247	4.78	-

Note: Mandals of AP, Taluks of Gujarat and watersheds of Maharashtra have been converted to equivalent blocks. Thus 184 taluks of Gujarat are equivalent to 218 blocks, 1503 watersheds of Maharashtra are equivalent of 366 blocks and 1104 mandals of AP are equivalent to 309 blocks.

OVER-EXPLOITATION OF THE MEHSANA ALLUVIAL AQUIFER IN GUJARAT



For centuries, the Mehsana alluvial aquifer in Gujarat exploited by large diameter, hand-dug wells using animal power. In recent years, deep tube wells have been drilled, and the area of irrigated crops has much increased. The success of these early deep tube wells led to further exploitation of the deeper aquifers and, as a consequence, water levels in both the deeper aquifers and also the shallow water table declined (see graph). In parts of central Mehsana, the decline in the water table was rapid, approached 3.0 m/year in the early 1980s and by the 1990s had reached 4.5 m/year.

The reason for the decline in groundwater levels is that the deeper tube wells do not tap alternative sources of water but derive most of their water (about 95 % according to modeling studies) as leakage from the overlying shallow aquifer. The modelling studies predicted further large declines in water levels with the result that many of the existing tube wells could become dry. (UNEP 2003)

Planning Commission The Planning commission, in mid term appraisal of the 9th Plan has said that there had been an increase of 51 % in the number of over exploited and dark blocks from 1985 to 1999. While the number of over exploited and dark blocks was 253 in 1985 it went up to 428 in 1999 and if this rate of exploitation was not reversed their number would double in the next 12 years. The 10th Five Year plan reported that out of 5711 blocks/ mandals/ taluks/ watersheds spread over 470 districts, 310 were inn over exploited category and 160 were in dark category, making a total of 470 in the two categories. So that number is going up, but it does not indicate alarming rise. To what extent does this data reflect the reality?

Tamil Nadu topped the States where groundwater was being over exploited with 97 (stated in midterm appraisal of 9th Plan) and 103 (as on April 1, 1998, as stated in 10th five year plan) of the total 384 taluks/ blocks/ mandals being identified as over exploited and dark areas, followed by Punjab with 70 (stated in midterm appraisal of 9th Plan) and 83 (as on April 1, 1998, as stated in 10th five year plan) of the 138 taluks/ blocks/ mandals identified as over exploited and dark areas. However, as stated in 10th five year plan the number 2 states in terms of number of blocks in over exploited or dark category was taken over by Rajasthan with 74 overexploited and 20 dark blocks, total of 94 blocks in the category, up from 56 stated in mid term appraisal of 9th plan.

In Karnataka, 18 of the 175 taluks have been identified as over exploited and dark areas, (the number went down to 16 as on April 1, 1998). They included Anekal, Bangalore (N), Devanahalli, Hoskote (OE), and Bangalore (S) and Channapatna (dark) in Bangalore Rural District, Hukkeri, Raibag, (dark) in Belgaum District, Indi (dark) in Bijapur District, Kolar and Malur (OE), and Chikballapur, Gouribidanur, Mulbagal, and Siddlagatta (dark) in Kolar District, Kollegal (dark) in Mysore District, & Tiptur and Tumkur (dark) in Tumkur District.

The mid-term appraisal of the Planning Commission said that though the Central Groundwater Authority was constituted as per the directions of the Supreme Court a few years ago to regulate the use of groundwater and its better management, there was need to take stringent measures to check further depletion of the groundwater resources. Those stringent measures are awaited. Some of the suggestions made by the report included that the areas identified as over exploited and dark blocks should be declared as notified areas and making it mandatory to obtain permission from the authority for digging new borewells, and prohibition of extraction of groundwater for commercial purposes. The report noted that in a country such as India where more than half of the population was dependent on groundwater, the pollution of groundwater was a serious matter and to forecast any groundwater pollution threat, studies on groundwater pollution need to be carried out in more industrial, urban, and rural areas by establishing groundwater pollution monitoring stations.

Dams stop groundwater recharge? Large dams almost invariably stop the flow of water in areas downstream from the dam site. As we have noted above, rivers are a very important recharge zones for groundwater. When rivers stop flowing in certain region, this recharge function automatically stops, leading to serious situation for groundwater in such regions. This problem is even more serious when the dams stop the river flow in plains areas, which are in fact the greatest recharge areas. This impact of dams is also visible in run of the river projects as in such projects, the water comes back to the river several kms downstream from the diversion site.

What is immediately required is to mandate that each dam must allow enough water downstream from the diversion point to ensure that groundwater recharge function of the rivers is not affected. This serious impact of the projects should also be part of impact analysis, mitigation plans and cost benefit calculations of these project and also integral to the decision making process.

Groundwater contamination According to UNEP study (2003), "Although groundwater is not easily contaminated, once this occurs it is difficult to remediate, and in the developing world, such remediation may prove practically impossible." In the table below we have put together the list of districts that are facing fluoride, nitrates and arsenic contamination of groundwater. The list if from Govt of India answers in Parliament.

No	States	Districts affected by excess nitrates (over 45 mg/l)	Districts affected by excess fluoride (over 1.5 mg/l)	Dists affected by excess arsenic (over 0.05 mg/l)	areas/ parts of dists affected by toxicity in GW due to heavy metals/ arsenic
1	Andhra Pradesh	Prakasam, Khammam, Nellore, Nalgonda, Nizamabad, Guntur, Kurnool, Karimnagar, Mahaboobnagar, Vijaywada	Prakasam, Anantapur, Nellore, Nalgonda, Rangareddy, Adilabad, Krishna, Kurnool, Cuddapah, Guntur, Karimnagar	-	Anantapur, Cuddapah, Mehboobnagar, Nalgonda, Prakasam, visakhapatnam, Bolaram Patancheru area in Medak district
2	Assam	Lakhimpur	Darrang, N Lakhimpur, Ngaon, Karbi-Anglong	-	Digboi
3	Bihar	Gaya, Patna, Nalanda, Nawada, Bhagalpur, Banka	Jamui	Bhojpur, Patna	Begusarai, Bhojpur, Muzaffarpur
4	Chhattisg arh	Raipur	Bastar, Bilaspur, Dhamtari, Kanker, Korba, Koriya, Raipur, Rajnandgaon	Rajnandgaon	Bastar, Korba
5	Delhi	West, southwest	Northwest, west, southwest, central	-	SW, S, NW, E and NE, Central (including Najafgarh drain basin)
6	Gujarat	Amreli, Banaskantha, Bhavnagar, Gandhinagar, Jamnagar, Junagarh, Kachchh, Mehsana	Banaskantha, Kachchh, Saurashtra, Panchmahal, Kheda, Mehsana, Sabarkantha	-	
7	Haryana	Ambala, Bhiwani, Faridabad, Gurgaon, Hissar, Jind, Kurukshetra, Karnal, Mahendergarh, Rohtak, Sonepat, Sirsa	Rohtak, Jhajjar, Jind, Hissar, Bhiwani, Mahendragarh, Faridabad, Gurgaon, Kaithal, Karnal, Kurukshetra, Sirsa, Sonepat, Rewari, Fatehabad, Panipat	-	Faridabad
8	HP	Una	-	-	Kala Amb, Purwanoo
9	J & K	Kathua	-	-	
10	Jharkhand	Palamu, Sahebganj	GIridih, Dhanbad	-	Dhanbad
11	Karnataka	Bijapur, Bangalore, Belgaum, Bellary, Chitradurga, Dharwar, Gulbarga, Hassan, Kolar, Mandya, Raichur, Shimoga	Bijapur, Gulbarga, Bellary	-	Bhadrawati
12	Kerala	Idukki, Kottayram Palghat, Pathanamithitta, Mallapuram	Palghat, Alleppey	-	
13	Madhya Pradesh	Bhind, Bhopal, Chhindwara, Dhar, Dewas, Gwalior, Indore, Khandwa, Manndsaur, Morena, Shivpuri, Sheore, Ujjain	Bhind, Morena, Hoshangabad, Guna, Jhabua, Tikamgarh, Chhindwara, Seoni, Mandla	-	Nagda, Ratlam
14	Maharash tra	Ahmednagar, Amravati, Akola, Aurangabad, Bhndara, Beed, Buldana, Chndrapur, Gadchiroli, Dhule, Jalaon, Jalna, Kolhapur, Latur, Nagpur, Nanded, Osmanabad, Pune, Sangli, Satara, Sholapur, Thane, Wardha	Bhanadra, Chandrapur, Nanded, Aurangabad	-	
15	Orissa	Angul, Bargarh, Bolangir, Boudh, Cuttack, Ganjam, Jagatsinghpur, Kalahandi, Keonjhar, Malkangiri, Nawapara, Rayagada, Sambalpur, Sundargarh	Bolangir, Khurda, Kalahandi	-	
16	Punjab	Bhatinda, Faridkot, Ferozepur, Patiala, Sangrur	Bhatinda, Sangrur, Mandsa, Moga, Ferozepur, Faridkot, Muktasar, Patiala	-	Ludhiana, Mandi Gobindgarh in Fatehgarh Saheb district
17	Rajasthan	Ajmer, Alwar, Bharatpur, Bikaner, Bundi, Churu, Dholpur, Ganganagar, Jaipur, Jaisalmer, Jhalawar, Jhunjhunu, Jodhpur, Nagaur, Sawai Madhopur, Udaipur	Ajmer, Barmer, Bhilwara, Bikaner, Dungarpur, Ganganagar, Hanumangarh, Jaipur, Jaisalmer, Jallore, Jhunjhunu, Jodhpur, Nagaur, Pali, Rajasamand, Sikar, Sirohi	-	Jhunjhunu (Khetri), Jodhpur, Pali, Udaipur.
18	Tamil Nadu	Coimbatore, Periyar, Salem, NA Ambedkarnagar, T Kottabomman, Dindigul-Anna, VR Padayachi	Dharampuri, Salem, North Arcot-Ambedkar, VIllaspuram-Padayatchi, Muthurmalingam, Tiruchirapalli, Pudukottai	-	Manali, North Arcot
19	Uttar Pradesh	Aligarh, Agra, Banda, Etawah, Ghaziabad, Hamirpur, Jaunpur, Jhansi, Kanpur, Mainpuri, Mathura, Piliphit	Fatehpur, Raibareli, Lakhimpur, Kheri, Lucknow, Unnao, Kanpur, Hardoi, Bulandshahar, Aligarh, Agra, Mathura, Ghaziabad, Meerut, Firozabad, Etah, Fatehgarh, Mainpuri, Mahoba, Allahabad, Varanasi	Ballia	Allahabad, Aligarh, Basti, Jaunpur, Kanpur, Saharanpur, Singrauli, Varanasi
20	Uttaranchal	Nainital	-	-	
21	West Bengal	Uttar Dinajpur, Malda, Birbhum, Murshidabad, Nadia, Bankura, Purulia, Howrah, Medinipur	Birbhum, Howrah, 24 Parganas	Bardhman, Howrah, Hoogli, Malda, Murshidabad, Nadia, N & S 24 Parganas	Bardhaman, Bardhaman, Durgapur, Hoogly, Howrah, Murshidabad, Maldah, Nadia, S & N 24 Paraganas
22	Chandigarh	Chandigarh	-	-	-

(Answer to question in Lok sabha, April 18, 2005, April 25, 2005, Rajya Sabha, July 13, 2004)

GROUNDWATER POLLUTION DUE TO LEATHER INDUSTRIES: EXAMPLE FROM TN

India produces about 13 % of world output of hides and skins. Effluents from tanning processes typically have a high biological oxygen demand, high chloride, may contain calcium and ammonium salts, and, depending on the particular process used, also high concentrations of trivalent chromium. In 1994, tanneries in Tamil Nadu accounted for about 60 % of Indian production. They were concentrated into a few centres near to Madras, on the banks of the Palar and Kundavanuru Rivers. These initially perennial rivers supplied the large amounts of water for the tanning process and also acted as receptors for discharged effluent. Ecosystem and other changes mean the rivers are now seasonal and this has prompted greater reliance on groundwater for processing while effluent continued to be discharged to the dry river beds. The declining availability of surface water for potable supply demands also stimulated use of shallow groundwater, which was available at depths of 9 - 12 m. However, effluent seepage to groundwater from the dry river channels has caused widespread contamination of the shallow aquifer, usually manifested as an increase in salinity and hardness. As a result, a whole new industry has arisen, dedicated to tankering in fresh water from uncontaminated areas. Continued high demand from tanneries for clean water has led to intense competition between industry and local domestic consumers, leading to inflated prices for groundwater of potable quality. (UNEP 2003)

Groundwater use and poverty As noted by the National Commission (GOI, 1999), exploitation of groundwater is greater in relatively higher per capita income states like Gujarat, Tamil Nadu, Punjab & Haryana. In the eastern region, groundwater development is quite low, namely eight percent in Orissa, nine percent in Bihar, 20.5 % in Assam and 34% in East UP. These areas are also known for low per capita incomes and wide spread poverty. Hence while groundwater development in these regions needs to be encouraged, care needs to be taken not to repeat some of the mistakes in development of Groundwater in other states. Hence, community monitoring and control should be key aspect. Moreover, along with development, recharge systems to ensure equivalent recharge of GW should also be mandatory.

Bright spots of Groundwater status While in very large parts of India groundwater levels are going down, there are some bright spots where the trend has been reversed. One clear example of reversal of trends is seen in Alwar district in Rajasthan. Here, over the last two decades, under combined efforts of the communities and Tarun Bharat Sangh, hundreds of local water systems like *johads* have been constructed. This has not only lead to a area described in dark category of groundwater exploitation becoming grey and then white, but in fact it has lead to rejuvenation of some local rivers. The president of India, in an unprecedented move, honoured this community for their efforts. There are some similar examples also seen in some areas Kutch and Sourashtra in Gujarat. In fact, in Gujarat, in 1990s, there was a big well recharging movement that lead to recharging of local aquifers by diverting the local streams to the well through a filtration pit. This community lead process lead to a remarkable improvement in groundwater levels. Jam Samadhiyala in Rajkot district of Gujarat is another interesting example.

The key aspect of above examples is also the key issue of community lead management of the available or developed resource. Without such management effort, there is little hope of sustaining the benefits of the created resource.

Groundwater and Climate Change According to IAH (International Association of Hydrogeologists) Working Group on Groundwater and Climate Change that was approved by the IAH Council in Bled in September 2003, there are many potential direct and indirect interactions between climate change and groundwater.

Examples of direct effects

- Changes in precipitation and evapotranspiration will influence recharge.
- Rising sea levels may lead to increased saline intrusion of coastal and island aquifers.
- Increased rainfall intensity may lead to more runoff and less recharge.

Examples of indirect effects

- Changes in natural vegetation and crops will influence recharge
- Increased flood events may affect groundwater quality in alluvial aquifers
- Changes in soil organic carbon may effect the infiltration properties above aquifers (http://www.silsoe.cranfield.ac.uk/iwe/projects/iahgroup/introduction.htm)

Urban Rural Conflicts As pressure on groundwater in Urban and Peri Urban areas increase, the conditions for conflicts develop between rural and urban areas. One example of what disastrous consequences can Urban areas bring in surrounding rural areas is what is happening in Chennai, see Annexure 2. Another such example, coming from Jaipur city in Rajasthan is described in the box below.

Jaipur Suburb's water crisis

There is considerable disquiet among the rural folks on the outskirts of the Jaipur about the spreading tentacles of the big city, which is taking into its grip the countryside. As colonisers acquire agricultural lands to convert them into townships, the villagers are feeling threatened about their future, especially on the water front, in an already water-scare area. The sense of insecurity about the ground water situation has grown so much that the residents of a village called Machwa (20 km from Jaipur), convened a 'Paani panchayat' to discuss the fundamental question of ownership of water. On the one hand when only from one hand pump 600 villagers are getting their drinking water and on the other side each urban occupant is flashing toilets and using scarce water for gardening. Over last 30 years the level of water has dropped 135 feet and it will just take five years to make the village waterless. The developers should promote water conservation techniques including rainwater harvesting and multiple use of water urgently. (*Dams, Rivers & People* June 2005)

MNC vs community conflicts As big industries and factories of Multi National Corporations put in big water extraction facilities, it is bound to affect the surrounding rural areas. One well known flash point in this regard is the conflict between the communities in Plachimada in Kerala and the Coke factory there. Similar conflicts are also coming to the fore in Varanasi, in Coimbatore and near Jaipur, to site just a few examples. These conflicts would only go up in future. The basic reason for this conflict is that the developers of these factories do not have pay anything for the groundwater, nor seek any permission from the local communities. This situation brings disastrous consequences for the rural areas and farmers.

Groundwater and Electricity This well known issues has many so not well known aspects. Firstly, a lot of the electricity supposedly being used in the farming sector for groundwater extraction is actually not being used for that purpose, but is being used for other purposes. Another issue to note is that there are huge inefficiencies in the pumps and related infrastructure partly because the quality of availability of electricity to farmers is worst among all the other users. Thirdly, if there were credible community controlled groundwater monitoring and control mechanisms in place, including necessary legal and institutional set up in place, lot of the issues connected with this would get resolved.

Groundwater as water storage space There is a big campaign on the part of mainstream water establishment, including the World Bank to push for increased surface water storages. However, one option to avoid the huge costs associated with such storages is to use the groundwater storages. This option has several advantages, arising from the basic character of Groundwater. However, this option is not even explored while advocating more surface water storages. This option becomes particularly relevant when one notes that very many of the groundwater aquifers in water scarce areas are empty to substantial extent.

According to well known hydro geologist Dr R J Rao, "The Ministry of Water Resources has established that the underground storage space available in the Cauvery basin from which groundwater could be safely pumped and recharged is 42.4 bcm, while 12 bcm/a of which could be safely utilised. Presently only 5.4 bcm/a groundwater is being used. The balance groundwater could be utilized safely within the basin itself to meet the water needs of the farmers." Dr Rao's advocacy of the sub surface dams is described in Annexure 1, but is no without substantial risks.

Groundwater recharge efforts According to a reply given in the Lok Sabha on July 5, 2004, "With a view to encourage rain water harvesting and artificial recharge to ground water, the CGWB has proposed a Centrally Sponsored Scheme at an estimated cost of Rs.175 crores for Artificial Recharge to Groundwater and Rainwater Harvesting for implementation during the remaining part of the X Five Year Plan. This scheme is under consideration of the Government of India. Budget allocation of Rs. 40 crores has been proposed during 2004-05 for this scheme." It is now known that NO money was spent, the programme was not initiated till April 25, 2005. According to a reply given in Lok Sabha on April 25, 2005, that scheme remained unimplemented and it remains as a proposed scheme.

In answer to a question in Lok Sabha on May 2, 2005, the government said, "CGWB has prepared a report entitled "Master Plan for Artificial Recharge to Ground Water", which envisages recharge of 36453 Million Cubic Meter volume of surplus monsoon runoff, through construction of 39.25 lakhs artificial recharge and roof top rain water harvesting structures." As stated in 10th five year plan, an area of 4.5 lakh sq km is identified in the master plan and the cost of the whole scheme is Rs 24 500 crores.

It is clear that while efforts towards groundwater recharge has been far from serious, there is little effort to stop the destruction of existing groundwater recharge systems.

Recommendations We need urgent measure to address the following critical issues concerning groundwater sector in India:

- Lack of monitoring of groundwater levels and need to share the information with the communities regularly
- Lack of monitoring of groundwater quality and contamination issues and need to share the information with the communities regularly
- Lack of legal instruments to manage the groundwater by the communities
- Lack of resources for groundwater recharging schemes
- Lack of mandatory provisions to ensure that those who extract groundwater have to ensure recharge of groundwater of at least equal quantity that is being extracted.
- Lack of provisions to ensure that dams release enough water downstream from the diversion point to ensure that the groundwater recharge function of the river is not affected.
- Lack of provisions to ensure transparency and accountability of the pollution control board to the communities and the nation.
- Lack of provisions to ensure that communities have right to access the industrial premises in their respective areas so that they can check the water use, waste water treatment and disposal and records pertaining to the same. There have been instances where industries even indulge in pumping polluted groundwater into the aquifers. Some time back Haryana Pollution Control Board came out with advertisements saying that they know this is happening and warning the perpetrators not to indulge in such practices. This is clearly an acceptance by the PCB that they have failed in their duty, but this also highlights the need to ensure central role for communities in pollution control as the PCBs hare failed in their responsibilities rather abjectly.
- Lack of provision to ensure that local water systems and forests that play such a crucial role in groundwater recharge are not destroyed.

References

1. Planning Commission, 2002, 10th Five Year Plan
2. Planning Commission, 2000, mid term appraisal of 9th Five Year Plan
2. World Bank, 1999, "Groundwater regulation and Management in India"
3. Answers in Rajya Sabha, various dates
4. Answers in Lok Sabha, various dates
5. UNEP 2003, Groundwater its susceptibility to degradation
6. Prof R Jagadishwara Rao, Oct 2003
7. Govt of India, 1999, Report of the Commission on Integrated Water Resources Development
8. World Commission on Dams, Nov 2000, *Dams and Development: A framework for decision making*
9. http://www.cgwaindia.com/
10. http://wrmin.nic.in/
11. International Assoc. of Hydrogeologists, http://www.silsoe.cranfield.ac.uk/iwe/projects/iahgroup/introduction.htm
12. Thakkar Himanshu, 1999. India Irrigation Options Study, done for World Commission on Dams, www.dams.org

Annexure 1

HARNESSING GROUNDWATER UNDER RIVERBEDS

Unlike surface runoff of rivers, showing high seasonal variation, the underground runoff is remarkably constant. Although flood flows of rivers cannot be harnessed without creating adequate live storage, the large static ground storage space available beneath the riverbeds allows for large-scale usage of groundwater. This storage space acts as a buffer to take care of the vagaries of monsoon and river flows with more groundwater pumped under drought conditions and more recharge of groundwater under flood conditions. Although the life of man-made reservoirs is quite low owing to high sediment load in river waters, there is no such problem for underground reservoirs. The question of groundwater depletion doesn't arise owing to recharging of groundwater by surface water available at all times. Excessive groundwater exploitation in the riverbeds doesn't cause any decline of groundwater levels in wells functioning in the upland areas. As groundwater is free of suspended solids and bacteria, it could be used without any treatment and there will be no clogging of pumping installations. One way to utilise this groundwater consists in the large-scale pumping of that water through a large-number of high-yielding wells of proper design at properly selected sites on a foolproof basis.

When a river is located at a lower elevation than the surrounding land, it is a standard engineering practice to pump surface water in the river through jack wells. To obtain adequate water when the surface runoff is less, it is necessary to either construct a dam across the river or divert river flows periodically into the jack wells through channels during summer. Besides need for treatment, the high concentration of suspended solids in the river may clog the pumping installations. All these problems could be overcome by resorting to pumping of groundwater rather than surface water in the river beds.

USE OF SUBSURFACE DAMS TO CONSERVE GROUNDWATER Groundwater flow in an alluvial formation consisting of well-sorted coarse sand beneath a riverbed can be around 100 m/day, while it is only a tiny fraction of one m/day in the rock surrounding it. If a subsurface dam of proper design could be constructed to prevent the entire flow of groundwater through or around such an alluvial aquifer having a width of a km and a depth of 30 m, the quantum of groundwater prevented from flowing would be more than a km^3/year.

Such a subsurface dam could be constructed at a site across the river where good quality sand occurs and hard rock is met at shallow depth both at the bottom and flanks by driving two closely spaced diaphragm walls keyed into the bedrock for some depth, and then making the intervening alluvium impervious through grouting. Such a construction doesn't involve submergence of any additional land and doesn't pose any seawater intrusion. No recurring expenditure is involved in its maintenance. It is however necessary to ensure that the yields of wells if any in the downstream are not unduly affected.

SUBSURFACE DAMS ACROSS MAJOR RIVERS In riverbeds where there is no exploitation of groundwater in the upstream, the groundwater blocked by a subsurface dam enhances either the storage of water in the reservoir created above it or substantial base flow in the downstream. In the latter case, the additional flows will be a boon for water-starving canals particularly located in the coastal tracts.

A subsurface dam across the Ganga River upstream of the Farakka barrage helps Kolkata to become an all-weather port, while people in parts of Bangladesh could have subsistence agriculture and fishing even during summer.

A subsurface dam across the Godavari River upstream of the Dowleswaram barrage ensures no shortages of water for the Rabi crop in the Godavari delta.

A subsurface dam across the Krishna River upstream at the Krishna barrage at Vijayawada or across the Cauvery ensures adequate water for two crops in the delta irrespective of the vagaries of surface runoff.

Such subsurface dams could be constructed across every small river joining the sea to put the associated groundwater presently joining the sea into use without the danger of any saltwater intrusion. (Prof R Jagadishwara Rao, Oct 2003)

Note: The subsurface dams and unsustainable use of aquifers under the riverbeds are not without risks. We are not endorsing this proposal, but only giving here as one of the advocated options and would like to make it clear that there are risks associated with this option.

Annexure 2

Disastrous implications of Chennai sucking up rural water

Over the last 5 years the farmers of two districts outside Chennai have started selling water from their irrigation wells to the city's water utility. Farmers find themselves fighting a losing battle with those among them selling water from their irrigation wells and with the water mafia. Mostly the selling is being done illegally. Farmers have obtained permission to sink wells for irrigation, but separate permits are needed for using irrigation wells to sell and transport water under the Chennai Metropolitan Area Groundwater (Regulation) Act, 1987.

Impact Vengaivasal's 42 ha lake was deepened and encroachments removed in 2001 under the NABARD-funded Water Resource Conservation Project-II. A Water Users' Association was formed and the villagers given the responsibility of maintaining the irrigation lake and channels. The lake overflowed in 2001 and 2002 but was filled only to half the capacity in the next two years. The average GW level has dropped 15 ft over the last summer to around 50 ft now. Wells have either been deepened or abandoned due to steady fall in the water table (The average depth of the present wells in the Palar basin is 69 ft, as per a MIDS study).

In the Palar basin, the village of Pazhayaseevaram has become a case in point for the devastation that over-exploitation can wreak. As compared to 1972-75 when there was 24-hour water supply in the village it was 1.5 hour a day in 2002. The irony is that this village, while supplying water in millions of litres per day for millions of urban citizens, is distributing water to its population lower than the permissible WHO standards says a DFID report of 2004. (The first pumping station was started on 24 Jan 1972 and can deliver up to 118.2 MLD.)

The farmers of Thiruvallur & Kancheepuram districts are up against selling of GW. GW exploitation has been happening for 40 years now and its impact is for all to see. In Minjur and neighbouring areas, there is seawater intrusion into the water table up to a distance of 5 km in-land. Agriculture in Minjur is now impossible. This would continue along the Arani-Kortrailaiyar basin if GW exploitation is not stopped forthwith. In villages like Velliyur, Vishnuwakkam, Magaral, Selai, and Kaivandur, Chennai Metrowater extracts ground water 24 x 7 with thirty 10 HP pumps. With dwindling levels, the decline in agriculture is clear in the last 2 years when water utility has started pumping from private irrigation wells.

Authors Marie Gambiez and Emelie Lacour of an Indo-French study on the "Tripartite agreement in peri-urban Chennai: Rural impact of farmers selling water to Chennai Metropolitan Water Board" note that while the number of farmers selling water has increased from 12 in 1993 to 22 in March 2001 in the village of Magaral, the duration increased from 12-hrs a day for four months in 1993 to round-the-clock, round-the-year in 2001. Though the agreement said farmers must give 18 hrs water per day "in reality we saw that the number of hours per day was never regular. In fact, the CMWSSB sometimes asks farmers to give water for 24 hrs." The local body had no role to play in the negotiations or in regulating the amount of water extracted. Says, M G Devasahayam, managing trustee of the Chennai based Citizens Alliance for Sustainable Living: "This is leading to the conflict, be it in the Telugu-Ganga Project, New Veeranam augmentation project or the farmers around the city. When the TGP was envisaged to bring 15 TMC of water from Krishna through the drought-hit Rayalseema, the farmers were left out of the talks."

Similar is the case of the New Veeranam Project (an irrigation lake that is a reservoir for the surplus from the Cauvery River). "While the quantum promised was 180 tmc after the irrigation needs are taken care of, if the water managers had held grassroots consultation, they would have realised it would be impossible to conjure it up. Now well fields like those in Arani-Kortrailaiyar basin are being dug and the farmers are apprehensive of loss of irrigation water," says Devasahayam.

(On April 2, '05 Madras HC endorsed the TN Govt's action of drawing sub-surface water from riverbed of Kollidam, that drains from Veeranam lake. Farmers of Cuddalore and Perambalur are now considering appealing the order in the Supreme Court.)

It is the case of the lawbreaker and the implementer being the same person. Chennai Metropolitan Area GW Regulation Act, 1987 vests powers with bodies such as Metrowater to issue licenses for wells. The Act does make the sinking of wells contingent on availability of GW. But Metrowater is itself proceeding to extract water over the contracted amount with no responsibility for the dwindling supply.

Farmers have taken recourse to rain-fed agriculture as their wells have failed and the irrigation lake is no more able to meet their needs. Paddy cultivation has come down from 63.6 ha annually to 2.5 ha, leading to loss of livelihood also among landless agricultural labourers. The study notes: "…the loss in agricultural work is so high, despite the non-agricultural work (from a sugar mill), their workdays have decreased from 250 to 190 (24% decrease). For women the reduction is from 190 to 150 (21%)." The socio-economic cost of such unbridled exploitation can be seen in the neighbouring district of Thiruvallur (where the Arani-Kortrailaiyar basin and the 3 reservoirs feeding Chennai are).

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