ITP RESEARCH SERIES 3

KARNATAKA STATE WATER SECTOR REFORM: CURRENT STATUS, EMERGING ISSUES AND NEEDED STRATEGIES

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1. Description of the Existing State Water Policy

Karnataka's water policy has the objective of creating an ultimate irrigation potential of 45 lakh hectares under major, medium and minor irrigation projects. It facilitates creation of an additional irrigation potential of 16 lakh hectares by individual farmers using ground water. The State envisages to provide drinking water at the rate of 55 liters per person per day in the rural areas, 70 liters per person per day in towns and 100 liters per person per day in the city municipal council areas and 135 liters per person per day in city corporation areas. The aim is to improve performance of all water resources projects, improve productivity of irrigated agriculture by involving users in irrigation management. It envisions to harness the hydropower potential of the State. Finally the State intends to provide a legislative, administrative and infrastructural environment, which will ensure fair, just and equitable distribution and utilization of the water resources of the State to benefit all the people of the State.

The occurrence and distribution of rainfall in the State is highly erratic. The annual normal rainfall is 1138 mm received over 55 rainy days. It varies from as low as 569 mm in the east to as high as 4029 mm in the west. About 2/3rd of the geographical area of the State receives less than 750 mm of rainfall. Even assured rainfall areas of the State experience scarcity of water in some years.

There are seven river systems in the State viz., Krishna, Cauvery, Godavari, West Flowing Rivers, North Pennar, South Pennar and Palar. Utilization of water in the West Flowing Rivers is hampered due to difficulties in construction of large storage reservoirs. Yield in the seven river basins is estimated as 3418 TMC at 50% dependability and 2934 TMC at 75% dependability. Yield in the six basins (excluding west flowing rivers) is estimated as 1396 TMC at 50% dependability and 1198 TMC at 75% dependability. The economically utilizable water for irrigation is estimated as 1695 TMC.

Availability of ground water is estimated at 485 TMC. Ground water resources have not been exploited uniformly throughout the state. Exploitation of ground water in the dry taluks of North and South interior Karnataka is higher as compared to Coastal, Malnad and irrigation command areas. There is deficiency of water for drinking, agricultural and industrial use in dry taluks of North and South interior Karnataka. Where adequate surface water is available, utilization of ground water resources is minimum. In about 43 taluks there is over exploitation of ground water resources. Further, groundwater exploitation has exceeded 50% of the available ground water resources in 29 taluks of the State. These 72 taluks are critical taluks from the point of view of the ground water exploitation. In the 72 critical taluks about 4 lakh wells irrigate an area of 7.5 lakh ha. Due to over exploitation of ground water resources, more than 3 lakh Dug-wells have dried. Shallow bore wells have failed and yield in deep bore wells are declining. Area irrigated by ground water extraction structures is decreasing. Consequently, more than Rs.2000 crores of investment made by the individual farmers on the construction of wells, pumping equipment, pipelines, development etc., have become in fructuous.

Objectives

Provide drinking water at the rate of 55 liters per person per day in the rural areas, 70 liters per person per day in towns and 100 liters per person per day in the city municipal council areas and 135 liters per person per day in city corporation areas. Create an ultimate irrigation potential of 45 lakh hectares under major, medium and minor irrigation projects. Facilitate creation of an additional irrigation potential of 16 lakh hectares by individual farmers using ground water.

- Improve performance of all water resources projects.
- Improve productivity of irrigated agriculture by involving users in irrigation management.
- Harness the hydropower potential of the State.

Provide a legislative, administrative and infrastructural environment, which will ensure fair, just and equitable distribution and utilization of the water resources of the State to benefit all the people of the State.

Water resources planning, development and management will be carried out adopting an integrated approach for a hydrological unit such as River basin as a whole or for a sub basin, multi-sectorally, conjunctively for surface and ground water incorporating quantity, quality and environmental considerations. Development projects and investment proposal will be formulated and considered within the framework of river or sub-basin plan so that the best possible combination of options can be obtained for poverty alleviation, increasing incomes and productivity, equity, reduced vulnerability to natural and economic risks and costs. Solutions to water allocation and planning issues will be found adopting a demand management approach.

Irrigation planning will take into account the irrigability classification of land, cost effective irrigation techniques and the needs of drought prone and rain shadow areas. Wherever water is scarce, the irrigation intensity will be such as to extend the benefits of irrigation to as large an area as possible in order to maximize production. Land and Water are mutually reinforcing resource systems, which are limited in the State. Land use pattern has perceptible influence on the hydrological characteristics, the soil erosion factors and soil is non-renewable and irreplaceable beyond a certain point of damage. Water availability is limited but it's irrational and overuse has resulted in low overall project efficiencies and considerable land degradation. The management of water and land resources and water and land use planning and management are closely intertwined and hence, there will be close integration of water use and land use policies. Appropriate cropping patterns will be adopted in co-ordination with the Agriculture Department. Drip and sprinkler irrigation to improve water use efficiency will be promoted. Irrigation and multi purpose projects will invariably include drinking water component.

For multi-sectoral water planning, inter sectoral water allocation, planning of water development programmes, management decisions, and resolution of water resources issues, a State Water Resources Board will be established. The Water Resources Development Organization will act, as technical secretariat for the State Water Resources Board. A State Water Resources Data and Information Center will also be established.

In planning and operation of water resources projects, water allocation priorities shall be broadly as follows :

a. Drinking water
b. Irrigation
c. Hydropower
d. Aquaculture
e. Agro industries
f. Non-Agricultural Industries
g. Navigation and other uses

Prioritization for incurring expenditure in respect of Major and Medium irrigation projects will be as follows :

a. Completion of on-going & committed projects
b. Promoting participatory irrigation Management
c. Operation and maintenance
d. Repairs & modernization

In irrigation projects where reservoirs are already completed, top priority will be given to the construction of the canals, field irrigation channels in the shortest possible time and steps taken to utilize the potential created.

The management of water resources shall be done adopting a participatory approach. Necessary legal and institutional changes will be made. The ultimate goal will be to transfer operation, maintenance, management and collection of water charges to users groups.

Minor Irrigation works and sub-systems of Major & Medium Irrigation works will be rehabilitated with participation by the users of these tanks and sub- systems and handed over to Users Organization for operation, maintenance and management. Technical assistance will be rendered to Water Users Societies / Associations and they will be encouraged to undertake land leveling and also take up cultivation of high value crops requiring less water for efficient use of scarce water.

To create awareness among citizens on de- centralization user participation and involvement in decision-making, implementation and management of water resources projects, campaigns will be undertaken.

Improve agricultural productivity and farm income by involving the Departments of Agriculture and Horticulture universities of Agricultural Sciences

Krishi Vigyan Kendras and Non-Government Organization to promote cost effective and also high value agricultural production technologies.

The Water Resource Department will be restructured to suit new approaches envisaged, increase efficiency of plan and non-plan spending and reduce non-plan spending. Available manpower will be trained and re- deployed based on needs.

A system of water rights along with suitable enforcing mechanisms will be established. Water quotas for different subsystems like distributory, sub distributory minors or laterals will be fixed in order to distribute water equitably and use water more efficiently. The prime requisite for resources planning and introducing water rights is a well-developed information system. A state of the art information system will be developed. This information system shall contain data on surface and ground water availability and actual use for diverse purposes in different basin/sub-basins. Action will be taken to improve governance, bring transparency in administration, reduce corruption and make the administration accountable.

Private sector participation will be encouraged in various aspects of planning, investigation, design, construction, development and management of water resources projects for diverse uses, wherever feasible. Private sector participation will help introducing corporate management in improving service efficiency and accountability to users. Depending upon specific situation, various combinations of private sector participation, in building, owning, operation, leasing and transferring of water resources facilities will be considered.

Water rates for various uses will be revised in a phased manner and fixed so as to cover at least the operation and maintenance charges of providing services.

A River, Stream and Tank Bed Authority will be established to remove and prevent encroachments and prevent eh occurrence of manmade floods. Unauthorised pumping / lifting / siphoning of water from main canals, branch canals distributaries will be prevented.

Reduce siltation of dams through soil conservation and a forestation measures. Undertake in co- ordination with the Forest Department and the Directorate of Watershed Development, measures for protecting the environment and improve the quality of life by planting different types of trees suited to the particular area. Allow water users organization to plant trees in the command area handed over to them for management and to share the benefits accruing with the Government.

Periodical reassessment of the groundwater potential on a scientific basis will be undertaken. Exploitation of groundwater resources will be regulated so as not to exceed the recharge capabilities. Ground water recharge project will be formulated and implemented.

A comprehensive coastal management plan will be prepared keeping in view the environmental and ecological impacts and future developmental activities regulated accordingly.

The efficiency of utilization of water will be improved and awareness about water as a scarce resource fostered. Rainwater harvesting and water conservation will be encouraged. Conservation consciousness will be promoted through education, regulation incentives and disincentives.

Catchments of the storages supplying water to urban centers will be protected from environmental degradation and industrial pollution. Steps shall be taken to ensure that effluents are treated to acceptable level standards before discharging them in natural streams. Disaster management strategy for drought and floods will be formulated.

A number of mini hydel schemes have been investigated. These schemes have negligible storage and no environmental rehabilitation and resettlement problems. Private Sector participation in establishing mini hydel schemes will be encouraged.

Close monitoring of planning, execution and performance of water resources projects will be undertaken to identify bottlenecks and to obviate time and cost overruns.

A perspective plan for training for integrated water resources development and management shall be prepared. Training will be imparted to all categories of staff of the government, Farmers and all varieties of users and also Panchayat Raj Institutions by organizing training courses, workshops, discussions, conferences and study tours. Promote integrated and co-ordinated applied research in water sector. Efforts to restore natural landscape, develop habitat to attract inland and migratory birds, beautify landscape around shores and islands will be made. Eco-Interpretation centers will be created to bring awareness and to educate society to protect and manage precious natural resources especially elixir of life viz; Water.

For implementing the above aspects, following is the action agenda

Formulate and implement projects and schemes of rainwater harvesting and recharging of underground water sources, with community participation.

Establish State Water Resources Board. Complete review of existing policies and formulate new policies. Review existing legislative framework, draft new legislation and propose amendments to existing legislative framework within 12 months, in order to achieve the Objectives enumerated in Para 4 antes.

Complete all on-going and committed water resource development projects by 2005.

Complete Command Area Development works by 2006 consistent with the policy of decentralization and participation.

Undertake and complete rehabilitation and development of all Minor Irrigation Tanks on the basis of participation by water-users including farmer, within period of 10 years and entrust these works and also subsequent Operation & Maintenance with Tank Users Associations which will themselves regulate water use, cropping pattern, levy and collection of water-user charges.

Establish Water Resource Data Information Center and collaborating arrangements with concerned Departments / Agencies. Develop protocols for data sharing and exchange. Establish direct access by water management units to water resource Data Center's databases and decision support systems like GIS and MIS. Make water accounting and audit mandatory.

Restructure the Water Resources Department to improve planning and management capabilities, eliminate multiplicity of functions, increase efficiency of plan and non-plan expenditure, train and redeploy staff based on needs, change operating rules to ensure transparency and accountability and make the Department responsive to user needs.

Assess overall water resource availability, current and future problems and conflicts and identify drought and flood risk zones in each river basin. Mobilize community and stakeholder participation through Users Organizations, empower them, provide training, technical support and create public awareness. Form and empower Water Users Co-operative Societies and Federations for Participatory Irrigation Management.

Develop integrated, conjunctive basin management plan using participatory approach.

Develop plans for modernization and rehabilitation of water resources projects as well as reclamation of water logged and salt affected lands and implement them.

Restructure and strengthen Training, Research and Development Institutions in the water sector to meet technology requirements to support basin planning, participatory approaches and render technical assistance to users organizations.

2. Current status of water supply (current and next 15 years)

2.1. Rainfall pattern

Karnataka receives 73 percent of its rainfall from south west monsoon from June to September and 16 percent of the rainfall from north east monsoon from October to December (Table 1). The south west monsoon obviously is the determining factor for agriculture in the State. The study by Krishnan (1991) considering the definition of drought by the II Irrigation commission that drought occurs when annual rainfall is below 75 percent of the normal rainfall, considering the data for 80 years (from 1901), in North eastern dry zone and central dry zone, drought occurred in more than 25 percent of the years (or once in four years)

Table 1: Distribution of Rainfall in Karnataka across seasons, monsoons and months

Season and Monsoon	Month	Average rainfall received (mm)
Kharif, South West monsoon	June - September	991.7 (73 %)
Rabi, North East monsoon	October - December	212.4 (16 %)
Cold season	January – February	8.3 (1%)
Summer season	March - May	142.3 (10%)
All seasons	June - May	1354.7 (100%)

Source: Perspective land use plan for Karnataka 2025, Karnataka state land use board, 2001,p. 565

Table 2: Rainfall, annual and season wise

Rainfall	Annual (mm)	Season wise	
		Northeast	Southwest
Normal	711.39	153	879
Actual (avg. of last 3 years)	1383	144	1062

Source: http://raitamitra.kar.nic.in/imp_agri_stat.html

Table 3: Season-wise Normal Rainfall (Avg. of 1941-1990) (mm)

Period	Rainfal
Summer (Jan.-Mar.)	13
Pre-monsoon (Apr.-May)	132
Southwest monsoon (June-Sept.)	879
Northeast monsoon (Oct.-Dec.)	193
Annual Total	1217

Source: http://raitamitra.kar.nic.in/imp_agri_stat.html

Table 4 : Average Rainfall for 2008 for Karnataka from 1178 rainguage stations is 1340 mm

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall	0	15	119	22	51	237	248	342	183	96	27	2
Season	Cold weather		Hot weather			South west period				North east period		
rainfall	15		192			1010				124		

Table 5: Normal rainfall, actual rainfall in 2007, 2008 and variation with normal for 2008 (mm)

Particulars	Normal rainfall	Actual rainfall for 2007	Actual rainfall for 2008	Variation with normal rainfall for 2008
Karnataka state	1197	1578	1340	+ 12

The rainfall for 2008 was 12 percent higher than the normal rainfall.

2.2. Surface water supply (reservoir and tanks - number and water quantity)

There are 80 reservoirs in Karnataka irrigating 12,91,110 hectares. There are 33217 minor irrigation tanks of all dimensions irrigating a meager 2,34,276 hectares. Other sources irrigate 160162 hectares. The area irrigated by major irrigation forms 77 percent of the total surface irrigated area and that by minor irrigation (tanks of all dimensions) and other sources form the rest (23 percent). However, both the major irrigation reservoirs and minor irrigation (tanks) receive water from rainfall and hence the variation in rainfall has the greatest impact on the surface irrigation.

Table 6. Surface water supply in Karnataka

Irrigation source	Number	Total Area (Gross) ha irrigated
Major irrigation reservoirs	80	1291110
Minor irrigation (Tanks of all dimension)	33217	234276
Others	19954	160162
Total surface irrigation		1685548

Source: Annual Season and Crop Statistics Report, 2007-08, Directorate of Economics and Statistics, Government of Karnataka, Bangalore

In addition, as the State is a riparian state to Cauvery, Krishna, Godavari, the major river systems, it has to share the reservoir water with Tamil Nadu, Kerala, Andhra Pradesh and Maharashtra according to the verdict of the Cauvery tribunal and the Krishna Godavari Tribunal which are under way. Even though Cauvery tribunal verdict is available as the riparian states have approached the Apex court challenging the final verdict, the allocation is still hanging among the three states. This year (2009) the monsoons have delayed and the reservoirs are already going dry. Large parts of Karnataka have gone without sowing and the impact will be severe on the food production in 2010. For instance at least 25 percent of the area may not be put to sowing due to the 2009 drought in Karnataka.

2.3. Groundwater supply (wells - number and water quantity) (for irrigation)

Karnataka state depends on groundwater for irrigation to the extent of 51 percent. Thus the State depends almost equally on groundwater and surface water for irrigation (Table 7).

Table 7: Groundwater supply in Karnataka

Groundwater structures	Number	Total gross irrigated area in ha
1. Dug wells (or Open wells)	456463	483074
2. Tube wells	619099	1288639
All Wells	1075562	1771713
Total surface and groundwater irrigated area		3457231

Source: Annual Season and Crop Statistics Report, 2007-08, Directorate of Economics and Statistics, Government of Karnataka, Bangalore

In Karnataka 1695 TMC of surface water forming 78 percent of the total volume of water irrigated fifty percent of the irrigated area of 16,85,548 ha while the remaining 485 TMC of groundwater forming 22 percent of the total volume of water irrigated the rest 50 percent of the irrigated area. This shows the lopsided distribution of surface water compared to groundwater resources. Thus prima facie there are compelling reasons to believe that groundwater farmers are relatively more efficient than the surface water farmers as the former have spread 22 percent of water on 50 percent of irrigated land, while the later have spread 78 percent of water on 50 percent of irrigated land. Thus $1/4^{th}$ of total water (=groundwater) is used on half the irrigated land and 3/4ths of total water (=surface water) is used on the other half of irrigated land in Karnataka.

Table 8: State of groundwater development in Karnataka as on 2004

Particulars	Volume in ha meters	Vol. in TMC
1. Net groundwater availability (supply)	1529659 ha meters	540.19
2. Groundwater use for irrigation	974731 ha meters	344.22
3. Groundwater use for domestic & industrial purpose	96581 ha meters	34.10
4. Groundwater use for all purposes	1071312	378.33
5. Average crop water requirement	83 cms or 830 mm	
6. Balance groundwater potential available	781340 hectares	

1 TMC = 2831.7 ha meters; 1 ha meter = 10000 M^3

Source: Department of Mines and Geology and CGWB, South Western Region, Report on Dynamic groundwater resources of Karnataka as on March 2004, June 2005, Bangalore, p. 116.

There is difference in the estimated groundwater drafted. According to the ASCR (Table 7) 485 TMC is extracted, while according to the CGWB, 378 TMC are extracted. These differences are bound to occur due to the differences between the area (linear) approach and volume (cubic) approach. What is crucial is to note that in Karnataka 91 percent of groundwater is used for irrigation and a meager 9 percent of groundwater is used for domestic and industrial purposes. The groundwater formations in India clearly indicate that more than 60 percent of the geographical area in India has hard rock formations which imply low recharge of groundwater from rainfall around 5 to 15 percent.

2.4. Issues relating to water supplies

(reference: http://waterresources.kar.nic.in/state_water_policy-2002.htm)

1. There are no institutional arrangements at the State level to consider sectoral water, demands, plan and manage water between them. Responsibilities of

water issues are fragmented between different departments without formal mechanism to ensure co-ordination.

2. Karnataka's developmental priorities have been influenced by the present need to utilize the share of river waters. Heavy investments have been made on creating storage capacities in irrigation projects, without investments on canals and field irrigation channels. Though there has been substantial increase in agricultural production, the revenue from water rates is to be increased proportionately.

3. Investments have been spread too thinly over large number of ongoing and new irrigation projects. Costs and time overruns have resulted in more expenditure and less commensurate benefits. The pace of creation of irrigation potential has been slow.

4. Priority for new construction in making investments has resulted in decreased availability of funds for operation and maintenance, rehabilitation and

5. modernization of existing irrigation works, reclamation of water logged and problematic lands.

6. There is a gap in the utilization of created irrigation potential due to delays in the construction of field irrigation channels, leveling of land and lack of farmer participation in the irrigation management.

7. There are 38,608 Minor irrigation tanks in the State. Storage capacities of most of these tanks are reduced due to siltation and deferred maintenance.

8. Expenditure on wages and salaries, operation and maintenance and interest payments have increased consistently and will further increase over the years. Revenue receipts from irrigation are meager and cover only a small part of the operation and maintenance costs.

9. The demand for drinking water in the urban and rural areas will increase in the coming years. This demand cannot be met entirely from groundwater sources. In about 4500 villages groundwater is not fit for drinking purposes on account of high fluoride or iron content or brackishness. Therefore, in the next two decades water supply systems for larger habitations will have to be based on surface water sources like perennial rivers and reservoirs and reduction in the irrigation water use may be inevitable.

10. Water quality problems like degradation from Agro- Chemicals, industrial and domestic pollution, Groundwater depletion, water logging, stalinisation and siltation are reducing the effective water availability.

11. Deficiencies in water management have resulted in inequitable distribution of water, under utilization of the irrigation potential created and problems of land degradation due to excessive use of water.

12. Unauthorized use of irrigation water, excess usage of water by farmers in the head reach and pumping of water from canals are depriving the tail-end farmers their due share of water. Productivity of irrigation is below potential. Suboptimal distribution of water and lack of integration of irrigation services with agriculture services have resulted in low yields, low cropping intensities and has prevented diversification of agriculture. Land development and agricultural extension have not kept pace with creation of irrigation potential.

3. Demand for water (current and next 15 years)

The usage of the word 'demand' as economists connote, assumes there is market for water. While market exists for groundwater and to some extent for surface water, there are no compelling reasons to believe that the water market is without imperfections. In addition, the water market is fraught with externalities and market failure which are discernible in groundwater and less pronounced in surface water. Irrigation is the largest user of water as more than 91 percent of utilization in Karnataka is for irrigation. It is crucial to note that the demand for irrigation water is 'consumptive' as the water used for irrigation cannot be recovered unlike the use of water for industry, domestic, municipal and other purposes, which are 'non consumptive' and hence can be recovered.

Theoretically the 'price' of water for consumptive and non consumptive use differs along with quantity and quality of water. The quality of water is relatively crucial for non-consumptive uses (domestic, industrial, municipal) and standards are much higher than for consumptive use (in agriculture). Even within non-consumptive use, the price / value differs widely. For example, Bangaloreans pay the highest price for drinking water in India and in Asia. Water price for domestic use varies from Rs. 6 to Rs. 36 per kilo liter (plus 20 percent of the cost towards sanitary), Rs. 36 to Rs. 60 for non domestic use, Rs. 60 per kilo liter for industries. Also Bangalore is the lone city with 100 percent metering in Asia. Even with 100 percent metering, the unaccounted – for - water is one of the highest being 40 percent. In Mumbai, the unaccounted for water is the lowest 18%, with Chennai 20%, Delhi (26%); Calcutta (50%), Hyderabad (51 %).

When the word 'demand' is used, it *prima facie* assumes there is a market, where in individual demand curves add upto market demand (with certain homegenity assumptions) and interaction of market demand and market supply curves yields the market price. However, when the word 'demand' is used to mean use or 'utilization', it can exist obviously without a market.

In the present context then, is there a price for water is a question. There are instances of selling 'groundwater' hence, we can obtain surrogate values for groundwater price. But due to presence of externalities, these prices are not signals of groundwater scarcity. These are surrogate only because this may not reflect the 'true' price, since it may reflect only ‘tip of the iceberg’ costs. As 'pumping' or 'energy' costs are also zero in most of the States, though dejure, in many States, farmers have to pay a 'flat rate' for electricity to pump out water.

3.1. Irrigation water

The price of groundwater is estimated with the hypothesis of existence of cumulative interference externalities, which includes inter alia, the intertemporal costs of prematurely and initially failed irrigation wells. The pumping costs are also estimated the pumping costs by installing electricity meter/s on to irrigation well/s. However these figures face stiff tests of validity and generality as they are highly location specific (for instance Deccan plateau), where the demand for groundwater is the greatest and where perennial source of surface water is at stake and vary with depth, HP and quality of the pump, quality of supply of electricity and so on.

The price of groundwater typically varies with the drilling cost, depth of the well, HP of the pumpset, casing pipe used, electricity initialization expenses, cumulative interference, installation of overhead groundwater structures, micro irrigation, yield of the irrigation well, water pumped out in a year and so on. If a typical irrigation borewell costs around Rs 2 lakhs (at 2009 prices) in hard rock areas inclusive of all costs including externality costs, yielding around 1500 gallons of water per hour, then for an average of 5 pumping hours a day, for around 300 days the total water pumped out is around 100 acre inches. At zero interest, assuming the life of the borewell to be 5 years, the cost per acre inch works out to Rs. 400 per acre inch. Earlier studies on groundwater costing in the Department of Agricultural Economics, UAS Bangalore sponsored by the Ford Foundation are presented in Table 9 and range between Rs. 200 and Rs. 500 per acre inch, as these studies estimated groundwater cost exclusively in areas fraught with negative externalities of cumulative interference. Thus a reasonable price of ground water is around Rs. 400 per acre inch at 2009 prices for irrigation of which around 50 percent is for pumping costs and the balance towards groundwater cost.

Table 9 : Net return considering value of groundwater and cost of electrical energy across agroclimatic zones of Karnataka

Zone	Well inter-ference	Gross irrigated area GIA per farm (Acres)	Dominant Crops	Water used Per farm (acre inches)	Method of irrigation	Water used per acre of GIA (acre inches)	Estimated KWHs of electricity used to lift ground water for 1 acre of GIA	Value (Cost) per acre inch of ground-water	Cost of electricity to lift ground-water for 1 acre of GIA @ Re 1 per KWH	Net returns per acre of GIA (after including value of groundwater and cost of electricity)	Net returns per acre inch of water (after including value of groundwater and cost of electricity)
Southern Transitional Zone	HIGH	5.16	Arecanut,	86.6	Drip	16.78	705	2700	705	23912	1425
Channagiri taluk	LOW	5.04	cotton, onion	95.2	Flood	18.9	794	529	794	12166	644
Central Dry Zone Madhugiri taluk	HIGH	5.32	Paddy	37.4	Flood	7.03	295	457	295	167	24
	LOW	5.74	, Arecanut	59.8		10.42	438	211	438	303	29
Southern Dry Zone Chamaraja-nagar taluk	HIGH	8.58	Sugarcane,	134	Flood	15.6	655	104	655	2273	146
	LOW	11.32	Paddy	145		12.8	538	74	538	2069	162
Northern Dry Zone Athani taluk	HIGH	2.99	Local Maize, jowar	4.6	Flood	1.54	65	972	65	3354	2178
	LOW	3.76	groundnut, turmeric	10.9		2.90	122	480	122	1978	682
Eastern Dry Zone Malur taluk	HIGH	3.85	Tomato, Potato Rose	57.4	Flood	14.9	626	287	626	8024	539
	LOW	3.50	Ragi, Tomato, Mulberry	37.8	Flood	10.8	454	394	454	6059	561
Eastern Dry Zone Devanahalli taluk	HIGH	7.83	Mulberry, Grapes, Ragi	45	Flood	5.70	239	308	239	3772	662
	LOW	5.43	Ragi Potato Mulberry	81	Flood	14.90	626	200	626	1775	119

3.2. Domestic use

When domestic use of water is discussed, it is crucial to note the percentage of water unaccounted for. The water unaccounted for is the difference between water released by the Water Board and the Water used by all users. The optimum level of unaccounted for water in a well managed urban water utility is around 15-20 per cent (Thornton, 2002). For Bangalore city the water unaccounted for is as high as 40 percent, even considering the fact that it has cent percent metering of water, it bagged several national awards for its efficient handling of various components of urban water management (Sastry, 2006). The price of water charged by BWSSB (Table 10) reflects the higher end prices for the resource.

Table 10:. Price of filtered Water for domestic use in Bangalore city

Sl No	Category & Consumption (liters per month)	Water price per 000 liters per month	Minimum Charges per month
I	DOMESTIC		
	0-8000	6	48
	8001-25000	9	201
	25001-50000	15	676
	50001-75000	30	1326
	75001-100000	36	2226
	100000 & above	36	5826
2	Sanitary Charges for domestic connection	(i) Rs. 15 flat rate for consumption of 0 to 25000 liters. (ii) From 25001 to 50000 liters - 15% on water supply charges per month . (iii) 20% of water supply charges per month against for consumption of above 50000 liters	

Price of water for non domestic use in Bangalore

The price of water for non domestic use varies from Rs. 36 per month for the lower slab users to Rs. 57 per month for higher slab users (Table 11)

Table 11: Price of water for non domestic use in Bangalore

Volume of water in Kilo liters	Price per 000 liters per month	Minimum Charges per month
1. Non Domestic use		
0-10000	36	360
10001-20000	39	390
20001-40000	44	880
40001-60000	51	1002
60001-100000	57	2280
10000 & above	60	NA
2. Industries	60	
3. Lorry Loads	250 (per Load)	
4. Swimming Pools	60 (per kilo liter)	
5. Public taps	3000 (per kilo liter)	

Water requirement

The water requirement for 2004 for domestic purposes . The highest requirement obviously is for Bangalore, followed by Belgaum, Gulbarga and Mysore districts. The lowest requirement is for Kodagu.

Table 12: District-Wise Estimated Requirement of Water for Domestic Purposes in Karnataka (2004)

Districts	Population (in '000)			Domestic Water Requirement (Excluding Cattle) (000 M3)			Domestic Water Requirement including Cattle (000M3)
	Rural	Urban	Total	Rural	Urban	Total	Total
Belgaum	3321	1053	4374	60741	86219	157284	192355
Bagalkot	1220	498	1718	22302	40807	61767	75540
Bijapur	1469	411	1881	26870	33688	67622	82701
Gulabarga	2367	882	3249	43290	72211	116819	142868
Bidar	1203	358	1561	21996	29334	56127	68642
Raichur	1278	436	1714	23370	35684	61617	75356
Koppal	1035	206	1241	18921	16885	44617	54566
Gadag	655	356	1010	11978	29122	36335	44437
Dharward	751	917	1667	13728	75090	59956	73325
Uttara Kannada	1004	403	1407	18353	33039	50592	61872
Haveri	1184	311	1495	21654	25455	53753	65739
Bellary	1372	734	2106	25082	60125	75711	92593
Chitradurga	1285	285	1570	23502	23341	56458	69047
Davanagere	1297	564	1861	23717	46179	66906	81824
Shimoga	1112	593	1705	20327	48582	61294	74962
Udupi	939	214	1153	17571	17571	41477	50726
Chickmangalur	953	231	1184	18937	18937	42584	52080
Tumkur	2155	527	2682	43150	43150	96432	117935
Kolar	1974	649	2623	53195	53195	94335	115369
Bangalore	809	5973	6782	489291	489291	243859	298235
Bangalore Rural	1529	423	1952	34650	34650	70185	85835
Mandya	1538	293	1832	24031	24031	65860	80545
Hassan	1473	317	1790	25952	25952	64350	78698
Dakshina Kannada	1214	757	1972	62036	62036	70895	86703
Kodagu	489	78	567	6406	6406	20386	24932
Mysore	1722	1007	2729	82488	82488	98129	120010
Chamrajnagar	848	848	1002	12622	36048	36048	44086
Karnataka	**36194**	**18630**	**54824**	**1526091**	**1971399**	**1971399**	**2410981**

Source: Central Water Commission (www.indiastat.com)

Per capita water

The per capita availability of water was 86 liters per day in 1900. Due to non availability of proper supplies, the per capita water availability declined steadily and it reached 45 liters per capita in 1931. In order to improve the water availability, the Thippagondanahalli dam was built across river Arkavathi down stream of Hessarghatta reservoir in 1933. Due to this, water availability improved substantially (Table 13).

Table 13: Consumption of water in Bangalore city (Million Liters)

Year	Total Receipt of water	Domestic	Non - Domestic	Public Fountains	Others	Total
1985-86	105474.88	50822.06	15859.49	11724.65	142.93	78549.13
1986-87	125217.18	45350.13	17743.10	12307.78	165.63	75566.64
1987-88	133980.00	63828.00	20982.00	25745.00	35.00	110590.00
1988-89	139084.00	72079.00	17483.00	25846.00	33.00	115441.00
1989-90	144165.00	77924.50	16208.12	25903.00	58.00	120093.62
1990-91	137173.57	59772.84	21371.70	32999.04	197.35	114340.93
1991-92	124654.09	54790.80	20203.68	33433.00	160.67	108588.15
1992-93	148380.69	59803.85	21599.95	41868.43	129.47	123402.20
1993-94	170535.62	65109.22	19934.47	46894.10	533.88	132471.67
1994-95	200403.60	65607.12	20399.94	54051.79	354.91	140413.76
1995-96	206817.79	71334..13	19331.10	55062.33	379.33	146106.89
1996-97	201154.34	70325.59	19047.46	54911.93	849.01	145133.99
1997-98	209604.69	70815.00	18656.13	54911.93	924.47	145307.53
1998-99	224005.80	76863.53	19714.05	54911.93	906.16	152395.67
1999-2000	236419.81	81983.19	20282.32	55062.31	902.01	157039.53
2000-01	247381.66	87982.08	20681.77	54911.93	955.47	164531.25

Water demand

Considering domestic and non-domestic water requirement including wastage totaling 140 liters per capita per day, the recommendation made at the conference of Secretaries, Chief Engineers responsible for Urban Water Supply and Sanitation at Mysore during 1989 (Million liters per day) the water demand projections have been made (Table 14).

Table 14: Water demand in Million Liters per Day for Bangalore city

Sl No	Year	Projected Population (In Lakhs)	Water Potential available (In MLD)	at 140 LPCD	at 200 LPCD	at 140 LPCD	at 200 LPCD
1.	1991	41.30	435	578	826	143	391
2.	1992	43.10	435	603	862	168	427
3.	1993	44.90	705	629	898	76	193
4.	1994	46.70	705	654	934	51	229
5.	1995	48.50	705	679	970	26	265
6.	1996	50.30	705	705	1006	---	301
7.	1997	52.10	705	729	1042	24	337
8.	1998	53.90	705	755	1078	50	373
9.	1999	55.70	705	780	1114	75	409
10.	2000	57.50	705	805	1150	100	445
11.	2001	60.00	705	840	1200	135	495
12.	2003	60.42	930				

Domestic water needs of rural and urban population for 2050

For Krishna basin, it is estimated that the population for Karnataka for 2050 will be 59.90 million for rural areas and 21.08 million for urban areas. Considering the per capita requirement of 150 liters per day for rural and 220 liters per day for urban, the drinking water needs are 115.62 TMC for rural and 59.78 TMC for urban population. The total requirement for water is 150.31 TMC for rural and 77.71 TMC for urban including the T and D losses of 30 percent. The total demand for the State including all areas can be conveniently taken as twice that of the demand for Krishna basin. Accordingly the total requirement for domestic water needs for urban and rural population in Karnataka in 2050 is 456.04 TMC.

3.3. Water use for Industry

The water needs for industrial use in Karnataka have been estimated for Krishna Basin to be 16.62 TMC in 2010, which comprises of 4.99 TMC of groundwater and 11.64 TMC of surface water. This is expected to grow to 29.64 TMC in 2025 (4.59 TMC of groundwater and 25.06 TMC of surface water) and to 50.45 TMC in 2050 (4.22 TMC of groundwater and 46.23 TMC of surface water). The groundwater scarcity is largely responsible for shift to surface water for industrial use in the State. Though the areas other than Krishna basin approximately form 25 percent of State's area, the industrial development is almost 50 percent of the State. Thus, it can be hypothesized that the industrial use in Karnataka will be double of the estimate for Krishna basin. Hence the total water use / demand for industry is accordingly 33.24 TMC in 2010, 59.28 TMC in 2025 and 100.9 TMC in 2050 with corresponding proportions of groundwater and surface water as already estimated above (Source: Technical consultancy services organization of Karnataka, 2004, Forecast of water needs of industrial units in districts / areas falling under Krishna basin, Government of Karnataka, Bangalore)

3.4. Water use for Livestock

The demand for livestock is estimated to be 28.82 TMC for Krishna Basin and twice this demand being 57.64 TMC is the demand for livestock for the State.

3.5. Issues relating to demand for water

Water use for agriculture forms almost 92 percent of total water demand and contribution of Surface water as well as groundwater to agriculture is almost 50 percent each. While 75 percent of groundwater cost is partially met by farmers as they invest on irrigation wells as also meet the repairs and maintenance costs, conveyance costs, excepting the cost of electricity (which is approximately 50 percent of the total cost or value of groundwater), with regard to surface water, farmers do not contribute towards the cost or value. This is a major issue to be addressed by WUAs in order to bring efficiency in water use.

Since agriculture is the largest user of water, any disciplining of water use should be from agriculture since even a small proportion of disciplined water use results in largest absolute saving of scarce water for other economic uses. Thus, irrigation water literacy should be the prime objective of development in order to educate the farmers regarding the precious water resources and the need for efficiency in water use which results in overall system efficiency.

Regarding drinking water, Bangalore city has metered water supply which is the Asia's largest water meter user. Even with almost 100 percent metering of water, the water unaccounted for is almost 40 percent. Thus there is need for reducing this large proportion of unaccounted for water. The other issue is the contribution of groundwater other than BWSSB to Bangalore. The real price of groundwater and the volume of groundwater extracted for drinking, domestic and other purposes in Bangalore urban area here is worth exploring. For instance, during 1994 ("Institutional check on well owners selling water", MG Chandrakanth, Deccan Herald, 25/6/1994), there were an estimated 300 private tankers buying water from owners of drinking water bore wells at the rate of Rs. 25 to Rs. 50 per 6000 liters, charging around ten times that price around Rs. 250 to Rs. 300 per tanker. In 2007, the price range is around Rs. 250 to Rs. 400 per tanker and there were 3500 tankers. With an inflation rate of 5 percent, the base price of Rs. 250 per tanker in 1994 should have been Rs. 471 in 2007. Thus, in real terms the price of water has fallen from the base price of Rs. 250 per tanker to [(471-250) = 221, Rs. 250-221=] Rs. 29 per tanker. Thus, the demand for water is overriding scarcity in Bangalore and while the price of water should have aggravated due to scarcity, in real terms price has fallen from Rs. 250 per tanker to Rs. 29 per tanker of 6000 liters (or down from Rs. 4.2 per 100 liters to 48 paise per 100 liters) at a compound drop rate of 15.27 percent per year. Conversely, this indicates that groundwater exploitation for commercial purposes in Bangalore is increasing at the rate of 15.27 percent per year. The situation in other urban, semi-urban areas of the state is no exception. Thus, overexploitation of groundwater for commercial purposes is apparent not only in economic terms but also in physical terms as the number of tankers which were around 100 during 1994, have mushroomed to around 3500 tankers in 2007, increasing by a compound growth rate of 31 percent per year.

On an average a well owner in Bangalore city sells to 10 tankers per day thus extracting around 60,000 liters per day. This amounts to around 0.58 acre inch per day and assuming that the borewell owner sells water every day, these amount to

213 acre inches, which can irrigate 5 acres of paddy. Thus, each well owner who is selling groundwater commercially is estimated to be drawing groundwater equivalent to an irrigation well in an year, in an urban area which totally lacks the recharge capacity, as virtually there is no space for recharge, as the soil/land are covered by either tar or cement.

In Bangalore, there are around four lakh borewells. These are supposed to meet around 50 percent of the water requirements (according to the 2007 Cauvery Tribunal Verdict). Due to commercial exploitation, each commercial borewell can result in total failure of several other surrounding drinking water wells, which are meeting the drinking water supplies of households. In several parts of Bangalore, many borewells have virtually dried up due to the commercial exploitation of groundwater. Thus, the Karnataka groundwater (control and regulation) Bill of 1996 /2002 should include the provision for imposing sanctions on borewells to limit their withdrawal exclusively to meet the household requirement and should not be permitted to sell / exchange groundwater for commercial purposes.

Instead, water tankers in turn can buy the groundwater from wells in rural areas by paying the market rate to farmers and then charge the urban consumers accordingly. Studies in the Department of Agricultural Economics, UAS GKVK have indicated that farmers who are selling groundwater for domestic purposes have realized greatest net returns and have also been efficient in water use in their agriculture as the water markets have a role to play in making farmers efficient users of groundwater. Thus, no water tanker in the urban area/s should be permitted to draw water for selling to either domestic or industrial or hospital or any other purpose for (i) conserving groundwater in urban areas which lack substantial areas for recharge and (ii) preventing failure of other groundwater wells which are meeting the drinking water needs of urban consumers. A suitable provision towards this should be included in the Karnataka Groundwater Regulation and Control Bill of 1996/2002, which may shortly be tabled on the floor of the legislature.

4. Supply demand gap for water (current & next 15 years)

The estimated demand and supply is subject to limitation of methodology used and the source of data used. The positive gap shown is due to lack of infrastructure to store the rain / river water. Groundwater utilization according to volume exceeds 70 percent of supply or availability. There are obvious differences between the sources of data as well as between volumetric measurement and the area measurement regarding supply and demand for water As a thumb rule, usually 1 TMC of water can irrigate 4000 ha of semi dry crops or 1000 ha of paddy or 1600 ha of sugarcane.

Table 15. Estimated Water Supply and demand in TMC (thousand million cubic feet)

Items	Current year	2020
Estimated Supply	1695 TMC of surface water 485 TMC of groundwater	1975 TMC of surface water 364 TMC of groundwater
Estimated Demand	A. Irrigation: 1362 TMC B. Industrial use 33.24 TMC C. Livestock : 57.64 TMC D. Domestic: 93.72 TMC Total: 1547 TMC	
Estimated Supply - Demand gap	+ 633 TMC	+ 316

Source: http://waterresources.kar.nic.in/state_water_policy-2002.htm,
1 TMC = 1 thousand million cubic foot;
Note:

A: is estimated using the crop water requirement from Table VI for the irrigated area under each crop in the State;

B: 16.62 TMC is the estimated industrial demand for water in Krishna Basin and twice this is taken for the State,

C: 28.82 TMC is the estimated water demand for livestock use in Krishna Basin and twice that is taken for the State

D: the demand for water is estimated considering 100 LPCD. The supply of groundwater for 2020 is assumed to reduce by 25 percent.

Table 16: Water potential and utilization

Source	Potential (ml.ha)	Created (ml.ha)	Utilized (ml.ha)	Remarks if any
Surface	3.5	2.68	1.69	Delay in implementing irrigation projects and capital shortage for completing ongoing works
Groundwater	1.0	0.90	1.78	Exceeds potential and hence well failure and associated negative externalities are colossal
others	1.0	0.033	0.33	
Total	5.5	3.62	3.80	Considering 'created' as supply and 'utilized' as demand, there is supply demand gap of 0.18 ml ha. The gap between Potential and Utilized will continue till the State is able to create the full potential.

Source: http://waterresources.kar.nic.in/introduction.htm
Note : Groundwater utilization according to area exceeds the potential as the utilization is 78 percent higher than the potential of 1 ml hectare. There are obvious differences between the volumetric measurement and the area measurement.

5. Cost and pricing of water

5.1. Cost of surface water in Rs/cu.m reservoir & tank)

The crop wise cost of surface water for reservoir / tank indicates that it ranges from Rs. 86 to Rs. 988 per ha depending upon the water use intensity of the crop. For instance for paddy the surface water cost is Rs 247 per ha, for sugarcane it is Rs. 988 per ha, for horticulture crops it is Rs. 148 per ha and for semi dry crops it is Rs. 87 per ha.

Table 17: Cost of surface water per ha

Sl. No	Crop	Irrigation need ac inches (or ha cms)	Surface water cost Rs/ha
1	Paddy	45	247
2	Jowar	12	87
3	Ragi	12	87
4	Bajra	12	87
5	Maize	24	87
6	wheat	24	148
8	Navane	8	87
12	Red gram	20	87
13	Horse gram	8	87
14	Black gram	12	87
15	Green gram	10	87
16	Avare	6	87
17	Cowpea	10	87
18	Other pulses	12	87
19	Bengal gram	10	87
21	Sugarcane (tons/ha)	79	988
22	Dry Chilli	28	148
23	Dry Ginger	31	148
24	Turmeric	31	148
25	Cardamom (tons/ha)	28	148
26	Coriander	16	148
27	Garlic	20	148
28	Pepper	20	148
29	Areca nut	31	148
30	Coconut	39	148
31	Cashew	20	148
32	mango	20	148
33	grapes	28	148
34	Banana	39	148
35	Papaya	24	148
36	pomegrante	24	148
37	lemon	20	148
38	guava	24	148
39	sapota	20	148
40	Potato	26	148
41	Sweet Potato	24	148
42	Onion	24	148
43	brinjal	16	148
44	Tomato	24	148
45	Beans	16	148
46	Cabbage	18	148
47	groundnut	14	148
48	Sesamum	10	148
49	Safflower	12	148
50	Sunflower	14	148
51	Soyabean	20	86
52	Castor	10	86
53	Linseed	14	86
54	Niger	10	86
55	Rape & Mustard	8	86
56	Cotton	28	148

5.2. Cost of groundwater in Rs/cu.m (open & tube wells) including pricing of Electricity in the state

The electricity tariff for pumping groundwater (during 2005, the latest) are as under: I. Till electric meters are fixed - For I.P. Sets Up to and inclusive of 10 HP, the farmers are to pay Rs. 20 per HP per month and 40 paise per unit (1 unit = 1Kilo watt hour); II. where electric meters are already fixed, farmers are to pay Rs 10 per HP per month and 40 paise per unit; III. for Coconut and Areca nut plantations, Lift Irrigation Schemes / Community Irrigation Schemes of all capacities. the tariff is Rs. 20 per HP per month and one rupee (or 100 paise) per unit; IV. for I.P. Sets above 10 HP, and for Private Horticultural Nurseries and Coffee and Tea plantations irrespective of sanctioned load. the tariff is Rs 30 per HP per month, and one rupee per unit. The Government has plans to install electric meters on all IP sets in future. An estimated 40 percent of the electrical power goes to IP sets in Karnataka. Thus electricity is almost provided free of cost to farmers in Karnataka. However farmers bear the brunt of negative externality due to interference of irrigation wells leading to initial and premature well failure.

Studies conducted in the Department of Agricultural Economics, indicated that in order to pump on acre inch of water 43 to 52 kilo watt hours of electricity were used (MG Chandrakanth, B Shivakumaraswamy, KM Sathisha, G Basavaraj, Sushma Adya, MS Shyamasundar and KK Ananda, Paying Capacity of Farmers considering Cost Of Groundwater and Electricity in Karnataka, Paper presented at the seminar organized by Karnataka Electricity Regulation Commission , 20th and 21st Aug 2001, Bangalore). According to WM Shivakumar (Karnataka Electricity Board, Research Wing, Bangalore, lecture presented to Department of Agricultural Economics, UAS Bangalore, dt 19/10/2004) the electricity used by irrigation well is 6532 kilo watt hours per year. Usually an irrigation well yields around 1500 gallons per hour. With an estimated 6 hours of pumping per day for about 250 days in a year, the total water extracted is around 100 acre inches per well. Thus 65 kilo watt hours are used to lift around 100 acre inches of water, according to this estimate. Thus the electricity used to lift one acre inch of groundwater ranges from 42 to 65 kilo watt hours. The cost of generation of power varies according to the source, ranging from 8.78 paise per kilo watt hour from hydro electric power to Rs. 7.6 per kilo watt hour from Thermal, the average being Rs. 3 per kilo watt hour, considering an average of 50 kilo watt hours to lift one acre inch of groundwater, it costs Rs. 150. Thus for 100 acre inches per irrigation well, the total electricity cost is Rs. 15000 per year. The cost of irrigation well including pumpset varies from Rs. 1 to Rs. 2 lakhs depending upon the depth and casing. Even assuming zero interest, and an average life of irrigation well around 5 years, the amortized cost per well ranges from Rs. 20,000 to Rs. 40,000 per year. Thus with the addition of electricity cost of Rs. 15000 per well, the total cost per year per well is Rs. 35000 distributed over 100 acre inches will result in a groundwater cost of Rs. 350 per acre inch.

5.3. Cost of municipal water supplies in Rs/cu.m

According to BWSSB, the cost of municipal water for domestic and non domestic purposes is Rs. 6 to Rs. 60 per cubic meter per month, one of the highest in the country (Tables 10, 11).

5.4. Cost of treated water supplies in Rs./cu.m

The cost of treated water is Rs. 6 to Rs. 60 per cubic meter per month (Tables 10, 11) since all municipal water supplied is treated water.

5.5. Pricing of water under crops sector in Rs/acre

The pricing of water under crops sector (Table 18) is the cost of groundwater taken as the amortized cost of investment on all wells on the farm, divided across the average life/age of the wells at a social discount rate of 2 percent. The irrigation cost of Rs. 10 per mm is the cost of groundwater which includes the negative externality arising from inclusion of investment on initially failed and prematurely failed irrigation wells. The irrigation cost of Rs. 6.33 per mm is the cost of groundwater which includes only the cost of successful well and hence excludes the cost of negative externalities.

Table 18: Cost of groundwater

Sl. No	**Crops**	**Irrigation water use in mm**	**Irrigation cost (Rs/ha) @ Rs. 6.33/mm**	**Irrigation cost (Rs/ha) @ Rs. 10/mm**
1	Maize	600	3798	6000
2	Onion	600	3798	6000
3	Paddy	1150	7280	11500
4	Potato	650	4115	6500
5	Sugarcane	2000	12660	20000
6	Tomato	600	3798	6000
7	Wheat	600	3798	6000
8	Cotton	700	4431	7000
9	Banana	1000	6330	10000
10	Pomegranate	600	3798	6000
11	Carrot	700	4431	7000
12	Mango	500	3165	5000
13	Coconuts(no.)	1000	6330	10000
14	Arecanut (Chali)	800	5064	8000

5.6. Pricing of water under domestic sector in Rs/cu.m

The water price for domestic use is highlighted in Table 10

5.7. Pricing of water under industry sector in Rs/cu.m

The water price for industry sector is highlighted in Table 11.

5.8. Pricing of water in other uses in Rs/cu.m

The water price for other uses is highlighted in Table 11

5.9. Opportunity cost of water under different sources

The opportunity cost of water varies widely across uses, the highest in industrial and the lowest in agriculture. For example for industrial use the water cost is Rs. 60 per cubic meter per month while that for domestic use is Rs. 6 per cubic meter per month from low to high water use. That for agriculture, the opportunity cost of groundwater is Rs. 3.4 per cubic meter. However the surface water cost is far lower. For agriculture, the opportunity cost of surface water varies from crop to crop. For example for paddy, the water charge is Rs. 247 per hectare. Paddy uses about 11497 cubic meters, the cost of which amounts to Re. 0.021 per cubic meter. However for semi dry crops, the water charge is Rs. 86 per hectare and for ragi which uses about . For example, ragi uses about 1232 cubic meters and with Rs. 86 per hectare as water rate, the opportunity cost of water is Re 0.07 per cubic meter. For sugarcane which uses around 20530 cubic meters acre inches per hectare, the water rate is Rs. 988 per hectare. Thus the opportunity cost of groundwater for sugarcane crop is Re. 0.048 per cubic meter. The semi dry crops are charged more than water intensive crops like paddy and sugarcane.

6. Water use efficiency (irrigation, domestic and industry sectors)

The water use efficiency varies widely across sectors. The efficiency is the lowest in irrigation followed by industry and domestic uses. The water use efficiency varies with method of irrigation also. The efficiency is the highest for drip irrigation farms while the lowest for flood or conventional irrigation farms. Since agriculture is the largest user of water (using 92 percent of all water), it is pertinent to deal in detail. The crops, area irrigated, productivity, consumptive use, common method of irrigation and water use efficiency (Table 19) indicates that the highest area irrigated is in paddy crop followed by sugarcane, maize, groundnut, sunflower, coconut, arecanut, wheat, Bengal gram.. Flow irrigation is the common method followed while drip irrigation is emerging as the innovative method for crops like coconut, grapes, mulberry. The water use efficiency obtained by dividing the yield obtained per ha by the water used per ha, gives the highest value for cabbage followed by grapes, brinjal, mulberry, banana. Thus, WUE is higher for fruits and vegetable crops compared to cereals and pulses. Even in value terms this holds good.

Table 19: Irrigation practices, crop yield, water use efficiency in Karnataka

No	Crop	Total Area (Ha)	Crop Yield (Kg/ha)	Irrigation in acre inches (or ha cms)	Irrigation practice	Water use efficiency = (kgs per acre inch = kgs/ ha cm)
1	Paddy	1032902	2985	45	Flow	66.33
2	Jowar	148906	1675	12	Flow, sprinkler	139.58
3	Ragi	38539	2250	12	Flow	187.50
4	Bajra	49521	819	12	Flow, sprinkler	68.25
5	Maize	447042	3716	24	Flow, sprinkler	154.83
6	Wheat	142900	1251	24	Flow, sprinkler	52.13
8	Navane	16225	244	8	Flow	30.50
12	Red gram	29178	464	20	Flow, sprinkler	23.20
13	Horse gram	934	335	8	Flow	41.88
14	Black gram	1463	175	12	Flow	14.58
15	Green gram	4691	126	10	Flow	12.60
16	Avare	2824	907	6	Flow	151.17
17	Cowpea	12274	562	10	Flow, sprinkler	56.20
18	Other pulses	17186	299	12	Flow	24.92
19	Bengalgram	100456	759	10	Flow	75.90
21	Sugarcane	479063	92000	79	Flow, drip	1164
22	Dry Chilli	43002	1032	28	Flow, sprinkler	36.86
23	Dry Ginger	9135	1322	31	Flow	42.65
24	Turmeric	13259	5049	31	Flow	162.87
25	Cardamom	859	58	28	Flow	2.07
26	Coriander	3231	150	16	Flow	9.38
27	Garlic	1672	672	20	Flow, sprinkler	33.60
28	Pepper	3186	214	20	Flow	10.70
29	Areca nut	154868	2250	31	Flow, drip	72.58
30	Coconut	219506	4093	39	Flow, drip	104.95
31	Cashew	301	565	20	Flow	28.25
32	mango	9504	5218	20	Flow, drip	260.90
33	grapes	12106	27313	28	Flow, drip	975.46
34	Banana	48371	19965	39	Flow	511.92
35	Papaya	2246	2428	24	Flow	101.17
36	Pomegranate	17467	6332	24	Flow, drip	263.83
37	lemon	7982	4451	20	Flow, drip	222.55
38	guava	3559	2915	24	Flow, drip	121.46
39	sputa	10478	3782	20	Flow, drip	189.10
40	Potato	9615	9318	26	Flow, sprinkler, drip	358.38
41	Sweet Potato	485	8387	24	Flow	349.46
42	Onion	53534	5978	24	Flow, sprinkler	249.08
43	brinjal	11782	9720	16	Flow	607.50
44	Tomato	30854	10201	24	Flow, drip	425.04
45	Beans	5622	6437	16	Flow	402.31
46	Cabbage	4449	20068	18	Flow, sprinkler	1114.89
47	groundnut	206820	799	14	Flow, sprinkler	57.07
48	Sesamum	1155	619	10	Flow	61.90
49	Safflower	1291	782	12	Flow	65.17
50	Sunflower	215624	750	14	Flow, sprinkler	53.57
51	Soyabean	12556	780	20	Flow	39.00
52	Castor	333	841	10	Flow	84.10
53	Linseed	202	322	14	Flow	23.00
54	Niger	74	191	10	Flow	19.10
55	Rape&Mustard	243	267	8	Flow	33.38
56	Cotton	55920	536	28	Flow, sprinkler	19.14
57	Mulberry	28767	20000	36	Flow, drip	555

Water use efficiency of different crops across drip and conventional irrigation

In Drip (Conventional) irrigation system 9.05 (3.86) qtls of mulberry [leaves as output], 10.50 (2.85) qtls of Grapes and 12.45 (5.03) qtls of tomato were produced per acre inch of water. The volume of water used per kg of output was lower in DIF (Drip irrigation farm) (0.023 acre-inch) than CIF (Conventional irrigation farm) (0.057 acre-inch) thus, drip is 40 per cent more efficient than conventional irrigation (Table 20). Similar results apply to the volume of water used to produce a quintal of output under the two systems.

The economic efficiency of water use is the net return per acre inch of groundwater used. The net return per acre-inch of water from mulberry, Grapes and tomato were higher in DIF (Rs.1384, Rs.4723 and Rs.2696 respectively) than CIF [Rs.525, Rs.769 and Rs.1040 respectively]. The net return per acre of mulberry, Grapes and tomato in DIF was relatively higher (Rs.7621, Rs.52,084 and Rs. 26,208 respectively) than CIF (Rs.4978, Rs.21,489 and Rs.22,796 respectively). The net return per acre inch was higher in arecanut from drip irrigation (Rs. 3186) compared to conventional method (Rs. 818). The net return per acre from arecanut was higher from drip irrigation (Rs. 58,237) than conventional (Rs. 37,556) and drip is 200 per cent more efficient than conventional irrigation. The net return per rupee of groundwater from drip (Conventional irrigation) in Mulberry is 2.88 (1.24), grapes 12.84 (10.26), Tomato is 2.47 (2.21) and arecanut is Rs. 14 (11) respectively. Thus the drip irrigation farms are at least 100 percent more efficient than conventional irrigation farms (Table 20). Mulberry provides the highest efficiency of 232 compared with arecanut (130), grapes (125), Tomato (112). .

Table 20: Water use efficiency across different crops (2009)

Particulars	Physical efficiency		Economic efficiency		
	Output per acre-inch of water (quintals)	**Water used per quintal of output (acre-inch)**	**NR per acre inch of water (Rs.)**	**NR per acre (Rs.)**	**NR per rupee of water [Rs.]**
Mulberry					
DI	9.05	0.11	1,384	7,621	2.88
CI	3.86	0.26	525	4,978	1.24
Efficiency	234	42	264	153	232
Grapes					
DI	10.50	0.09	4,723	52,084	12.84
CI	2.85	0.35	769	21,489	10.26
Efficiency	368	26	614	242	125
Tomato					
DI	12.45	0.08	2696	26208	2.47
CI	5.03	0.19	1040	22,796	2.21
Efficiency	248	42	259	115	112
Arecanut					
DI	50	0.023	3186	58237	14
CI	17	0.057	818	37556	11
Efficiency	300	40	400	200	130

Note: Efficiency= [DI/CI]*100, DI= Drip irrigation farms, CI=Conventional irrigation farms

Source: 1. C N Priyanka, Externalities in groundwater use in drip and conventional irrigation farms in eastern dry zone of Karnataka,2. P Mamatha, Externalities in groundwater use in drip and conventional irrigation farms in southern transition zone of Karnataka, Unpublished MSc (Agri) theses Dept of Agri Economics, UAS Bangalore; 2009

Irrigation efficiency as Potential for expansion and constraints

For outreach, there is need to identify the crucial variable/s on which the extension services need to be provided. Towards this Endeavour, stepwise discriminant function analysis was performed. In the Eastern Dry Zone of Karnataka, out of the 6 variables considered for the analysis, the Cropping intensity, water used in acre inches and net returns per acre inch of water were the three crucial variables favoring adoption of drip irrigation (Table 21). With the Mahalanobis D^2 of 646.79, the discriminant function was significant (Priyanka, 2009) displaying a canonical correlation of 0.919, the square of which (0.84) indicates 84 percent of the variation in the dependent variable [the method of irrigation] is explained by three independent variables namely cropping intensity, water used in acre inch and net returns per acre inch of water. The major variable among three was net returns per acre inch of water and this accounted for 98.75 per cent of the total distance between Drip and Conventional irrigation farms.

Table 21: Factors discriminating Drip (DIF) and Conventional irrigation farms [CIF]: Step wise Discriminant Function analysis for Eastern dry zone, Karnataka (2009)

Sl. No.	Discriminating variable	Discriminating co-efficient (L_i)	Group mean value		$L_i(d_1-d_2)$	D^2 = 646.79 Percentage contribution
			DIF (d_1)	CIF (d_2)		
1	Cropping intensity	0.803	268	265	2.409	0.37
2	Groundwater used in acre inches	0.283	23	43	5.666	0.88
3	Net returns per acre inch of groundwater (measure of efficiency)	0.142	5462	964	638.716	98.75

Source: CN Priyanka, Externalities in groundwater use in drip and conventional irrigation farms in eastern dry zone of Karnataka, Unpublished M.Sc (Agri) theses Dept of Agri Economics, UAS Bangalore; 2009

Similar analysis in the Southern transition zone of Karnataka (Mamatha, 2009). The discriminant function was highly significant with the Mahalanobis D^2 of 1064.24, with a canonical correlation of 0.741, the square of which (0.55) indicates that 55 per cent of the variation in the method of irrigation is explained by the discriminant function. The major variable was net returns per acre inch of groundwater as this accounted for 99 per cent of the total distance between the groups (Table 22).

Table 22 : Factors discriminating Drip DIF] and Conventional irrigation farms [CIF]: Step wise Discriminant Function Analysis for Southern transition zone, Karnataka (2009)

Sl. No.	Discriminating variable	Discriminating co-efficient (L_i)	Group mean value		$L_i(d_1-d_2)$	D^2=1064.24 Percentage contribution
			DIF (d_1)	CIF (d_2)		
1	Net returns per acre inch of groundwater (measure of efficiency)	0.850	3800	2548	1064.20	99
2	Net returns per rupee of water	0.033	17.3	16	0.04	1

Source: P Mamatha, Externalities in groundwater use in drip and conventional irrigation farms in southern transition zone of Karnataka, Unpublished MSc (Agri) theses Dept of Agri Economics, UAS Bangalore; 2009

Thus, the net returns per acre inch of groundwater which is the highest in the case of drip irrigation compared to conventional irrigation plays the key role in the adoption of drip irrigation. An analysis of the marginal productivity of groundwater further illustrates the importance of the method of irrigation in shaping the marginal productivity.

Water use efficiency impacted by method of irrigation

For the Eastern dry zone, the net returns per farm were regressed on water used per farm for irrigation and intercept and slope dummy variables [0 for conventional and 1 for drip (intercept dummy D1 and slope dummy D1X]. The results indicated that

$Y = 15292 + 465X + 9911D_1 + 1960D_1X$ was the function obtained
t values (1.41) (2.45) (0.72) (6.17); Adj $R^2 = 0.56$, $R^2 = 0.76^{**}$, F = 36, n=81

For DIF the threshold net return is Rs. 15292 per farm equivalent to return from inputs other than irrigation water. The marginal productivity of groundwater is Rs. 465 per acre inch at any level of use. Due to drip irrigation, the threshold net return per farm gets shifted by Rs. 9911. Hence the threshold net return per farm due to drip irrigation = Rs. 15292 + Rs. 9911 = Rs. 25203. The marginal productivity of the drip method of irrigation = Rs. 1960. The marginal productivity of the groundwater applied through drip irrigation then = Rs. 465 + Rs. 1960 = Rs. 2425. The estimated net return per DIF farm at the average level of use of groundwater = Rs. 15292 + 465 (60) + 9911 (1) + 1960(1) (60) = Rs. 170703*. The estimated net return per farm in CIF is Rs. 15292 + 465 (94) = Rs. 59002. Thus Y = 25203 + 2425 X is discerned for DIF and Y = 15292 + 465X is for CIF.* Using similar procedure the following results were obtained for arecanut farmers in southern transition zone.

Y = 47762 + 546X + 12524D1 + 1314D1X
t value (2.49) (4.12) (0.39) (2.31), Adj R2 = 0.26, R2 = 0.29**, F = 10, n= 90

The threshold net return is Rs. 47,762 per farm, the return to inputs other than irrigation water. The marginal productivity of groundwater is Rs. 546 per acre inch at any level of use. The marginal productivity of the drip method of irrigation is

Rs. 1314. The marginal productivity of groundwater applied through drip irrigation = Rs. 546 + Rs. 1314 = Rs. 1860. The threshold net return per farm gets shifted by Rs. 12,524 due to drip irrigation. The estimated net return for DIF is 47762 + 546 (63) + 12524(1) + 1314 (1)(63) = Rs. 177466. The estimated net return for CIF is Rs. 47762 + 546 (171) = Rs. 141128. Thus Y = 47762 + 546 X is discerned for CIF and Y = 60286 + 1860 X is discerned for DIF.

In order to model the investment on coping mechanism, investment on drip system was Tobit regressed on independent variables such as net return per farm (Rs.) and water used in acre inches per farm. Here, investment on drip irrigation will be the actual cost of drip irrigation for drip farms, while it becomes zero for farms with conventional irrigation. The willingness to pay for drip irrigation is estimated using the Tobit maximum likelihood model where at least one value for dependent variable should be zero . The results (SAS output) (Table 23) for eastern dry zone of Karnataka indicated that the variables, net return per farm (Rs.) and water used in acre inches were significant at 5 and 1 per cent respectively. The log likelihood function was significant with a high value of -401. For every acre inch of water saved in drip irrigation, the willingness to invest on drip irrigation increases by Rs. 933. The minimum investment for drip irrigation is Rs.10262 per farm. The average drip investment per farm was Rs.41,115. For every one rupee increase in net returns per farm, the willingness to pay for drip irrigation increases by 0.23 rupee. The results amply demonstrate the scarcity value of groundwater has reflected in motivating farmer to invest Rs. 932 on drip irrigation for every one acre inch of groundwater saved in the process of adoption of drip irrigation.

Table 23: Modeling investment on Drip irrigation system in Karnataka

Variable	Coefficient	Standard Error	t-value	Coefficient	Standard Error	t-value
	Eastern dry zone, Karnataka			**Southern transition zone, Karnataka**		
Intercept	10262**	5.12	1967	3688	0.52	7000
Net return per farm (Rs.)	0.23*	0.10	2.22	0.22**	0.017	12.85
Water use (acre inches) per farm	-932.96**	247	-3.77	-354.2**	47.98	-7.38
Number of observations	68			90		
Log likelihood function (Tobit)	-401			-522		

Note: * and * * indicates significance level at 5 % and 1% respectively.

Source: 1. CN Priyanka, Externalities in groundwater use in drip and conventional irrigation farms in eastern dry zone of Karnataka,

2. P Mamatha, Externalities in groundwater use in drip and conventional irrigation farms in southern transition zone of Karnataka, Unpublished M.Sc (Agri) theses Dept of Agri Economics, UAS Bangalore; 2009

Thus for outreach, it is crucial to impress upon the farmers that net returns per acre inch of groundwater will be the higher in the drip irrigation method than conventional irrigation method. Thus the potential for expansion lies through usage of such crucial variables for diffusion of drip method of irrigation.

7. Irrigation subsidies at state level last 10 years

The total investment up-to the end of March 2000 on Irrigation in Karnataka state is Rs. 14,267 crores comprising Rs.13,399 crores on major & medium irrigation and Rs. 868 crores on minor irrigation. This entire investment is a subsidy towards surface water irrigation.

Karnataka state, has disbursed subsidies of Rs 260 crores for 164,000 hectares of horticulture crops since 1991-92. The total area under micro irrigation is 164000 ha forming 10 percent of the total area under horticulture. The Central scheme offers 50 per cent of the cost of micro-irrigation system or a fixed amount, whichever is less as subsidy. Thus, Centre's share is 80 per cent and the State meets 20 per cent. Karnataka is offering in addition, 25 per cent to the already existing 50 percent Central subsidy, thus totaling 75 per cent, in order to encourage micro irrigation to horticulture. Among the districts, 100 per cent subsidy is given to Bijapur and Kolar districts.

In Karnataka, the drip irrigation program is implemented by Department of Horticulture, while the Sprinkler irrigation is implemented by the Department of Agriculture. A study on the evaluation of micro irrigation in India (http://www.ncpahindia.com/articles/article18.pdf) indicates that in sprinkler irrigation for groundnut and cotton, the saving in water to the tune of 35 to 40 percent, while that in drip irrigation for horticulture crops (fruit crops?) the saving is 40 to 65 percent, and for vegetable crops 30 to 47 percent. The micro irrigation resulted in savings in labor in irrigation, weeding, harvesting and eliminated drudgery. The labor saving was higher for field crops than horticulture crops especially in weeding and in irrigation. There was reduction in the use of electrical power in pumping due to reduced hours of pumping. As liquid fertilizer was expensive, only 30 percent of the sample farmers adopted fertigation using soluble urea as the major fertilizer.

According to the report, there was an increase in productivity of crops upto 25 percent in Karnataka for Banana. In addition farmers received a price premium of 5-10 percent due to quality fruits. The program also resulted in social equity. The subsidy in Karnataka as mentioned earlier is 75 percent (50 percent from GOI and 25 percent from the State) and limited to Rs. One lakh per farm which includes construction of brick lined storage tank of 32 m X 29 m X 3 m with 25 lakh liters. Regarding implementation, Karnataka has decentralized by delegating powers to the Raitha Samparka Kendras (RSK) and by assigning separate staff for micro irrigation scheme. By maintaining the seniority list of farmers transparency is brought using standardized procedures and practices with time limits for sanction and implementation. Single window system is created at hobli level to redress farmers' grievances. The 4 percent VAT on drip irrigation equipment also gets subsidy and in addition there is exemption of stamp duty on documents used for availing loan for micro irrigation. The Government has also provided for notarized lease agreement instead of registered lease agreement for tenant farmers to encourage micro irrigation for share cropping. However the support from institutional finance for micro irrigation schemes in Karnataka is negligible due to lack of coordination.

There was delay in release of subsidy and this resulted in inordinate delay in release of subsidy from 6 months to one year as reported in the study. The subsidy fixed during 2006 has not been revised and only covered 42 percent of the unit cost of micro irrigation. In the implementation, there was lack of commitment on the part of the Departments of Minor irrigation, Department of Mines and Geology (Groundwater), Watershed development department, Agriculture Department, Panchayath raj institutions, Watershed development Department, as perhaps they did not consider water use efficiency is a crucial factor. In addition, the Extension support to micro irrigation was also meager. Therefore the equipment suppliers dominated in providing information. Excessive documentation of maintaining 18 documents for bank finance increased the transaction cost of farmers in general and illiterate farmers in particular (http://www.ncpahindia.com/articles/article18.pdf).

In the case of sprinkler irrigation, the financial assistance per farm would be a maximum of Rs. 7500 per ha. AS the sprinkler systems unlike drip system are moveable, one sprinkler set can cover more than one ha by shifting the set periodically. The assistance for sprinkler irrigation is limited to those crops for which drip irrigation is uneconomical. A farmer can avail assistance for sprinkler as well as drip irrigation depending upon the crop and the combined area from both should be below five ha per farm. Both sprinkler and drip irrigation subsidy will not be available for a crop on the same plot/field being cultivated by the farmer. In addition, assistance for sprinkler irrigation alone, is discouraged as it is far less efficient than drip system. The estimated cost of sprinkler system is Rs. 13690 for 63 mm diameter, Rs. 14270 for 75mm dia and Rs. 17280 for 90 mm diameter.

Any farm will eligible for assistance only if adequate water is available for the area proposed to be brought under Drip/Sprinkler irrigation. The installation of Drip/Sprinkler Irrigation system and the assistance should be limited to the area for which adequate water is available. This scheme does not fund for creating new water sources, the funds for which are available for other programs such as NHM, IWDS, SGSY, SGRY, IWDP, RSVY, which have adequate provision for creating water resources. And the water from wells funded by these agencies should be used in conjunction with drip/sprinkler irrigation.

8. Needed strategies to cope with the supply demand gap

8.1. Investment strategies (physical quantity and cost)

8.1.1. Surface water

The investment on irrigation (upto 2000) in Karnataka state is Rs.13,399 crores on major & medium irrigation and Rs. 868 crores on minor irrigation (using surface waters), totaling Rs. 14,267 crores. The irrigation potential created is 36,22,921 ha of which 4,53,054 ha are under 8 completed major and 32 completed medium irrigation projects; 12,88,717 ha under 19 major and 21 medium on going irrigation projects, bringing total potential area under major and medium projects to 17,41,171 ha; 9,39,566 ha under minor irrigation projects using surface water; 33021 ha under 13743 small irrigation tanks with less than 4 ha of command area and 908563 ha of irrigation from groundwater sources.

The state constituted Karnataka Neeravari Nigama Limited under the company act 1956 in order to expedite projects under Krishna basin by 2004-2005 by mobilising additional resources. Similarly KRISHNA BHAGYA JALA NIGAM LIMITED was constituted under the company act of 1956 to expedite the works of Upper Kishna Project and to complete them by mobilising additional resources.

The potential area for new investment in major irrigation is 18,80,000 ha with an investment of Rs. 1,25,000 per ha and rehabilitation cost of Rs. 75000 per ha. The potential area for new investment in minor irrigation is 967000 ha under tank irrigation requiring Rs. 78106 per ha (Table 24).

Table 24. Future investment in irrigation systems

Irrigation type	Average New investment (Rs/ha)	Average Rehabilitation investment (Rs/ha)	Average O &M (Rs/ha)	Potential area for new investment (ha)	Potential area for rehabilitation (ha)
Major irrigation	1,25,000	75,000	Rs. 510	18,80,000	3,00,000
Minor irrigation:					
Tanks	78,106	10,000	Rs. 510	967000	48350
Wells:					
a.Dug wells	50,000	None	2500	35000	None
b.Bore wells	1,00,000	None	5000	781340	None

Source: 1. Documents of Irrigation projects ; 2. The JSYS is rehabilitating 2000 irrigation tanks at the cost of 124.97 US $ million irrigating 72000 ha. This works to Rs. 78,106 per ha (at the exchange rate of Rs. 45 per US $); 3. Dug wells are not a common mode of investment on groundwater, but tube wells are.

It has been estimated that in order to complete the unfinished projects in Krishna in Schemes A and B, Rs. 16424 crores are necessary. In order to complete schemes in Cauvery basin, Rs. 2241 crores are required, and for that in Godavary Basin Rs. 256 crores are required. For other schemes a total of Rs. 769 crores are required. In all Rs. 33464 crores are required to complete the surface irrigation projects in Karnataka.

8.1.2. Groundwater

The potential area for new investment in groundwater irrigation is 35000 ha under dug wells with an investment of Rs. 50000 per ha and 781340 ha under borewells with a new investment of Rs. 1,00,000 per ha. The future investment potential in groundwater micro irrigation reflect the potential of horticulture in the State to offer both food and economic security to farmers (Table 25).

Table 25 : Future investment in micro irrigation

Sl. No	Micro irrigation	Current area (ha)	Potential area (ha)	Drip/ sprinkler Cost (Rs/ha)	Subsidy level (%)	Yield Increase (%)	Water saving (%)
Crops under Drip irrigation							
1	Coconut	65852	131704	58442	50 to 70	25	33
2	Arecanut	38717	77434	35000	50 to 70	30	38
3	Mango	6286	9504	25000	50 to 70	25	40
4	Grapes	3983	12106	44000	50 to 70	45	40
5	Sapota	1139	2619	35000	50 to 70	42	48
6	Mulberry	28767	47180	43400	50 to 70	36	42
7	Tomato	1542	7713	34000	50 to 70	10	56
8	Potato	480	1923	40500	50 to 70	15	30
9	Pomegranate	4367	10000	35000	50 to 70	30	40
Crops under Sprinkler irrigation							
1	Bajra	990	2476	25000	50 to 70	19	56
2	Cabbage	88	222	30000	50 to 70	3	40
3	Chillies	860	2150	35000	50 to 70	24	33
4	Cotton	1118	2796	40000	50 to 70	50	36
5	Cowpea	245	613	25000	50 to 70	3	19
6	Garlic	33	83	35000	50 to 70	6	28
7	Red Gram	583	1458	30000	50 to 70	57	69
8	Groundnut	4136	10341	25000	50 to 70	40	20
9	Jowar	2978	7445	25000	50 to 70	34	55
10	Maize	8940	22352	35000	50 to 70	36	41
11	Onion	1070	2676	35000	50 to 70	23	33
12	Potato	192	480	30000	50 to 70	4	46
13	Sunflower	4312	10781	25000	50 to 70	20	33
14	Wheat	2858	7145	25000	50 to 70	24	35

Source: 1. CN Priyanka, Externalities in groundwater use in drip and conventional irrigation farms in eastern dry zone of Karnataka,2. P Mamatha, Externalities in groundwater use in drip and conventional irrigation farms in southern transition zone of Karnataka, Unpublished MSc (Agri) theses Dept of Agri Economics, UAS Bangalore; 2009; 3. GL Thamana Devi, Economic impact of tank rehabilitation on groundwater recharge for sustainable groundwater use, Unpublished MSc(Agri) thesis, Dept of Agricultural Economics, UAS Bangalore 2008.

8.1.3. Recharge programs

The major groundwater recharge program is through Watershed development programs through the Watershed development department of Karnataka (Table 26). It has been estimated that around 18180 micro watersheds have to be treated covering an area of 24,05,187 ha at a cost of Rs. 8397 per ha.

Table 26: Watershed investment in Karnataka

Particulars	Number	Area / cost
No. of micro watersheds delineated	18180 (@ 500ha per micro watershed)	2405187 ha
No. of micro watershed treated/developed	5694	1702814 ha,
Total cost		Rs. 12992.8 million
Average Cost (Rs/ha)		Rs. 8397 per ha
Overall performance level (satisfactory/good/very good)	Satisfactory	Satisfactory
Key implementing agencies (such as Govt. depts.. NGOs etc.,	Eight, NWDPRA, RVP, DPADP, DDP, IWDP, WGDP, KWDP, NABARD, SUJALA	Watershed Development Department, Government of Karnataka, Bangalore
Major issues in watershed development	Three	Governance, accountability, transparency, property rights, e governance necessary for effective implementation

8.2. Management strategies (physical quantity and cost)

8.2.1. Crop management programs

The crop management programs include promotion of less water intensive, high value crops. Such crops largely are horticulture crops which use far less water, but yield high value.

8.2.2. Water management programs

In surface irrigated areas, the net returns from major irrigated crops such as paddy and sugarcane, even after considering the economic cost of water, should be positive in the command area. With this farmers have the capacity to pay for canal water up to Rs. 600 per acre of paddy, and up to Rs. 1200 per acre for sugarcane. The WUCS (Water users cooperative society) has to educate the farmers regarding the treatment of water as an economic good. In a study conducted in Cauvery basin (Rohith, 2008), the WTP for additional water rate for assured irrigation in summer indicated that the probability of willingness to pay is 0.87. Thus, farmers are not averse to pay additional amount for water if supplied in summer. Despite the odds facing any cooperative venture, about twenty percent of the WUCS had comfortable funding position with an average fund of around Rs. 3 lakhs per society. The remaining 80 percent of the societies are not comfortable with their total fund amounting around Rs. 20,000 per WUCS. Thus there is potential for the moderate and poorly performing WUCS to catch up with well performing WUCS. The farmers with conjunctive use irrespective of their location, head (Rs. 6896) or tail reach (Rs. 3306) received the highest net returns per acre in the command area. The conjunctive use fetches maximum net returns when compared to other situations, and we promote it to address the problem of drainage and water logging in head reach and to address the problem of inadequacy of water in the tail reach. Among the factors motivating a farmer to be a member of WUCS, the size of holding is the most important followed by the proportion of ground water irrigation to total irrigation (29%). Thus conjunctive use of ground water and surface water forms a crucial variable to motivate farmer as member of WUCS along with size of holding.

It is desirable for the project level committees to start functioning efficiently and the water management issues at the project level have to be deliberated in the larger interest of the members of WUCS. For efficient water management, the state's continuing support to WUCS at all levels of the irrigation systems is necessary. The users' institution should be the permanent institution, as a part of irrigation management and should not be treated as adhoc organization. The support of the local Non Government Organizations in social mobilization can be availed as it is a challenging task to mobilise farmers to adopt to new system of water management through WUCS.

Appropriate training programmes should be arranged to enable the members of the WUCS to understand and involve in preparing the action plan of the WUCS. The farmer member of WUCS should be trained in efficient water conservation, storage and use technique such as piped water supply, conjunctive use of surface and ground water with appropriate crops and varieties, and use of latest water use efficient technique like aerobic rice cultivation and SRI (System of Rice Intensification).

8.3. Other strategies (physical quantity and cost):

Groundwater resource is becoming increasingly scarcer over time and space in the dry agro climatic zones of Karnataka. This is apparent inter *alia* from the increased proportion of well failure, drastically reducing age and life of irrigation wells, a virtual shift from dug wells to bore wells for groundwater irrigation. Given the modest interest on the part of the farmers as well as the policy makers on augmenting the supply side of groundwater through watershed development and tank desiltation programs including the institutional innovations, farmers are resorting to bringing efficiency in water use through drip irrigation or by supply side approach by drilling additional well / or by reboring existing well/s. The economic message is that in situations of economic scarcity of groundwater, it would be wise on the part of the farmers to resort to water use efficiency rather than venturing on additional source/s of groundwater, which is/are not only risky to strike but also risky to sustain.

For outreach, the major variable identified by the studies is the net return per acre inch of groundwater used as this accounted for 99 per cent of the total Mahalanobis distance between farmers adopting drip irrigation and farmers using conventional method of irrigation. The farmers need to be educated regarding this crucial variable along with technical aspects of drip irrigation.

9. Reforming the State water policy

Comments on the Karnataka Groundwater Regulation and Control Bill of 2006

The proposed GWA (Ground Water Authority) has the opportunity to link the irrigation tanks of the State with augmenting the Groundwater resource, as a *quid pro quo* measure. To begin with, for the farmers who possess irrigation wells in the command area of irrigation tank, in the plains (with usual exceptions of specific areas like the Malnad / coastal / hilly regions as and when necessary) who are supplied with electricity from a specified Grid, can form an identified community of groundwater users (as an association / users group) to contribute towards maintenance of irrigation tank(s) by desilting the irrigation tank, and in addition maintain Recharge pits exclusively for their irrigation borewells.

In general, with regard to groundwater regulation, for the State, it becomes difficult and sensitive to impose fines / penalties on groundwater farmers, due to the large number of farmers and political economy. Hence, instead of imposing fines or penalty clauses, it is better to consider LINKING any developmental assistance from any of the line departments of Agriculture / Horticulture / Fishery / RDPR / Sericulture / Woman and child welfare …. to only those groundwater farmers who are complying with the provisions of the Act. This is a possible and feasible solution, and is CARROT policy, with no STICK policy. Because mere differentiation by *quid pro quo* of such of those groundwater using farmers who comply with the Act will only receive any sort of subsidy or assistance (other than the free electricity), is a good indicator for other groundwater using farmers who are not complying with the provisions of the Act, who hence will not receive any developmental assistance (other than free electricity), will in itself serve as STICK.

The experience of how Northern China is handling Groundwater regulation and Management in implementing is crucial for Karnataka and India. This needs to be explored by visit to the area by legal and technical experts of the state. The experience of the US and Israel are always usually quoted. Those experiences are directly not very relevant to Karnataka / India, since the number of groundwater users is so limited that it is very easy for the Government to handle the situation. But the sheer number of groundwater users in India is the LARGEST in the world. This adds to transaction costs, sensitivity of the issue and becomes the political economy issue. Situation hence needs to be handled only and only with

(i) carrot policies as described above
(ii) education of farmers and users of groundwater
(iii) support to adoption of water use efficient devices of sprinkler / drip irrigation
(iv) support to farmers cultivating perennial crops using groundwater such as desirable tree species among horticulture, forest, biofuel crops

If water logging conditions are there, the Act needs to encourage extraction especially in command areas. Hence the question of isolation distance / depth regulation needs to be examined for head reach, tail end regions separately under canal command areas. In the head reaches the Act needs to be liberal, since it should promote groundwater extraction. While in the tail reach the Act can be in its regular mode.

The Act excludes all Government / Public wells drilled / sunk for drinking water purpose.

No part of this Act should collide with that Act which protects drinking water in Karnataka. Hence it is necessary to relook at both the Acts for corroboration than collision. It is also necessary to examine this Bill with Karnataka Land Reforms Act. Especially because a stage has already come in some parts of the State for the Government to even ration groundwater for agriculture / drinking / domestic / industrial purposes. Since it is virtually impossible to monitor the volume of groundwater extraction by user/uses, especially in agriculture, but it is not so difficult to regulate on the number of irrigation well/s user is possessing, since this data should be available from the ESCOMS, if it is necessary to put a cap on the number of 'functioning' wells a user can possess, this is an implementable measure. But then the question, is if a farmer can register for additional well/s in the name of his sons/ daughters / wife or other relatives.

Therefore it is necessary to study the Karnataka Land Reforms Act and the provisions of ESCOMS as to who is the owner of the well. Should the farmer have TITLE TO LAND to have the irrigation well? And if so, since all the land records are computerized (?) and since ESCOMS also have the names of the farmer/s or users who are provided energization for their groundwater well/s, it becomes relatively easy for the Groundwater bill to consider putting a cap on the number of functioning well/s a farmer/user can possess. This number can vary across regions.

Thus since it becomes extremely difficult for the ACT to deny farmers/ users violating the isolation distance (which itself is questionable by law and by technical parlance), it is relatively easier to allow farmers/ users to possess the right to at most ONE or TWO wells (or this number can be decided at agroclimatic / watershed level / command area level). By this provision, the ACT can not only allow the Easement right for every user to at least have the right to groundwater, but also can regulate groundwater extraction (not by volume but) by rationing the resource among different users. One has to appreciate, it is not sharing prosperity, but sharing poverty of groundwater resource among rich / poor / and all users. Hence as every user expresses his/her right to possess groundwater in agriculture, s/he should be convinced to share the resource by imposing atmost s/he can have one or two wells (or the decided number by the act) and cannot posses say 5 or 10 wells just because s/he is a large farmer or claims to have adequate groundwater supplies in his/her land.

The specific roles of institutions such as Karnataka Disaster Management Cell, SAUs, Department of Mines and Geology, CGWB, ESCOMS in regulation has to be carved.

The Diasaster Management Cell should be provided by assistance to equip with groundwater data in drought prone areas.

The SAUs should get assistance (for using data after installation of groundwater meter and electrical meter and) for analyzing data regarding groundwater extraction for different crops and seasons for different farming systems in different research stations which represent different agroclimatic regions of the state, regarding the extent of groundwater extraction as well as electricity.

This data should be periodically provided to the Groundwater Authority for appraising regarding the

1. groundwater extraction and potential in different agroclimatic zones for different farming systems
2. extent /probability of well failure in different agroclimatic zones
3. data on how much water needs to be extracted / or how many irrigation wells are needed for deriving a basic agriculture income which can keep the groundwater farmer / user to achieve a threshold level of living in different agroclimatic zones
4. What should be role of DMC, DMG, and the proposed water resources and regulation authority?
5. Recharge methods those need to be devised for different agroclimatic regions, hydrogeological formations by SAU research efforts which are economically worthwhile
6. interference among irrigation wells of different interwell distances, interwell depths using tracers / isotopes / other modern techniques and how the effects of interference among wells can be addressed at farmer's / user's level and at macro level
7. the performance indicators of GW Authority
8. whether GIS enabled dynamic website be developed, to enable farmers / users to approach the authority for permits / notifications / and other services as prescribed by the Act as also to appeal to reduce delays and improve efficiency in working of the Authority
9. Irrigation tanks which are relatively more in southern Karnataka than the Northern parts. Hence for northern Karnataka, water streams which are disappearing need to be rejuvenated with appropriate technologies

The bill needs to deal with groundwater sales / groundwater market since this influences groundwater extraction of neighboring users/uses and may contravene with provisions of the Bill. While selling groundwater for agriculture purpose can be permitted in the Act. Selling groundwater by extracting groundwater in urban areas should be banned, since (i) there are no recharge areas in urban areas to bear with huge extractions and (ii) such extractions are resulting in large scale failures of domestic water wells in urban areas, which increases the pressure on urban water supplies which are currently unable to meet. Instead the bill can provide for extraction of groundwater from rural areas for sale in urban areas, which not only reduces the pressure on the recharge poor urban areas, but also results in transfer of income from urban to rural areas.

The bill puts the onus on the farmer regarding the permit for well drilling. It should instead by a joint responsibility of the farmer, the driller and the technical department (of Mines and Geology). The permit should have the request from the farmer and the authorized driller so that the farmer / user also will have a say in driller's quality works and the Act will facilitate responsible work from the driller in accordance with the technical feasibility from the DMG. In the draft, the bill has no role for the Department of Mines and Geology in helping the farmer to locate the irrigation well extraction point. The Department of Mines and Geology needs to list the cadre of recognized geologists (working / retired / public / private) who can help the farmer / user in locating the irrigation well to be drilled / constructed in accordance with the provisions of the Act.

Among the different line departments, the DMG stands out, with its history of having conducted research in groundwater extraction since its inception due to the untiring efforts of Dr BP Radhakrishna the doyen of Groundwater resource in Karnataka. The DMG has brought out several research reports in the field of groundwater in different regions of Karnataka, which deserve adequate attention of the Groundwater Authority. Similarly the research reports of the CGWB, southern region.

The Pollution control Board has a role in maintaining groundwater quality from point source of pollution. The farmer who drills well / already has a well should be assured to draw pollution free water in the Act and the Act should provide the farmer to sue the point source polluting firm/s to stop polluting his well. Since farmers use their water from irrigation well not only for irrigation, but also for domestic use including drinking purposes, assuring groundwater quality is the crucial aspect of the bill. It is not possible to exclude such of those farmers who are using irrigation well water for drinking purposes, or such of those users of domestic wells who are using their water for non domestic purposes such as washing cars, or irrigating lawns, or for industrial users to use their water for lawns etc. Thus water quality is a crucial parameter which cannot miss the Groundwater bill.

The farmer/user also has conservation / recharge obligations on the farm. Here too only carrot policies should be considered rather than stick. That is, only those farmers who are following the conservation / recharge requirements of the Act should be provided with subsidies / incentives of the Government line departments instead of blank provision for all users. There should be no penalties imposed on non users at least till the Act gains initial experience. Goal of authority is to ensure sustainable and equitable use

Isolation distance / depth cannot be enforced, since there can be no blanket isolation distance / depth in hard rock areas where groundwater access varies inch to inch. In addition the research information on these aspects is not convincing. It is difficult to be as accurate as 182 meters as isolation distance between two wells. Rational definition at the scale of a State is difficult. Instead cap on the number of irrigation wells is a reasonably easier measure or regulating, which not only provides every farmer/user the right to possess at least one functioning irrigation well, but also will not provide farmers / users with exploitative / extractive access to groundwater, and since the records are with ESCOMS, it is easy to identifier the land owner and the well owner, which should go together. The title to land and title to well should be the same and will be easier to handle by the GWA.

It is better to remove the word Control, from the Bill. Regulation is acceptable not Control. As Karnataka, is the second arid region after Rajasthan, obviously GW resource will have pressure. When land holdings are getting fragmented and subdivided, it is difficult to control extraction of groundwater. In addition the question of equity both intra and intergenerational equity are crucial. The Act should also be consistent with economic reforms.

The existing well owners should also be registered because, some of them may have failed irrigation wells but their electrical connections may be live. However the ESCOMS would merely multiply the electricity provided with the number of IP sets connected, irrespective of whether the irrigation well is functional or not.

One time registration of Rigs with RTO is adequate. It is better if the RTOs are involved in cancellation of license to the driller since the drilling equipment is housed in the vehicle, which is under the control of RTO

Regarding application for groundwater permit, the farmer/user should be provided as to where s/he can apply for permit. The existing institutions at village level be used for the purpose instead of creating new institutions. An appellate authority within this act be created to enable the farmer/user to appeal in case of conflicts of interest.

In Karnataka, ESCOMS are planning to install separate 11 KV agriculture feeder as well as 11 KV non agriculture feeder parallelly. This will enable to identify any new groundwater user / unauthorized user relatively easily.

The Karnataka state can also learn from experiences of Tamil Nadu in energization of IP sets. In Tamil Nadu, now it takes at least 5 years for energization of new IP sets due to stringent rules of ESCOMS.

Water conservation through both rain water harvest as well as roof water harvest should be promoted through the Act. In urban areas those who are following roof water harvest can receive incentives in their electricity or water or land rental bill, compared to those who do not comply with the Act.

There is a need for integrated water management both in urban and rural areas and avoid fragmentation of institutions with fractional approach. Farmers who are using defunct dug wells as recharge structures, using drip / sprinkler irrigation need to be treated with carrot.

Whether the inflow to irrigation tanks / dams are affected due to watershed programs is a difficult question to answer as there is no research base for this. With vast tracts of rainfed lands, watershed development program being the only developmental program, unless adequate research proof is available, it is difficult to draw conclusions. However during periods of drought, using irrigation tank water as percolation tank water is to be encouraged as it was attempted during the 2001-04 drought period, which helped many irrigation wells to be recharged as recommended by the State level weather watch committee.

Is the Act comprehensive ?

Gives an impression that Act is applicable only in Notified Areas of the State, not the whole of Karnataka, though the Act apparently mentions "whole of Karnataka"

IWRM – is crucial

Thus, all wells whether for drinking / domestic / industrial / commercial / agriculture use, should be under the purview of GW authority (without exceptions, since this Act is on Groundwater, not on well/s.

- User of groundwater (definition)
- All wells are considered (exemptions are excluded here)
- Well title has to be clearly defined (how is this connected to Title to land?)
- 'Well' definition does not include the volume of water drawn (for instance, a well may not yield water – due to premature / initial failure),
- Provision for dealing with well failures in the Bill? i.e. if a farmer has obtained a permit and if the well fails initially, should s/he again apply for permit or provision is made for such contingencies?
- No mention of isolation / depth specifications
- The Bill has no specifications regarding Isolation distance and /or isolation depth/s linked with technology of water use (like drip or sprinkler).
- Notification of areas
- The Bill / Act seems to apply only for Notified Areas of Karnataka
- Should it not apply to all areas of the State
- The grant of permit to extract / use GW is restricted only to notified area. This should be for all areas of the State, not just notified area, since GW authority has responsibility for GW for the entire State.
- Bill does not deal with GW extraction in urban areas by tanker water sellers
- Water markets are legal / illegal is not dealt by the Bill
- There are umpteen number of water sellers through tankers in urban areas
- Many of these tankers extract groundwater within the city limits (where there is absolutely no recharge)
- They are also responsible for failure of many domestic wells in urban areas
- The 'tanker' water price in real terms has reduced over time – competitive over extraction
- Disclaimer statement and insurance
- Due to risky nature of investment on GW in HRAs, no Authority can guarantee the yield from any well sunk or drilled for any duration
- Hence can farmers be encouraged to (compulsorily) insure well drilling / extraction similar to vehicle insurance with Insurance companies
- Every year vehicle insurance has to be renewed and similarly well insurance
- Incentive clauses

- Instead of penalty clause, there can be incentive clauses – like those who grow light duty crops / adopt sprinkler / drip irrigation, can get subsidies / incentives in all Governmental programs compared to those who continue to grow heavy duty crops
- It becomes difficult to monitor farmers who continue to grow heavy duty crops (Sugarcane in Belgaum district, Paddy in Madhugiri, for instance)

- Description of well and location
- The well description needs to include, type, depth, diameter, distance with nearest well, nearest functioning and failed well,
- Can include GPS (latitude, longitude), precise definition of location, in addition to survey number and owner of the well
- No clause to deal with transfer of well water: How far the farmer/s can transfer water? This is just shifting the zone of exploitation
- No clause to deal with sale of well water: is it legal to sell water? Currently it is not legal.
- Accountability of the Authority
- No provision to make the authority accountable for its decisions (right or wrong)
- For example there is no reason why the Authority cannot go wrong in issuing permits for drilling well
- There is no limit on the number of permits in a year for a farmer / region / village ?
- If farmer does not shift from paddy / sugarcane, the penalty clause (fine upto Rs. 5000 plus imprisonment for 6 months) applies, but who / how is monitored?
- Instead create incentive structures: like subsidies / programs of the Govt for farmers tagged to farmers who grow light duty crops. But this needs a computerized list of farmers who posses wells and the list supplied to all developmental departments
- Defunct well / registration / reasonable clause
- What is a defunct well is to be defined
- Is this in terms of water yield or area irrigated or both?
- Registration of agencies / individuals who construct dug wells (is not covered)
- What is 'reasonable' clause has to be explained
- What are the likely situations which warrant limiting the use of water / extraction of water
- What is 'inferior quality' work by driller – needs to be specified
- (any loose end, non specific institution, may lead to rent seeking and lack of transparency)
- How does authority regulate fraudulence?
- What about farmers who use sources of power other than electricity (solar / diesel ….)
- Currently at all India level only 36 percent of IP sets use electricity, rest use diesel (NSSO 2005)
- Information on technical details of well drilled should also be sought from the driller

- Driller to be made more accountable
- Installation of water meters be made compulsory
- Can illegal GW well be treated on par with illegal urban construction (Act appears to treat that way)
- Instead add incentives for good practices (automatically good farmers get differentiated)
- Link developmental program assistance to only those who follow GAP as in GW bill
- For implementation of the Bill, it is proposed at to address to community of farmers (regarding water harvesting).
- If farmers in different locations can obtain electricity through separate grids (as in Gujarath for instance) then a convenient number of farmers belonging to one grid can form an association.
- If a farmer member does not comply then the electricity supply can be regulated at the Grid level.
- Thus peer pressure can work. And can be used for all developmental (water harvesting, compliance) purposes.
- Water harvesting be made mandatory for all well users (farmers, domestic users, industrial, commercial, government.. Universities..)
- In rural areas / urban areas, water harvesting / recharge structures be made mandatory, and for nil compliance, be delinked from development incentives
- In urban areas roof top harvesting be made compulsory and should not be limited to size of 100 sq meters and above
- Separate rule for bigger apartments of size > ___ meters be drawn (Apartments can cumulatively affect individual groundwater wells of domestic users)
- Technical specifications of water harvesting is also crucial
- Contravention: For example in Land Reforms, there is a subtle contravention. Those who earn more than Rs. 2 lakhs of income from non agricultural sources, can neither own nor bequeath land
- The driller license needs to be linked with RTO

- The driller is mobile and has to have two permits – the vehicle permit and the drilling permit. It is better to merge with one for accountability. For instance, the vehicle may be fit, but if driller failed to comply with the Act, his driving license be cancelled
- Companies escape by outsourcing drilling works. Thus both thc drilling companies and driller should be made accountable.
- Though the onus of permission should be both with farmer / driller, since the number of drillers is few, driller can be made more accountable and this reduces transaction cost of implementing the law
- The Bill empowers to restrict pumping of GW from high yield wells (above 5000 gph) by installing a pumpset not above 5 HP capacity
- Majority of *IP sets in Karnataka are above 5 HP capacity, and their well yield is below 5000 gallons*

- Northern China is facing gw problem as we are facing. How GW regulation and management Act has been successful in china (Need to be explored)
- Concept of My land, my water: It may be my land, but not my water. GW cannot be private property, it is a national property. We may be pumping others' water. When land is transferred, GW is also transferred, is acc to Easement. But this is not true in reality.
- Remove the word 'reasonable'' in the Bill
- If water logging conditions are there, encourage extraction from such areas
- Distance between two irrigation wells in command area is not mentioned
- Unit of measurement
- GWA will advise the govt to notify the area, also to denotify the area
- Apply this act to all areas, not just notified areas

- Total appropriation of the rights
- GW right may be well defined as state ownership
- Regulation of GW market, how much water you have right to utilize
- Can we restrict on number of functioning wells a farmer or user can have?
- Myth of GW: scientific basis of data, weak basis
- Rural-urban requirement: equity is not maintained, also focusing rural water user as most irrational
- Any one wants new borewell / open well, GWA should consider what are the other sources of irrigation, how many wells he already has, what is implementing machinery at local level.
- Crop diversity is crucial. Would regulation of gw affect crop diversity?
- How can we enforce isolation distance, any downscaling
- There is no map on GW in Karnataka regarding level or distance between wells,
- Looking into isolation distance without looking into geology is not correct
- Bill mentions accurate 182 meters between wells Is this feasible to use across districts. It needs to be for each region, distances need to rationally defined
- Goal of authority is to ensure sustainable and equitable use

- Bill is not properly drafted. This original bill was drafted in 1987, when there was no economic reform, Better to keep regulation, rather than control
- Karnataka is the second arid region after Rajasthan, obviously GW resource will have pressure. When land holdings are getting fragmented, how can we prevent from drilling?
- Question of equity.
- Why do we want existing well owners to register? Farmers with failed wells, why should they register (because they still have valid electrical connections)

- Cultural aspects of water use is missing in the bill
- Water use and religion is not dealt

- Rigs are registered with transport authority, why want them to register again?
- Urban rural equity wrt groundwater use

- Every 10th house has a borewell in Bangalore.
- People with borewell sell water in urban areas.
- Free power will subsidize desertification. GW has to be recharged.
- This bill is biased against rural people. Urban groundwater level, how do we bring under purview of GW management authority.

- Whom should the application be made in the village for permit etc? Farmer should not be troubled

- GW may be considered by the KWDT award
- Previous Krishna water dispute award did not consider GW into consideration.
- This time tribunal has been positive and is considering GW.
- AP and Mh had 1.5 times groundwater than Karnataka on a relative basis.
- IWMI has brought out a very good study.

- Farmers tapping fastest and the mostest, as Ciriacy Wantrup states in his famous book 1968.
- Automatic switches to compensate for irregular power supply, pumping at night and repumping at day
- Promote low water intensive crops (but market forces will they promote these?) can institutions be stronger than markets?
- Pumps are working at 45 percent efficiency
- Improvement in pump efficiency leads to energy saving
- Installation of electric meters a move by GOK is a welcome measure

- Now in Karnataka, separate 11 kv agri feeder will be introduced
- This helps to know how much load is on the system.
- If new pumps are unathorizedly being used, they can know immediately from the service station.
- They will also have 11 kV non agri feeder parallelly, hopefully there will be some way of preventing unauthorized use of power.
- Whether u make power free or not, KPTCL has not been able to recover any dues.

- Nitrate contamination, single largest threat to groundwater quality. How the bill tackles this
- Have we understood hydrogeology properly of ours. How to isolate agriculture use and domestic use.
- Roof top rainwater harvesting - a good program of GOK augments GW and also gives quality, quantity water

- Integrated water management both in urban and rural areas. We have fractional institutions, no single authority for water resources.
- Do we need to create another institution.
- Linking rainwater harvesting with new borewell. Why specify 100 sq meters. Say per sq meter 50 liters should be recharged

- WS management never highlighted GW for domestic consumption.
- Even JSYS did not deal with it.
- Can we think of defunct borewells, open wells as recharge structures
- Do our watershed management practices interfere with water harvesting and affecting dam inflows?

- Sectoral approach is crucial
- Is there any conflict among institutions / laws
- Bring harmony, avoid conflicts of jurisdiction of laws
- Need for Authority to become self funding body
- Allign its functions with its objectives – spacing is not mentioned in the body of the text
- Composition unwieldy, bureaucratized, local authorities not included, research institutions etc
- Can make subcommittees to guide the body (making the authority slim one)
- Mechanism of enforcement of orders
- Powers and functions – vagueness of activities
- Objectives : conservation, recharge, sustainable use
- Users should include state, local authorities, who also consume water, have role in recharge
- Urban – rural use, terminologies of scarcity
- Water cess act, royalty payable by the user to the state
- Land ownership-water ownership, easier said than done
- Appellate authority
- Participatory governance
- Community as part, notion of stewardship, make water business of all, else falls short of constitutional expectations
- Large number of stake holders are left out
- Stake gainers, stake losers

10. Implementation mechanisms (who and what to be done)

The problems in the state water sector as outlined in the State Water Policy are outlined for possible solutions:

a. Lengthy and time consuming procedures for sanction and approval of major irrigation projects by the Central Water Commission, Government of India
b. Lack of institutions to consider sectoral water demands similar to IWRM. Water responsibilities are fragmented among departments and there is no co-ordination
c. WUAs are not properly geared up to appreciate the economic scarcity of water and hence farmers need to be made aware of water payments similar to PES
d. Public investment on water is low and is thinly spread over a number of ongoing and new projects. Due to inflation and time overrun, expenditures

have increased without commensuration with the benefits. Hence pace of realizing irrigation potential is sluggish

e. Demand for new irrigation infrastructure has reduced fund allocation for O and M, rehabilitation and modernization of existing irrigation works, reclamation of water logged and problematic soils
f. Due to delays in construction of field channels, land leveling and poor farmer participation in the PIM, there is widening gap between potential and actual area irrigated
g. The storage capacities of 40,000 minor irrigation tanks is reduced due to siltation and poor upkeep
h. Due to rapid urbanization, migration and economic growth demand for water for domestic, drinking , municipal and industrial purposes in both urban and rural areas will raise and cannot be met totally from groundwater. Due to increasing fluoride, iron and salt levels, in 4500 villages groundwater has been unfit for drinking. The water use efficiency literacy has to be increased as also the perennial sources need to be explored along with improving efficiency of consumptive use
i. Due to industrial pollution and poor monitoring by the pollution control boards surface water and groundwater quality is severely affected. Proper institutions and PES need to be set up to address the predicament.
j. There is inequity in supply and distribution of water resources in all sectors leading to inefficiencies and externalities in utilization. Farmers in tail reach have always been the sufferers due to excessive use in addition to unauthorized use elsewhere. Phase-wise E governance is crucial in bringing efficiency and equity in water distribution and use
k. Productivity of irrigation is below potential. Sub-optimal distribution of water and lack of integration of irrigation services with agriculture services have resulted in low yields, low cropping intensities and has prevented diversification of agriculture. Land development and agricultural extension have not kept pace with the creation of irrigation potential.
l. Lack of transparency in sanction and approval of projects by the authorities
m. Lack of public investment (Scarcity of capital) with the State to implement existing irrigation projects / schemes
n. Problems / delays / litigations in land acquisition in the process of civil works
o. Delays in the construction of field irrigation channels, leveling of land and lack of farmer participation in the irrigation management
p. Sluggish progress in interstate river water disputes
q. Lack of irrigation extension covering surface water and groundwater by both State and Central governments
r. Lack of professional linkage with departments of agriculture / horticulture by the Department of Irrigation /Department of Water resources resulting in lack of coordination and appreciation for problem solving
s. Lack of awareness programs for farmers educating the absolute and relative scarcity of water for irrigation and the need to use it efficiently
t. Due to increase in wages and salaries, operation and maintenance and interest payments O and M charges increase over the years. However the

revenue receipts from irrigation are meager and cover a modest part of O and M.

u. Regarding electricity provision to pump groundwater, the estimated subsidy is around 50 percent in the cost of groundwater. The electricity tariff for pumping groundwater (during 2005) are as under: I. Till electric meters are fixed - For I.P. Sets Up to and inclusive of 10 HP, the farmers are to pay Rs. 20 per HP per month and 40 paise per unit (1 unit = 1Kilo watt hour); II. where electric meters are already fixed, farmers are to pay Rs 10 per HP per month and 40 paise per unit; III. for Coconut and Areca nut plantations, Lift Irrigation Schemes / Community Irrigation Schemes of all capacities. the tariff is Rs. 20 per HP per month and one rupee (or 100 paise) per unit; IV. for I.P. Sets above 10 HP, and for Private Horticultural Nurseries and Coffee and Tea plantations irrespective of sanctioned load. the tariff is Rs 30 per HP per month, and one rupee per unit. The Government has plans to install electric meters on all IP sets in future. An estimated 40 percent of the electrical power goes to IP sets in Karnataka. Thus electricity is almost provided free of cost to farmers in Karnataka. However farmers bear the brunt of negative externality due to interference of irrigation wells leading to initial and premature well failure

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