Water Resources

We never know the worth of water till the well is dry
-Thomas Fuller

Water Resources

CURRENT STATUS

Water resources constitute mainly surface and groundwater, with rainfall being the basic source.The environmental concerns pertaining to water resources centre around water resource management, specifically relate to both quantity and quality issues. The main issues of concern are conservation of existing water resources and prevention of further degradation and depletion. The associated issues include rejuvenation of degraded traditional surface water bodies, enhancing the availability of water through water harvesting measures, and recharge of ground water resources. More important is the judicious and economic use of both ground and surface water for agricultural, industrial and domestic purposes. Karnataka is subjected to repetitive droughts. The National Irrigation Commission has identified 12 districts and 88 taluks in the state as chronically drought affected.

The mean annual rainfall in the state is 1355 millimeters with more than 73 per cent of it being received from the South-West monsoon. In the period between 1970-2003, deficit rainfall was recorded on 22 occasions and the highest deficit of 55 percent was observed in 1983. Annual rainfall variations across agro-climatic zones in the state are too wide, ranging from 585 millimeters in the northern dry zone to 3893 millimeters in the coastal zone. More than 75 percent of the land in majority of the districts in the state is rainfed.

Harvesting the skies

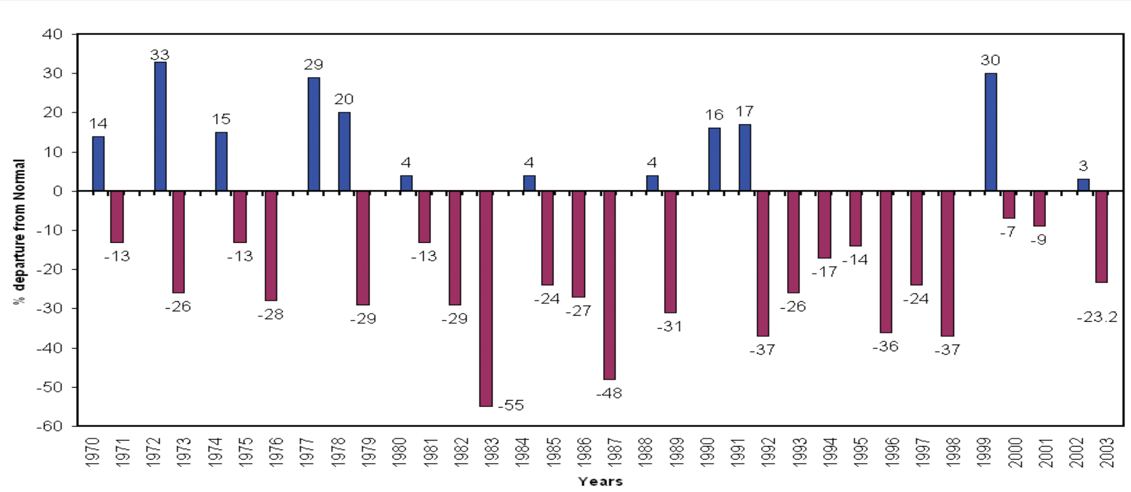
Due to three consecutive years of deficit rainfall the Karnataka governement decided to implement cloud seeding. The experiment christened Project Varuna was taken up in 15 districts. Following encouraging results, operations were intensified from 14 September 2003 onwards.

Cloud seeding (also known as weather modification) is the deliberate treatment of certain clouds or cloud systems with the intent of affecting the precipitation process(es) within those clouds. Cloud seeding needs rain-bearing clouds which must be deep enough and in a suitable temperature range. For cloud systems which are warm, hygroscopic or water attracting material such as sodium chloride, urea, ammonium nitrate, are sprayed on. Where the precipitation is cold, glaciogenic or ice-forming agents such as silver iodide, compressed liquid propane and dry ice are used.

Of the total cropped area of 10.80 million hectares, only 21.50 percent is irrigated while the balance 78.5percent of agriculture is under rainfed conditions. Two-third of the total geographical area falling in the semi arid zone receives less than 750 millimeters of annual rainfall with frequent drought conditions.

The National Commission for Integrated Water Resources Development Plan 1999 has made the following remark *"Water conservation in every sphere and increase in efficiency of water use in every activity should be the*

Percentage departure from normal rainfall in Karnataka



Source: Drought monitoring cell, GoK

overriding consideration in water resource development and management. The methods and means of water resource management should be sustainable over time both from the point of development needs and preservation of environment". Projects are being planned and executed to achieve the objective of optimal utilisation of available water resources.

Due to the efforts of the State Government in executing a number of major, medium and minor irrigation projects some of the taluks got relief from drought.

Availability : Surface water

There are seven river systems in the state namely, Krishna, Cauvery, Godavari, West Flowing Rivers, North Pennar, South Pennar and Palar. The annual average yield in the seven river basins is estimated to be 3438 TMC. The yield in six basins excluding west flowing rivers is estimated to be 1440 TMC . However, the economically utilizable water for irrigation is estimated as 1695 TMC. Most of the water from west flowing rivers cannot be used for irrigation due to topographical and environmental constraints.

There are 36,679 tanks in the state having a command of 6,84,518 hectares. The total irrigation potential of the minor irrigation surface tanks is estimated as 10 lakh hectares. There are about 448 lift irrigation projects in the state irrigating an area of 0.97 lakh hectares.

Other sources under minor irrigation include anicuts, pick ups and minor irrigation works having 1.24 lakh hectares of irrigation potential.

Groundwater

Availability of ground water is estimated as 485 TMC. Exploitation of ground water in the dry taluks of North and South interior Karnataka are higher when compared to Coastal, Malnad and irrigation command areas. Groundwater development is not uniform in different parts of the state The stage of groundwater development varies from district to district.

Initiatives of the government

- The Department of Water Resources has put in place necessary legal provisions to enable the formation of Water Users Societies or Cooperatives (WUCs) These societies are empowered to procure water from irrigation department, prepare water budget, levy and collect water charges and manage the water distribution system.
- Geo-metric centre has been setup in the Water Resources Development Organisation making the Water Resources Department self reliant in implementing GIS and Remote Sensing
- The Karnataka Irrigation (Levy of Water Rates) Act, 1957, has been ammended enhancing water rates for different crops, domestic and non-domestic uses of water. This would boost mobilisation of financial resources and also prevent excess use of water
- The Jala Samvardhane Yojana Sangha (JSYS), has been set up to facilitate planning and implementing the task of rejuvenation of tanks with community participation.
- The Raitha Kayaka Kere programme of the Minor Irrigation department focuses on improving rural livlihood by developing and strengthening community-based approach for improving and managing selected tank systems.
- The Lake Development Authority has been set up in 2002 for restoration of tanks in urban areas.

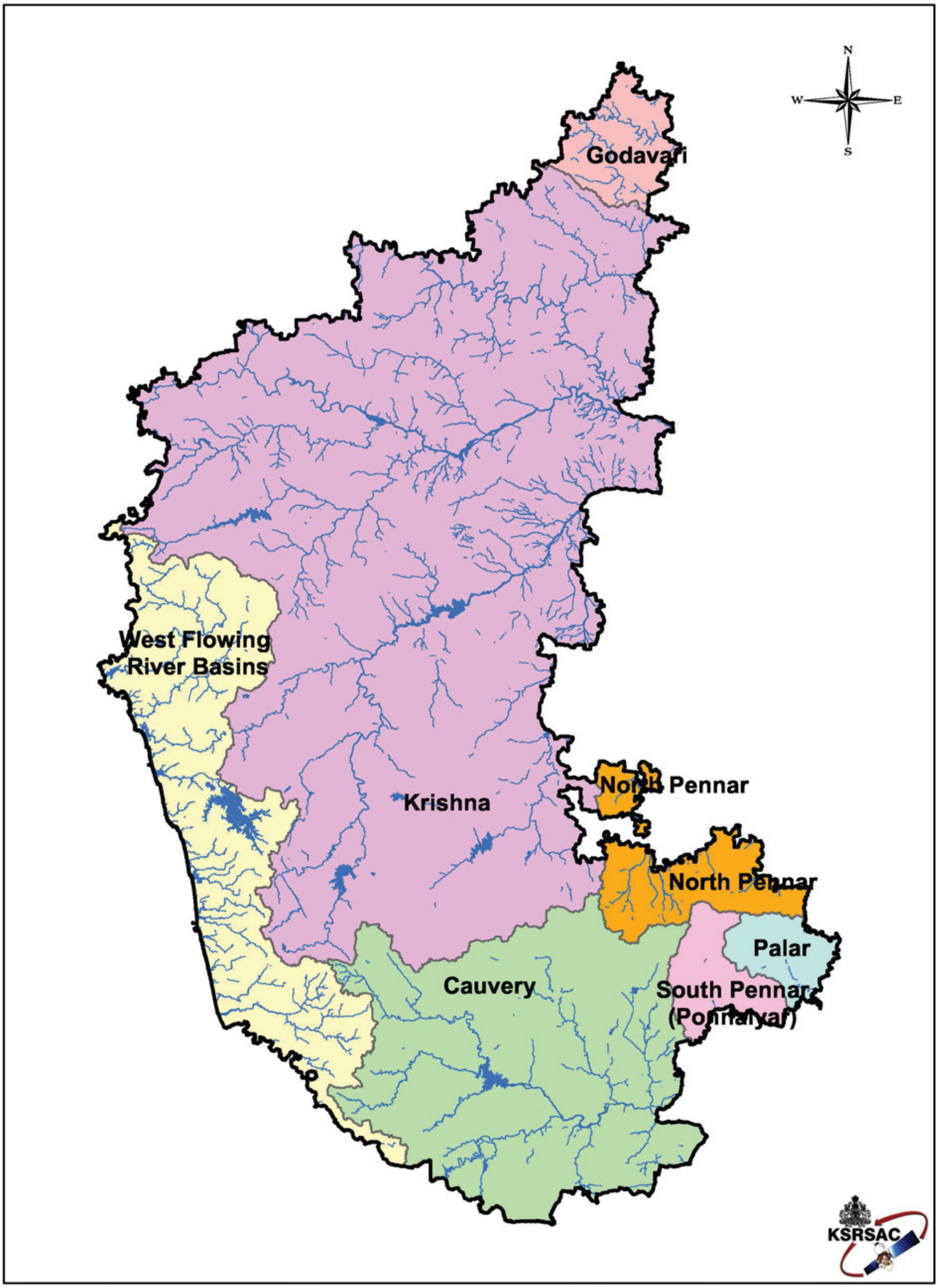
Utilisation: Surface water

Moving on to the utilisation of available surface water resources, of the ultimate irrigation potential of 55 lakh hectares, the state has been able to create a potential of 35.35 lakh hectares (65 percent) from both surface and ground water. About 35 percent of the potential remains to be tapped.

Nearly 4.53 lakh hectares in the state has been irrigated by 8 major and 32 medium completed projects. The ultimate irrigation potential of 19 major and 21 medium ongoing projects will be 15.17 lakh hectares. Upto the end of March 2003, a total irrigation potential of 19.70 hectares has been created under major and minor irrigation projects (Water Resources Department, 2003).

Most of the major irrigation projects are multipurpose in nature envisaging irrigation, hydropower, flood control and water supply components. Medium irrigation projects are mainly single purpose projects. Major/medium irrigation projects have been a great boon to the state and have proved to be the sheet anchor for ensuring that the

River basins of Karnataka



sustainability and reliability of food production is insulated from recurring droughts and floods. Minor irrigation surface water projects are expected to irrigate about 10 lakh hectares.

Groundwater

Ground water utilization for irrigation has grown from 1.35 lakh hectares in 1960-61 to 8.61 lakh hectares in 1997-98. In addition, there is also increase in the cropping intensity in well irrigated areas, indicating multiple cropping and cultivation of water intensive crops. 85-90 percent of ground water is used for irrigation in the state. About 6 percent of the total ground water available in the state is utilized for domestic purposes. The dependency is higher in the rural areas .

Though the ultimate planned irrigation potential from major and minor irrigation projects is 1035.76 TMC as on April, 2003, the utilization is only 716.29 TMC. The gap between planned potential, and potential actually created and utilized is a cause of concern considering the economic costs involved. Delay in construction of field channels, leveling of land and lack of farmers' participation are the main reasons for delay in utilization. (Irrigation department data dated 02/05/2003). To create and utilize the balance surface water of 319.47 TMC for irrigating the remaining 10.26 lakh hectares under major and medium irrigation projects, an amount of Rs 7372 crore would be required at the existing rates as in April, 2003.

■ ISSUES AND IMPACTS

The environmental problems linked to water resources pertaining to availability, distribution, management, utilization and sustenance are discussed here

Inequities in sectoral distribution and inadequacy in availability of water

In the national and state water policies, drinking water receives first priority followed by irrigation, industry, power, fishing and recreation. Irrigation however constitutes more than 85 percent of the present utilization of surface and ground water in the state. In the proposed master plan for utilization of water from the Cauvery and Krishna basin, domestic water supply gets 1 percent in the Krishna basin projects, and nearly 10 percent in the Cauvery basin.

Estimation of sectoral utilization of water for 2003 (in TMC)

Purposes	Krishna	Cauvery	West Flowing**
I. Irrigation	443.87	320.9	42.68
	[93.2%]	[88.62%]	[9.72%]
II. Domestic use	4.3	15.36	3.78
	[0.9%]	[4.24%]	[0.86%]
III. Industry use	0.34	1.36	3.58
	[0.07%]	[0.38%]	[0.81%]
IV. Water needed for Hydel Power generation		-	389.00 [88.6%]
V. Evaporation loss	27.71	20.48*	-
	[5.82%]	[5.65%]	
VI. Other***	-	4	-
		[1.1%]	
Total	**476.22**	**362.1**	**439.04**

* Evaporation loss taken to be 6% appx. from total withdrawal for irrigation
** Utilization as on 1999 plus on-going schemes
Figures in bracket are percentage to total

With increasing population, urbanization and industrialization, drinking water naturally receives the highest priority. If appropriate measures are not taken to achieve water use efficiency in all sectors, there would be reduced availability of water for irrigation and other sectors in the future.

Construction of irrigation projects is not an end in itself. Operation and maintenance is more important for realizing full benefits envisaged at the time of approval of the project. Equity, timely supply and efficiency in distribution of water are the three attributes of successful operation. The operation strategy has to meet the requirements of water throughout the crop season. The operation of the water delivery system requires systematic study of cropping pattern in the command area and the crop water requirements.

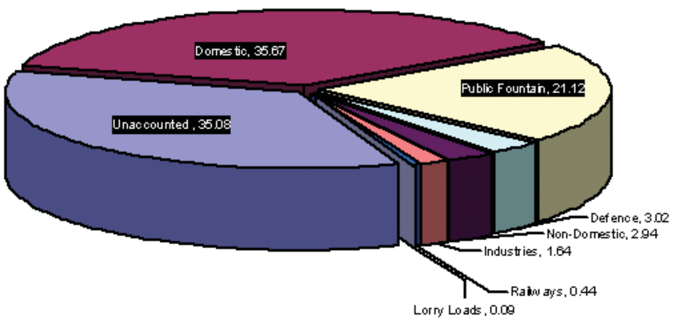
Inefficiency in use of water in domestic and agriculture sectors.

The overall efficiency is measured by the extent of water actually used by the crop out of the water released from the reservoir. Seepage, evaporation, leakages and wastage during nights reduce the overall efficiency. There is gross inefficiency in use of water in the agriculture and domestic sectors. In the agriculture sector, generally only 40 percent water-use efficiency is achieved. This can be attributed to percolation of water in the fields into the ground, losses due to spillage, seepage of water from unlined canals and evaporation. Percolation and evaporation are high in water logged areas mainly due to over application of water and poor drainage.

There is under utilization of water in other potential areas due to non completion of irrigation projects in the stipulated time period. As of March 2003, only 69 percent of the planned surface water irrigation potential in both major and medium projects was utilized.

There is considerable scope to reduce conveyance losses from the irrigation system by lining the entire canal system. The conveyance efficiency in the unlined irrigation system, which is about 56 percent, can be increased to 88 percent when the whole system is lined. Therefore there is considerable scope of improving the efficiency of water use by lining the system.

Sectoral utilization of water in Bangalore (2001-2002)



Models of water resource management

- **Pani Panchayats** organized in Maharashtra after 1972 drought, are co-operatives based on the concept of managing water resources at the community level on the principle of equal sharing and distribution.
- **Water users societies** near Wagdad dam in Nasik, Maharastra recieve water from the Irrigation department on a volumetric basis and distribute the same among participant farmers.

  Those who own wells, charge incremental water rate of Rs.100 per hectare per watering. The farmers have agreed not to construct new wells.
- **Rajiv Gandhi Watershed Management Mission's** programme with bottom-up approach was initiated in 1994 in Madhya Pradesh. In this programme government and non-government agencies play a catalyzing, facilitating and coordinating role. The mission aims at improving land and water resources in environmentally degraded villages with community participation. Politicians, bureaucrats, technical experts, NGOs and beneficiaries are part of the programme.
- **Tarun Bharat Sangh** in Rajasthan is actively involved in construction and maintenance of 'Johads" (traditional check dams of mud) with community help using only manual labour.
- **Ralegaon Siddhi** –implements community initiated watershed development programmes under the leadership of Anna Hazare. The program has acted as catalyst for overall development of the village.
- **Sukhomajari village in Haryana**- Water User Society founded in 1981, manages and distributes water on equal rights. In this government program, the beneficiaries also take active part. Other common property resources are transferred to village societies.
- **Rejuvenation of "Ahar"** (traditional flood water harvesting system) and Pynes (channels) in Bihar- The Institute for Research and Action, with 100 percent community participation has initiated rejuvenation programme since 1999. Nearly 75 Ahars have been rejuvenated. This has increased production of paddy and work opportunities.

Per capita fresh water availability

There are variations in per capita fresh water availability for different population groups and other sectors in the state. In rural areas, 36 percent habitations receive less than 55 litres per capita per day of water which is a norm prescribed under State Water Policy-2002. Of this, 7.8 percent of the habitations receive less than 20 litres per capita per day of water (2002). In urban areas, the availability is 67 litres per capita per day. 88 percent of the towns in the state do not have adequate supply of water as per the respective norms.

Steps like lining the system, provision of adequate control systems such as measuring devices at all outlets, prevention of leakage and pilferage, rotation of supplies like WARABANDI with obligatory night irrigation and training of farmers for efficient water application practices will considerably improve overall efficiency.

The details pertaining to the extent of water wasted in domestic and agricultural sectors is not available. However, the details that are available on the extent of water logging and crop violation do support the conclusion that there is inefficiency in water use or over application of water.

Farmers often misuse water from canals and tanks by over application and also violate the prescribed cropping pattern. They adopt water intensive monoculture crops like paddy and sugarcane ignoring leguminous crops that are beneficial to the soil. Thus, large extent of land has been rendered unfit for cultivation due to water logging and salinity. Crop violation and poor drainage in irrigation project areas are the major factors contributing to inefficiency. Evaporation coupled with water logging causes accumulation of salts leading to loss of fertility and degradation of soil. This impact could be seen particularly in the low lying areas. Water logging also retards plant growth by cutting off oxygen supply to the root system, in the same way acidity and alkalinity are also caused.

Therefore, sustainable management of irrigation potential is an urgent need. In the domestic sector, inadequate water supply causes stagnation of waste in drains and due to inadequate water flow, the village drains become main centers for mosquito breeding and spread of diseases.

Depleting ground water resources

Depleting groundwater is a major problem in many parts of the state. As per the 1994 status, in about 43 taluks there was extraction of groundwater in excess of 65 percent that made them Grey taluks. Further, the groundwater exploitation exceeded 50 percent of the available ground water resources in 29 taluks of the state. Thus, in these 72 taluks (43+29), there was over drawl of groundwater. Out of the 4 lakh wells irrigating an area of 7.5 lakh hectares in these taluks more than 3 lakh dug wells dried up .

Twenty one taluks declared as dark and grey areas in 1994 have been considered as safe watershed areas in 1999. This could be attributed to various regulatory measures like cut in financial assistance for additional borewell drilling and introduction of recharge measures in some affected parts. But, watersheds in 12 additional taluks have been identified to be over developed areas in 1999. Kolar, Bangalore Rural and Tumkur are districts where ground water depletion has reached critical levels. These districts also face acute problems of drinking water quality. When compared to the coastal, malnad and irrigation command areas, ground water exploitation in the dry taluks of interior north and south Karnataka is very high.

Ground water draft in the overdeveloped areas is more than net annual recharge. This has resulted in sharp decline in ground water table and reduction in water yield. Large number of ground water structures have gone dry in these areas, due to lack of proper recharge measures.

Conveyance losses from unlined, partially lined and lined irrigation systems

System details	Percent loss of water released from reservoir				
	Main canal	Distributary	Field water courses	Total conveyance losses	Conveyance efficiency
Entire system unlined	15	7	22	44	56
Only canals lined	4	7	25	36	64
Canals and distributaries lined	4	2	26	32	68
Whole system lined	4	2	6	12	88

Source: Perspective land use plan for Karnataka 2025

More than 90 percent of rural public water supply schemes depend on ground water. Due to inadequate water supply ground water has become a major source for private water supply in the urban areas.

Inadequate treatment of watersheds

Prior to 1999, taluks were considered as the unit for categorising groundwater extraction. From 1999, onwards, watersheds have replaced taluks as the unit. Based on this methodology, watersheds have been categorised depending on the level of groundwater extraction as safe, semi critical, critical and overdeveloped. Of the 380 watersheds in the state, 56 (42 over exploited, 6 critical and 8 semi critical) have been categorised as over developed.

Watershed management is a scientific approach aimed at resource conservation for sustained productivity. It involves insitu conservation of moisture. It is widely accepted as the unit for planning and implementation of programs relating to drought mitigation. Here, measures like afforestation, pasture development, percolation ponds, check dams, vegetative gully checks, bunding, ploughing across the slope and contour-ploughing help in drought mitigation. In addition, watershed management includes crop diversification, cultivation of fruits, trees and grasses in different combinations, livestock raising and other income generating activities that minimize the risk of crop failure and enhance the stability of farm income.

Classification of Watersheds

The total recharge comprises of components such as recharge from rainfall during monsoon and non monsoon recharge from other resources such as return recharge from groundwater and surface water irrigation during monsoon and non-monsoon, seapage from tanks and recharge from groundwater harvesting structures. Out of the total recharge obtained, 5% has to be deleted as natural discharge. The ultimate value forms the net recharge. Total draft comprises of draft for irrigation as well as domestic and industrial needs.

The stage of development is arrived at by dividing the draft for irrigation and the draft for domestic usage during the year of assesment by the net recharge.

The **1994 Methodology** classifies taluk as

Dark- >85 percent , Grey->65 to <85 percent White- <65 percent.

The **1999 Methodology** classifies watershed based on the stage of development as

Over exploited- >100 percent with declining long term trend in ground water level.

Critical-90-100 percent with long term decline in ground water level.

Semi- Critical- 70-90 percent with decline in pre or post monsoon ground water level.

Safe-<70 or 70-90 percent without any significant change in ground water level.

1994: Dark and Grey taluks

Districts	Taluks
Bangalore (U)	Anekal, Bangalore (N), Bangalore (S)
Bangalore (R)	Channapattana, Devanahalli, Hoskote, Doddaballapur, Ramanagar
Belgaum	Chikkodi, Hukkeri, Athani, Bailhongal
Bellary	Hagari bommanahalli
Bidar	Bidar
Bijapur	Indi, Bagewadi, Bijapur
Koppal	Kustagi
Chitradurga	Challakere. Chitradurga
D.Kannada	Bantwal, Sulya, Belthangadi
Hassan	Channarayapatna, Arasikere
Kolar	Chikkaballapur, Kolar, Malur, Chintamani, Gouribidanur, Mulbagal, Sidlaghatta, Srinivaspur
CR Nagar	Kollegal, C.R.Nagar
Tumkur	Koratagere, Gubbi, Madhugiri, Tiptur, Tumkur, Turuvekere, Kunigal, Sira
Total	**43**

Fifteen percent of the watersheds fall in the over developed category and are in critical condition. So far, less than 25 percent of the area available for watershed development in 17 districts is covered under different programmes. In 1999, the net recharge was estimated to be 2.50 million hectare meters in safe watersheds and 0.27 million hectare meters in over developed watersheds. The balance ground water available after its uses for different purposes is, 1.568 million hectare meters in safe areas and negative (–0.377 million hectare meters) in over developed areas. As per the 1994 ground water status report, net draft of ground water in Bangalore was 13959 hectare meters whereas the net recharge of water was 12198 hectare meters (-14 percent).

Groundwater status in Karnataka (as on 31st December, 1999)

1	Total No. of Watersheds (300 – 1400 Km^2 range)		380
2	No. of Watersheds categorized as 'SAFE'		324
3	No. of overdeveloped* Watersheds		56
	a) Over Exploited	42	
	b) Critical	6	
	c) Semi-critical	8	
4	No. of taluks in which the Overdeveloped Watersheds are fully/partly covered		34
5	No. of Districts		10
6	Total No. of Overdeveloped villages not feasible for Groundwater development programmes		5692
7	Total No. of Groundwater Structures		8,65,818
	a. No. of dug wells		2,94,745
	b. No. of dug-cum-borewells		41,699
	c. No. of borewells		5,29,374
8	Net Recharge		
	a. Safe Watersheds	Mha.m	2.502
	b. Overdeveloped Watersheds	Mha.m	0.274

*Over developed = Over exploited
Source: Hydrology Project, DMG, 2003

Deteriorating surface and groundwater quality

Quality of water is affected by the excessive use of pesticides and fertilisers in agriculture, dumping of sewage and industrial effluents into water bodies without treatment.

Decline in groundwater levels can lead to deterioration of water quality. Of the total 1895 wells under observation by the Department of Mines and Geology, water level showed increase in 418 (22 percent) wells while, decline was observed in 1109 (56 percent) wells. The tapping of deep seated groundwater through borewells without implementing recharge measures accompanied by uneven/scanty rainfall has considerably reduced the availability of groundwater in the state. Depleting groundwater resources have enormous impact on the environment both in the form of inadequacy and quality. In the absence of effective recharge measures, the environmental impacts continue to be a cause for concern.

The effects on human health because of contamination are also very serious. Since the industrial sector does not get sufficient share of surface water there is heavy dependence on groundwater which in turn aggravates the problems relating to quantity and quality.

Degradation of traditional and community owned tanks

Minor irrigation works serve as a source for growing irrigated crops. Minor irrigation tanks have high rate of degradation due to silting. Their surface areas are usually large in relation to their limited storage, causing substantial evaporation losses. These works also serve an important purpose of recharging groundwater and provide the only means of irrigation to chronically drought-affected areas.

In the past, rural communities took responsibility of restoring and maintaining the water tanks in the villages, which are the oldest natural rain water harvesting structures. As a result of State taking over ownership of the tanks, their degradation started and has continued till today. Tanks have lost their water holding capacity to an extent of 30 percent due to siltation and with tanks drying up, the water table has gone down in many parts of the state.

Women, poor and those belonging to the weaker sections of the society suffer due to degradation of tanks as they have to find alternate sources, walk long distances and

Water quality affected by chemicals used in agriculture

Increased fertilizer use results in rise in potassium concentration in ground water which in turn results in increase in the pH value of command area water. Pesticide residues of Benzene Hexachloride (BHC), lindane, endosulphan, Di chloro di phenyle tri chloro ethane (DDT), and dieldrin get absorbed in food and water. It is estimated that only 10 to 15 percent of the pesticide application reaches the target organism leaving the remainder to be absorbed in air, water and soil. The rate of accumulation of pesticides in aquatic routes is higher than through aerial and terrestrial routes due to the chemical nature of pesticides which are have high lipo-solubility and low water solubility. Carcinogenic effects, immune suppression, respiratory problems, nausea, disturbances in sleep, genetic disorders and joints deformity are reported to be associated with fertiliser and pesticide poisoning through water, air and food. There are reports of physical deformity, childhood blindness and cancer attributed to aerial spraying of endosulfan, in some villages of Kasargod district of Kerala which is bordering Karnataka.

Watershed development programmes in the state

There are 380 watersheds in the state. The target area to be covered under various watershed programes is 1.25 lakh hectares and the area covered as of November 2003 is 29.10 lakh hectares which forms 24.90 % of the total treatable area. There are many examples of better natural resource management through watershed based treatment. In the Kutangere watershed, land use pattern has undergone significant change. The gullies formed by erosion were reclaimed by implementing silvi pasture system. In addition, agro-horticulture systems have replaced agricultural crops.

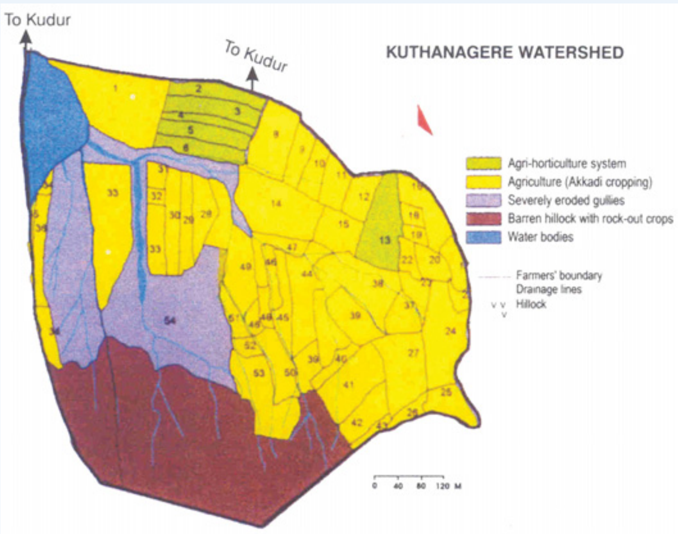
In the Hirehalla watershed in Belgaum, as much as 4285 hectares of wasteland was treated, and 298 hectares of land brought under forest vegetation. In Allapura, sediment flow reduction was acheived by implementing watershed based land treatment.

In the Kallambella watershed, after the project was implemented, the average yield of groundwater inside the watershed area was 2321 gallons per hour as compared to 850 gallons per hour outside the watershed.

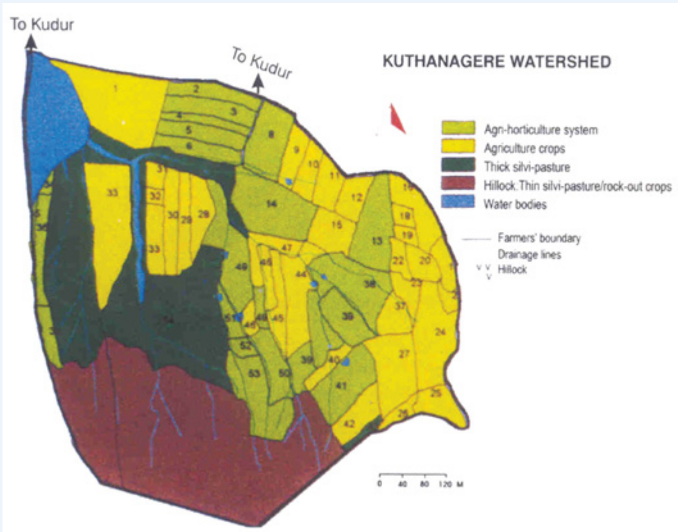
Some examples of watershed treatment

Name of Watershed	Activity	Area before project (in hectares)	Area after project (in hectares)	%
Arasinakere, Mysore	Plantation/ irrigated crop	5445	10198	87.29
Hirehalla, Belgaum	Reclaiming Wasteland	7301	3016	58.69
Hirehalla, Belgaum	Forest vegetation plantation	47	345	634
Margutti, Doddahalla Gulbarga	Increased area of water body	11	72	554.6
Chandakavate, Bijapur	Dryland horticulture	380	2437	541.3
Allapura	Sediment flow reduction	4.06	1.11	72

Map of the Kuthanagere watershed



Before treatment



After treatment

wait in queues to collect water for drinking as well as domestic purposes. There is also loss of bio diversity due to degradation of tanks.

The time series data shows a decline in the command area and fluctuations in area irrigated from year to year depending on tank fill due to rainfall variations, while the number of tanks and gross area irrigated in the last 10 years remained constant.

Apart from irrigation of the agricultural lands, tanks play the pivotal role in recharge of groundwater. Desilting of tanks with appropriate catchment area treatment measures can bring back nearly 4.40 lakh hectares under irrigation with existing the infrastructure.

Siltation in river basins and command areas

Reservoirs and tanks in the state are losing their storage capacity due to heavy siltation. This in turn causes inadequate supply of water and also recurrent floods in some areas. Floods not only cause economic loss but also result in inundation of fertile top soil and erosion. Siltation which results from soil erosion in the catchment areas is one of the major problems in canal and tank irrigation systems. As a result there is loss of storage capacity and reduction in water spread area and water availability. The problem of siltation is higher in Krishna basin (Tungabhadra, Ghatprabha, Malaprabha and Bhadra) and in Linganmakki (Sharavati river).

Community approach to tank management…….success in innovative techniques
(Jala Samvardhana Yojana Sangha)

Cheluvanahalli, a small village in Kolar taluk in Kolar district situated on NH4 is a shining example of community participation in improving a local tank, Papanaikanakere. An integrated tank development and management plan costing Rs.9.75 lakh was prepared in June 2002. The community contributed Rs.0.60 lakh and the balance money came from Jala Samvardhana Yojana Sangha. The tank users group of the village has blended the traditional knowledge with modern engineering principles while restructuring the worn out tank bund.

A weak tank bund

Rejuvnated tank bund

Feeder channels in 2.08 square kilometers of catchment were treated with the check dams, boulder checks and vegetative stabilization with soil binding species like bamboo, agave etc. The tank development was completed in 6 months. Now the tank can apart from irrigating 80 acres of land directly support livelihood of the entire village. Afforestation carried out in the tank foreshore and catchment provides biomass needs and enhances the quality of eco system.

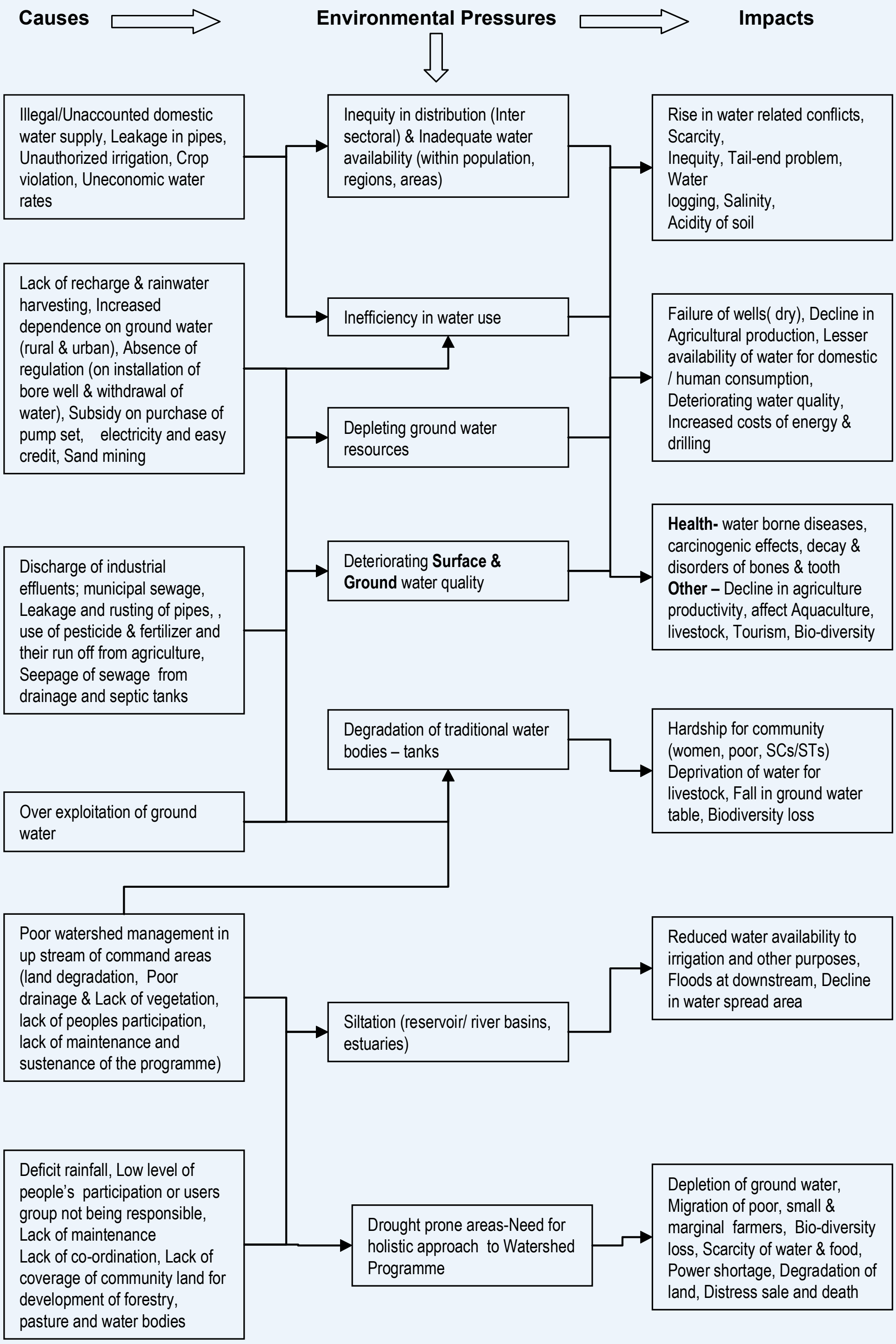
Low cost kitchen garden, Cheluvanahalli

The low cost gardens providing fruits and vegetables to the poor and landless families in Cheluvanahalli village have proved that developing tank systems can provide sustainable livelihood. The strategy used for this was very simple and practical. The silt removed from tank bed was used to develop small plots of garden approximately measuring 10 feet by 15 feet in public lands. The total initial investment was Rs 500 per plot including the cost of labour. Water was made available through low cost drip irrigation system. The beneficiaries grow more than ten varieties of vegetables. Apart from using the vegetables for the family they have been able to earn additional income of Rs.200 per month.

Karnataka community based tank management project is focusing on optimum water management. The Madagascar method of paddy cultivation is a good example of this. The unique feature of this system is maintenance of moisture level at field capacity instead of the conventional method of continuous sub mergence. With this method, water requirement is reduced by 50 percent and the crop yield increases 2-3 times. Even the seed requirement for sowing is only 7.5 kilograms/hectare instead of 70 kilograms/hectare in conventional method.

Madagascar method of paddy cultivation

Causes, pressures and impacts: the Link

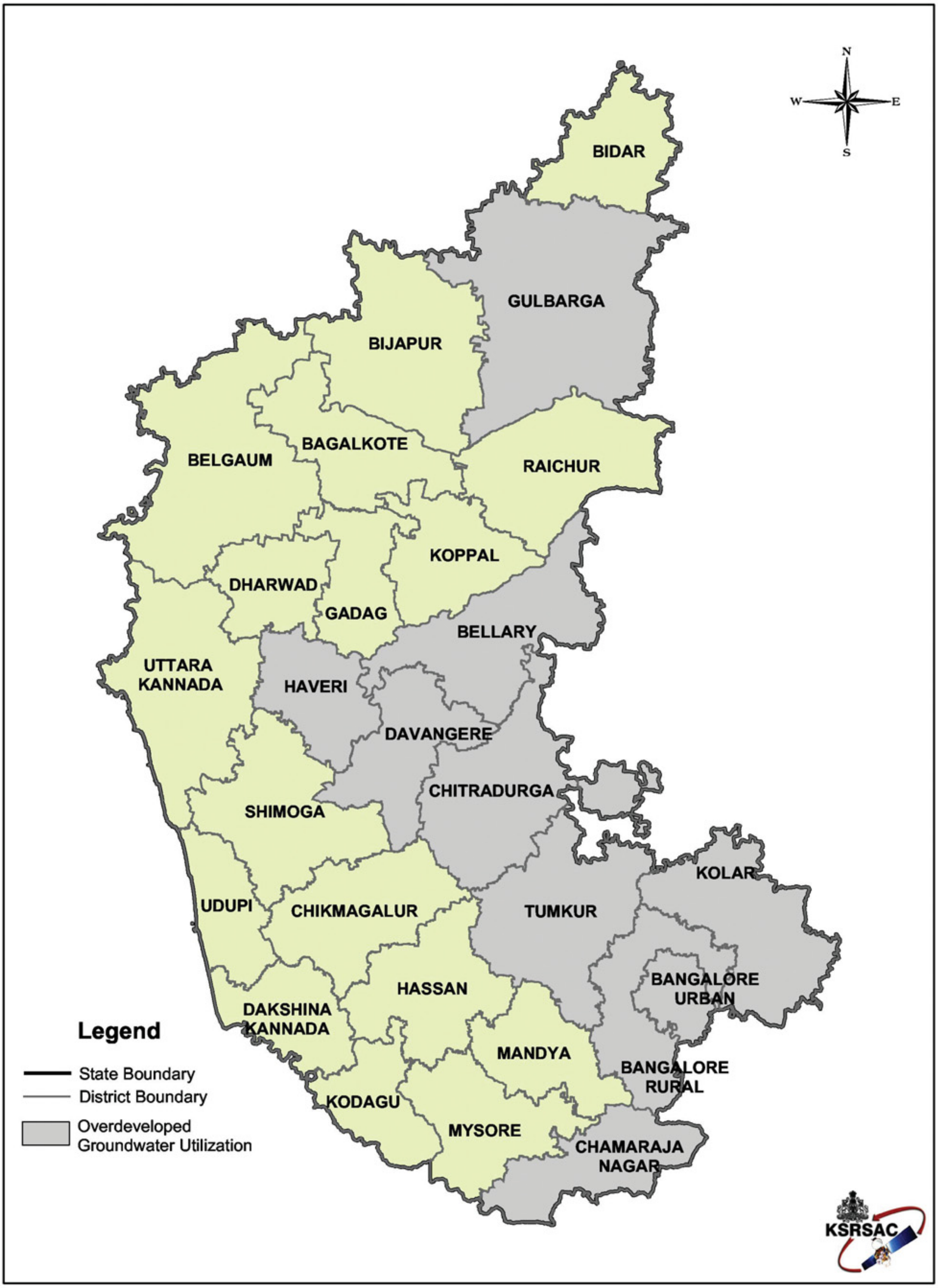


HOTSPOTS

The objective of presenting hotspots is to highlight the magnitude of the problems related to environmental degradation with a view to enable the decision makers to select activities like recharge of ground water, prevent pollution, step up watershed development programmes etc. It may be noted that some problems are unique to a particular water basin as they depend on soil condition, utilization of water etc.

There is ground water pollution in the downstream of

Districts with overdeveloped groundwater utilisation



industries in Mysore and Shimoga districts. Policy intervention is needed on a priority basis to tackle this problem.

TRENDS

The Water and Land Management Institute, Dharwad (WALMI), has projected (rough estimates based on all India figures) the future water requirements of Karnataka. The projections have shown that the requirement of water for industrial and other sectors would double in a time span of 25 years. Though there is a likelihood of increase in irrigation demand, its share in the total projected water demand would decline in future due to increasing demand from other sectors.

The nonadherence to the planned cropping pattern poses problems in water releases, equitable supplies to tail end farmers in distributaries and canal network. Shortage of water in the reservoir during non rainy season poses problems of serving the entire command during the years of low rainfall. Excessive cultivation of high duty crops like rice in double cropping system leads invariably to water logging and salinity due to drainage congestion in lower reaches.

In the ongoing Kabini project the actual coverage as of 1999-2000 was 72,606 hectares rice, 14,922 hectares of kharif semidry, and 4579 hectares of sugarcane as against the planned cropping pattern of 53,000 hectares rice, 1. 02 lakh hectares rabi semidry and 60,000 hectares of kharif semidry. In Harangi, as against the planned area of 1.17 lakh hectares of kharif semidry and 14,466 hectares of rice, the respective crops were grown on an area of 40,144 hectares and 37,242 hectares respectively. No rabi semidry crops are grown even though an area of 35,129 hectares was planned. In Hemavathy the area under rice was 1.26 lakh hectares as against the planned area of 13000 hectares. There was an area of 5713 hectares in sugarcane (perennial) though it was not planned. Under semidry kharif and rabi, areas planned were 3.90 lakh hectares and 2.66 lakh hectares respectively. The actual coverage was 74,800 hectares in khaif semidry and none in rabi season.

Violation of cropping pattern and poor drainage in irrigation project areas are the major factors causing increase in water logging and salinity. Cropping pattern violation has been going on for many years without any institutional intervention. The only instrument that is available but rarely used is levy of penalty. Land irrigability analysis based on soil surveys is made for every project area. Localised cropping pattern is recommended along with the list of crops not suitable for the specified soil. But, farmers do not have enough economic incentives to follow the right cropping pattern. Violation of cropping pattern is higher in the Krishna basin under major irrigation projects. The area under crop violation has increased during the period 1996-97 to 2000-01 in the Krishna and Cauvery basins. Unauthorized irrigation results in over utilization of water and is found to be high under lift irrigation schemes.

Seepage loss during conveyance and on field is also a problem connected with water use efficiency. Conveyance efficiency is estimated to be 56 percent in unlined canals and 88 percent in lined canals.

Groundwater extraction for agriculture is higher and unregulated. Average annual gross draft for ground water structures in Karnataka is estimated to be 0.9 hectare meters for dugwell with pumpset and 1.7 hectare meters for borewell with pump set. This trend cannot continue in the light of increasing number of overdeveloped watershed areas and deteriorating ground water quality.

There is a sharp decline in the depth of water levels in Bangalore (5.4 m), Chitradurga (8.44 m), Dharwad (5.4 m), Bijapur (3.03 m), Bellary (5.93 m), Kolar (5.2 m), Tumkur (5.96 m) and Raichur districts during the period from 1978 to 1996.

Pollution load due to sewage from towns and cities is estimated to be 785 tons per day in the state. Annually, 5608 tons of waste is dumped in different towns of the state. Solid waste, ranging from 210 to 500 gms/capita/ day (population of the towns ranging from 5 lakh to 50 lakh), is generated The hazardous pollutants from all these are carried into the surface and ground water through run off water. Samples drawn from the rivers indicate presence of high level of biological oxygen demand, total coliforms

Basin wise presentation of hotspots

Problems	River Basins				
	Krishna Basin	Cauvery Basin	Godavari Basin	West Flowing River Basin	Other Basins (Palar, South and North Pennar)
I. Inequity & inadequacy					
Pressure on existing water resource – surface	Dharwad, Bellary, Bagalkot, Bijapur, Tumkur, Gulbarga, Belgaum, Haveri	Bangalore (U), Kodagu , Hassan, C.R.Nagar	-	Uttar Kannada	Kolar
II. Inefficiency in water use					
Salinity and waterlogging	Bellary, Bijapur, Chitradurga, Raichur, Gulbarga, Dharwad, Shimoga, Belgaum, Davengere	Bangalore (U),Mysore	Bidar (Chulkinala)	Kali, Pavenje, Netravati, Gurpura(UK&DK) D.Kannada, U.Kannada	-
III. Deteriorating water quality					
Surface Water	Davangere (Tungabhadra river Davangere and Harihar), Shimoga(Bhadra river-Bhadravati and Thirthahalli), Bellary & Koppal (TB river), Bagalkot (Krishna river)	Mandya(Hebbal river), Bangalore (Arkavathi –Kanakapura town), Mysore (Kabini river –Nanjangud & Cauvery- Srirangpattana and K.R.Nagar) C.R.Nagar(Cauvery- Kollegal)	-	Uttar Kannada (Kali river-Dandeli), Dakshin Kannada (Netravati & Sullia)	-
Ground Water	Tumkur, Chitradurga, Gadag Bagalkot, Davanagere, Dharwad, Haveri, Bellary	Bangalore(R&U), Mandya, Tumkur (Kunigal), C.R.Nagar)			Kolar
Seepage of Fertilizer and Pesticides	Raichur, Koppal, Belgaum, Dharwad, Chikmagalur, Shimoga, Bellary	Bangalore (U &R), Mysore, Kodagu, Mandya, Hassan	-	D. Kannada	Kolar
IV. Depleting ground water resources					
Decline in depth and low water table(1990-2000) & 2002	Bagalkot, Bellary Chitradurga, Haveri, Belgaum, Gadag, Davangere, Tumkur, Dharwad, Koppal, Gulbarga	Chamarajnagar, Bangalore (R&U), Hassan, Mandya	Bidar	-	Kolar
V. Drought prone area- need for watershed treatment					
	Chitradurga, Tumkur, Dharwad, Gulbarga, Haveri, Gadag, Bellary, Bijapur	Bangalore(R), Mysore	-		Kolar
VI. Siltation in reservoir, river beds & estuaries					
	Belgaum (Ghataprabha & Malaprabha reservoir); Bellary (Tungabhadra reservoir), Shimoga (Bhadra reservoir)	-	-	Linganmakki reservoir (Shimoga), Kali(U.K) Netravati & Gurpur (D.K)	-

and faecal coliforms.

Karnataka is the seventh largest consumer of fertilizer and pesticides and accounts for 5 percent to 7 percent of country's total fertilizer and pesticide use. The problem of contamination of surface and ground water would be more in water logged and low lying areas.

Siltation directly affects the water holding capacity of tanks. Nearly 30 percent of the tanks in the state have lost their water holding capacity and the rate of silt deposition in irrigation tanks is estimated at 8.51 hectare meter /100

Sectoral water utilization with future requirement (in TMC)

Sectors	Year	
	2000	2025
Domestic (drinking)	58.15	91.62
	(4.4%)	(4.95%)
Irrigation	1110.06	1356.74
	(84%)	(73.33%)
Industries	47.57	125.1
	(3.6%)	(6.76%)
Hydro/Thermal Power	52.86	65.19
	(4%)	(3.52%)
Others	52.86	211.44
	(4%)	(11.43%)
Total	1321.44	1850.1

Source –Water & Land Management Institute (1998), Dharwad

square kilometers/year.

The occurrence of high rate of sedimentation in Malaprabha and Tungbhadra reservoirs is reported by ground surveys carried out by Karnataka Engineering Research Station. According to ground surveys, sedimentation rate is 0.38 percent in Tungabhadra and 0.3 percent in Malaprbha reservoir.

Analysis of percentage water availability for past ten years in major reservoirs in Karnataka (1990-2000) shows that there is decline in storage capacity in Linganmakki, Varahi and Supa, lowest storage of 53 percent of average was found in Malaprabha reservoir in 2001. These trends will have drastic impact on water availability for hydel power in Linganmakki and for crops and drinking supply in command areas of Malaprabha reservoir and for Hubli-Dharwad city.

Basin–wise details of unauthorized irrigation and Violation of cropping pattern 2001 (% to total area irrigated)

Irrigation	Krishna	Cauvery
Unauthorized irrigation		
Minor	-	8.71
Medium	3.39	-
Lift	25.19	-
Major	11.89	0.09
Crop Violation		
Minor	-	30. 34
Medium	39.52	-
Lift	12.48	2.34
Major	33.22	28.15

Rainwater harvesting

Rainwater harvesting is an important tool to address the problem of water scarcity and effective conservation of rainwater. It is the process of collecting and storing rainwater in a scientific and controlled manner for future use.

Rainwater harvesting is based on a simple concept. Rainwater is collected from the roof of a building, community structures,landscapes, open fields, green parks, storm water drains, roads, pavement etc and stored ready for re-use as required. Water from these platforms can be filtered and directly be put into a percolation pit or open well or dispersion trench to recharge the groundwater. It reduces runoff and flooding of storm drains and involves least capital investment with high returns at the household and community level.

In a normal domestic situation this water can be used for flushing toilets, general cleaning, garden irrigation and washing clothes. Typically this can account for nearly half of the water used for most of the year.
In most buildings, rooftop rainwater is removed through pipes and is let out into storm drains outside the plot area. Rooftops generate large quantities of runoffs as losses due to percolation and evaporation are negligible.

Industries and institutions can benefit hugely from harvesting rainwater because on one hand they have to pay high tariff for use of water and use the large roof area available on the other. Therefore, payback periods for rooftop rainwater harvesting systems are shorter.

At present, there is a necessity to integrate designing of rainwater water harvesting with conventional building practices.

CAUSES

Scarcity of water in urban areas has made water an economic commodity and has lead to the emergence of unregulated private water market. The absence of regulatory mechanism to control this undesirable development is a cause for concern. Inefficiency in use of water across different sectors could be attributed to various reasons. In the agriculture sector, the main causes include crop violations, unauthorized irrigation etc. Poor lining of canals result in conveyance loss. Water supplied for irrigation is highly subsidized and water supply rates were revised only recently. Though water rates have been revised by making appropriate amendment to the law, it is still doubtful whether there would be full recovery of water rate from farmers. The cooperation of water users societies and their participation is also very important.

Increasing dependency on ground water for irrigation, domestic, commercial and industrial use due to non-availability of surface water in some parts of the state and inadequate and untimely availability of surface water in many parts, lack of recharge initiatives by government, local bodies and community, are the major causes for ground water depletion.

Artificial structures for recharge of groundwater need to be constructed in critical areas where depletion and extraction are high. The Department of Mines and Geology has identified watersheds, where there is overexploitation of groundwater and those, which are in critical condition. But, the department does not take up any comprehensive recharge measures and is implementing only experimental and demonstration programmes for artificial recharge.

There is lack of coordination among the Command Area Development Authority, the Irrigation department, the Zilla Panchayats, Gram Panchayats, Watershed department and users community in distribution, management and sustenance of water resources. Degradation of tanks due to siltation is also a cause for declining ground water table. Changing life styles and urbanization also add to over use of water. There is excess use of water particularly in urban areas, due to use of flush toilets. The absence of regulation in installation of ground water structures and spacing of borewells is a major cause for over utilization of ground water. Consequently there is an increase in the number of wells over the years without proper hydro- geological survey.

Water contamination due to fertilizer and pesticides is mainly on account of over and improper application and, inefficiency in the use of water. Over application of water leads to water logging and as a result there is rise in water table.

Studies indicate that areas with high water table in irrigated regions have higher ground water contamination.

Non point sources of contamination and usage of foreshore areas of the tank for defecation and bathing and discharge of sewage without treatment have resulted in degradation of tanks.

Sectors having impact on water resources

Environmental pressures	Sectors impacting the water resources				
	Agriculture (Irrigation major, medium & minor) watersheds, etc.	Industry	In adequate urban planning and waste management	Household sector	Mining
I. Depletion of water resources					
(I) Surface	High	-	Medium	High	-
(ii) Ground	High	Low	Medium	High	-
II. Inequity in distribution and inadequate water availability	High	Low	Medium	High	-
III. Water pollution					
(I) Surface	High	High	High	High	High
(ii) Ground	Medium	High	Medium	High	High
IV. Degradation of tanks	High	High	High	High	Low
V. Inefficiency in water use	High	-	High	High	-
VI. Drought prone areas	High	Medium	-	Low	-
VII. Siltation	High	-	-	Low	High
Total	**High**	**High**	**Medium**	**High**	**High**

The consequent high pollutant inflow has resulted in eutrophication leading to proliferation of weeds.

There is a need for holistic approach for management of tanks for reducing in flow of silt and monitoring of water quality. The degraded pasture lands should also be restored as degraded grazing lands lead to soil erosion and siltation in tanks and reduce storage capacity.

There is also a need to check encroachment over the feeder lines or natural drains, which drain water to tanks. It may be noted here that in many urban areas, slums have come up in tank beds.

Main causes of tank siltation are:

- Over grazing and destruction of vegetative cover in catchment area leading to higher runoff and soil erosion.
- Improper land and crop management practices, along the slope cultivation and inadequate soil conservation measures in the catchment area.
- Encroachment of forest for agriculture resulting in reduced tree cover and
- Extending cultivation to marginal lands inducing accelerated soil erosion.

PRIORITISATION

The degree and severity of environmental pressures based on quantity and quality issues vary from region to region. Considering this aspect a prioritization exercise has been attempted to rank the environmental problems keeping in view their socio-economic and ecological impacts and the urgency of the problem.

For purpose of prioritisation five regions of the state were considered namely Northern plateau, Southern plateau, Coastal areas, Western ghats and Bangalore. The priorities for each region were complied and a prioritisation matrix for the whole state was arrived at.

The objective here is to highlight key issues and facilitate institutional intervention in terms of policies and programmes for attending to the problems.

The prioritisation matrix for the state as a whole has been

Prioritisation matrix

Problems	Socio-Economic/Ecological Impacts							
	Impact on Public Health	Loss of Biodiversity	Impact on Vulnerable groups	Productivity loss	Impact on critical Ecosystem	Irriversibility/ reversibility	Urgency of the problem	Total scoring
1. Depleting Ground Water Resources	5	5	5	5	3	3	5	31
2. Inequity in distribution/ inadequate availability of water	5	5	5	5	3	3	5	31
3. Deteriorating water quality								
(I) Surface	5	3	5	3	3	3	5	27
(ii) Ground	5	3	5	3	3	3	5	27
4. Degradation of tanks	3	3	5	3	3	3	5	25
5. Ineffieiciency in Water Use	3	1	3	5	5	3	3	23
6. Drought prone Area Need for Watershed treatment	1	3	5	5	3	1	3	21
Total	**27**	**23**	**33**	**29**	**23**	**19**	**31**	**185**

Scale: 1= low, 3 = medium, 5= high

Equitable distribution of water, the Bundi model

In Bundi district of Rajasthan, farmers have come together to monitor water distribution and ensure sufficient canal irrigation in tail areas. This has been possible with the help of district administration, law (police), people and concerned public officials. To increase efficiency and reduce the seepage loss in canals, cutting of vegetation, application of chemical treatment to weeds and desiltation have been carried out by the community with government assistance. Rotation irrigation, education to farmers and formation of water users' societies are initiatives undertaken in Bundi command area.

Source: Planning Commission, 2003

presented here. A close analysis of the prioritisation matrix brings out the following problem areas.

- Depletion of water resources and inequitable distribution with inadequate availability of water, are the two major problems facing the State with respect to their severity and impact. These two problems have become acute in the recent period due to drought and water quality problems. Depletion of ground water is a priority issue in all regions except Western ghats and coastal region.
- In Northern plateau, on one side there is inefficiency (excess use) in use of water for agriculture and, on the other side, there are drought prone areas which need watershed treatment. Water is polluted in Tungabhadra river at Davangere and Harihar due to industrial effluent discharge. High level of siltation is observed in the Tungabhadra reservoir and the problems of water logging and salinity are severe.
- In Southern part, surface and ground water pollution and degradation of tanks rank second and third in terms of priority.
- Water pollution in Bhadra and Kali river and inefficient use of water in Bhadra command area add to the problems of water quality, water logging and salinity in Western ghats region.
- In the coastal areas, prevention of further degradation of tanks and pollution of water in the ghat sections, and management in water distribution for domestic purposes in the water scarcity areas appear to be priority issues. Salinity and water logging caused by intrusion of salt water are also major problems in coastal areas.
- Key issues for Bangalore city include degradation of tanks, depletion of ground water and inequity and inadequate availability of water for drinking purpose. Many tanks have disappeared/encroached and the existing ones are sources of contamination. Domestic waste discharge particularly from extension areas into the lakes has lead to water pollution. Satellite imageries and information available with the Survey of India indicate that nearly 2789 lakes have dried up and there are only 330 live lakes in the medium to large range in Bangalore metropolitan region.

ACTION PLAN

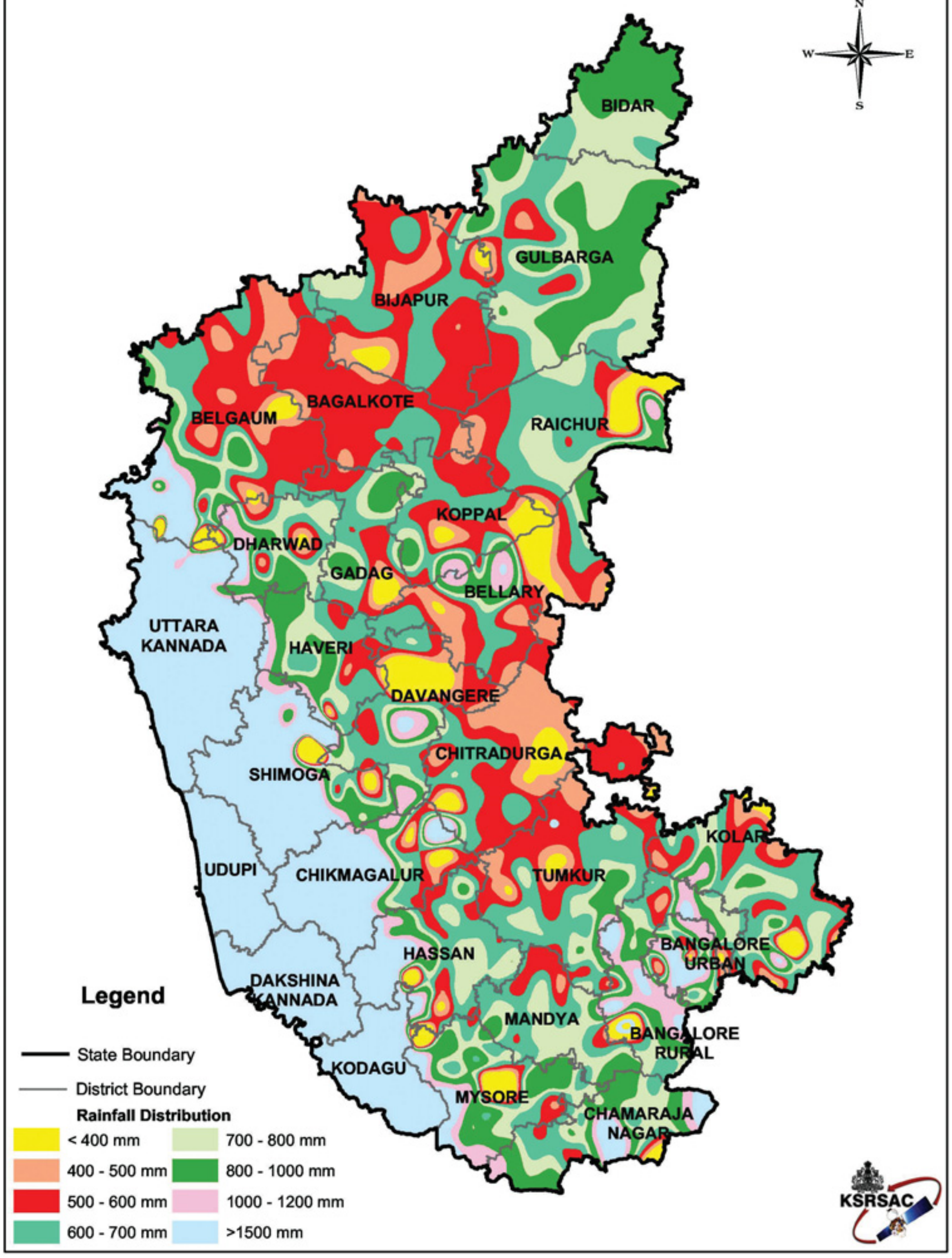
- Basin wise planning and management system for optimum utilization of groundwater and surface water for next 25 years should be evolved.
- Protection of water bodies: desilting of lakes, fencing, and other measures should be taken for protection of water bodies.
- All major commercial and industrial units should use recycled water.
- A comprehensive ground water recharge programe involving the concerned departments of Watershed Development, Mines and Geology, Minor Irrigation and other Urban Local Bodies in over exploited and drought hit areas should be conceived and implemented.
- Bio drainage strategy may be taken up on an experimental basis as a remedy for water logging, soil salinity and for prevention of mosquito breeding in command areas of irrigation projects
- Action be taken for the use of geo fabrics, low-density polyethylene and rigid plaster for lining the irrigation canals to reduce the seepage losses.
- The existing data on water resources though voluminous does not cover all important aspects particularly the following:
    - Basin wise water flow in rivers.

- Utilization of surface and ground water by different sectors namely industries, domestic, irrigation and other uses.

- Large quantity of water is being exploited for non-domestic purposes like construction, gardening and by health care establishments and water is being supplied through tankers in urban areas. At present there is no control on this activity. Legislation to be enacted to set up regulatory mechanism to prevent over exploitation of water in critical areas and to ensure water quality.

- Conjunctive water use involves management of all water resources in an area to optimize the total water use over a period of time. This method should be adopted to tackle the problems of salinity, water logging, and the associated problems of acidity and alkalinity.

Distribution of rainfall across the state



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