Pricing Policy and Its Role in Groundwater Management—A Karnataka Experience

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Abstract: Karnataka state has seen a sudden spurt in groundwater structures during the last fifteen years resulting in over-exploitation of groundwater resource in many taluks. Out of 175 taluks, 22 are fully and 102 are partly over-exploited as per the groundwater resource estimation as on 2004. In terms of areal extent, 30% of the state comes under the over-exploited category where an annual overdraft of 0.22 mham of ground water is taking place. This has caused lowering of water table with an average decline of 0.24 m/annum and drying of about 106,529 wells as per Minor Irrigation Census 2000-01. This situation has resulted in an estimated loss of Rs. 596 crores in terms of investment, irrigation potential and additional pumping cost. There is an urgent need to arrest this alarming situation by scientific means and sustainable groundwater resource management options.

This paper deals with the role and necessity of groundwater pricing in management as a measure to minimize the draft and to induce innovative methods of groundwater utilization. It also deals with issues and policies to determine the price of ground water.

An attempt has been made in this paper to compute the groundwater price in terms of investment towards watershed treatment to recharge groundwater aquifer so as to maintain the available dynamic resource in the area and to avoid the adverse impact of overdraft. The case study of the watershed management programme covering Basavapura micro watershed in Gauribidanur taluk, Kolar district, Karnataka has been discussed.

INTRODUCTION

Water is a vital resource essential for the survival of all forms of life and for maintaining healthy ecosystems. Consequent to rising water demand, due to increase in population, irrigation, industrialization, it is rapidly becoming a scarce commodity in many parts of the country, requiring innovative approaches for conservation and judicious use. Dependence on ground water in Karnataka state is so high that 50% of irrigation is from ground water and about 90% of the need of drinking water is met from this resource. As groundwater development is under the control of private sector and there is no regulations to restrict the usage, indiscriminate sinking of wells and uncontrolled pumping of ground water is rampant to meet the growing need of water for farming sector. This has resulted in exploitation of 70% of available groundwater resource and over-exploitation of 80 of the

234 water sheds covering an area of 30% of the state. It has also resulted in deterioration of groundwater quality and ecological imbalance in some parts indicating an urgent need to save it from further deterioration and bring the state out of this situation by scientific management of ground water by the way of water conservation, artificial recharge and groundwater pricing. Ten out of eleven taluks of Kolar district are included in the 22 over-exploited taluks of the state. The stage of groundwater development in Kolar district taken as a whole is about 196%. All the 11 taluks of the district are over-exploited with the stage of development varying from 117-239% (Table 1). This shows a grim situation of over-exploitation resulting in continuous falling of water level, drying of wells, dwindling yields and loss of irrigation potential. To cope with the situation the farmers have gone for deeper and deeper bore wells, resulting additional stress on the groundwater regime. As of now the bore well down to 300 to 350 m is of common site in the district unlike in other parts of state where the maximum depth is around 150 m.

Table 1. Stage of groundwater development in Kolar District

Taluk	*Available resources ham/y*	*Present Draft ham/y*	*Stage of development %*	*Category of the taluk*
Bagepalli	5700	7000	117	Over-exploited
Bangarpet	9765	21850	224	Over-exploited
Chikaballapur	5910	13160	223	Over-exploited
Chintamani	4530	8530	188	Over-exploited
Gauribidanur	5085	11015	217	Over-exploited
Gudibanda	1225	2375	193	Over-exploited
Kolar	4570	6725	147	Over-exploited
Malur	4870	11630	239	Over-exploited
Mulbagal	6990	13985	200	Over-exploited
Sidlaghatta	5740	13155	229	Over-exploited
Srinivasapura	4190	5520	132	Over-exploited

IRRIGATION

Kolar boasts to have more than 4400 tanks most of them were dry for last several years, except for 2005, which was a high rainfall year, and hence did not contribute as a significant source of irrigation. The district is heavily dependent on ground water for irrigation with 99.5% of the area irrigated in district is through ground water during 03-04 year (Fig. 1).

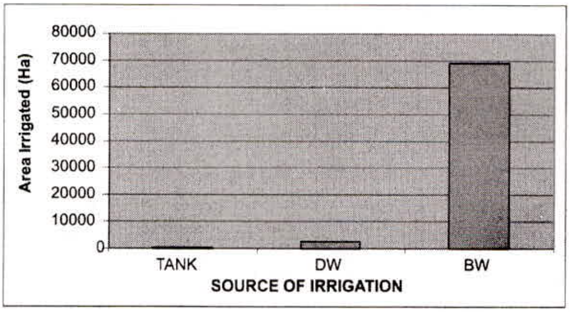

Fig. 1. Source-wise irrigation in Kolar district.

GROUNDWATER DRAFT

There are 10,405 dug wells, 2423 shallow bore wells and 50,445 deep bore wells in the district as per MI Census 2001 with a well density 8/km^2 which is quite high for hard rock terrain. Further many of these wells are not sustainable and farmers are either deepening their bore well or going for new deeper bore wells incurring wasteful expenditure.

Drying of Wells

As the stage of development in the state is about 70%, in several parts of the state groundwater structures go dry year by year. A total of 106,529 wells have gone dry in the state as on 2001 (Table 2) of which 15,638 are in Kolar indicating that about 15% of dried groundwater structures are in Kolar. As the entire district is under over-exploited category with continuous falling trend in water level drying up of wells is quite common. A total number of 12,820 dug wells, 562 shallow bore wells and 2256 deep bore wells have dried in the district as on 2001 (Figs 2-4).

Table 2. Wells dried in Karnataka as on 2001 (MI Census)

Sl. No.	*District*	*Dug wells*	*Shallow bore wells*	*Deep bore wells*	*Total*
1	Bagalkote	1190	547	1090	2827
2	Bangalore	1404	43	308	1755
3	Bangalore Rural	7463	216	1531	9210
4	Belgaum	9399	899	2440	12738
5	Bellary	1746	410	135	2291
6	Bidar	2696	321	450	3467
7	Bijapur	4210	46	1166	5422
8	Chamaraja Nagara	265	102	354	721
9	Chikmagalur	173	1033	34	1240
10	Chitradurga	3770	594	1227	5591
11	Dakshina Kannada	1283	71	224	1578
12	Davanagere	379	1249	1302	2930
13	Dharwar	581	510	360	1451
14	Gadag	1377	975	100	2452
15	Gulbarga	4039	393	137	4569
16	Hassan	290	1029	83	1402
17	Haveri	2800	325	1146	4271
18	Kodagu	23	1	1	25
19	Kolar	12820	562	2256	15638
20	Koppal	1887	762	100	2749
21	Mandya	758	394	276	1428
22	Mysore	215	363	18	596
23	Raichur	406	62	141	609
24	Shimoga	618	344	290	1252
25	Tumkur	16709	607	2133	19449
26	Udupi	369	7	2	378
27	Uttara Kannada	409	69	12	490
	TOTAL	**77279**	**11934**	**17316**	**106529**

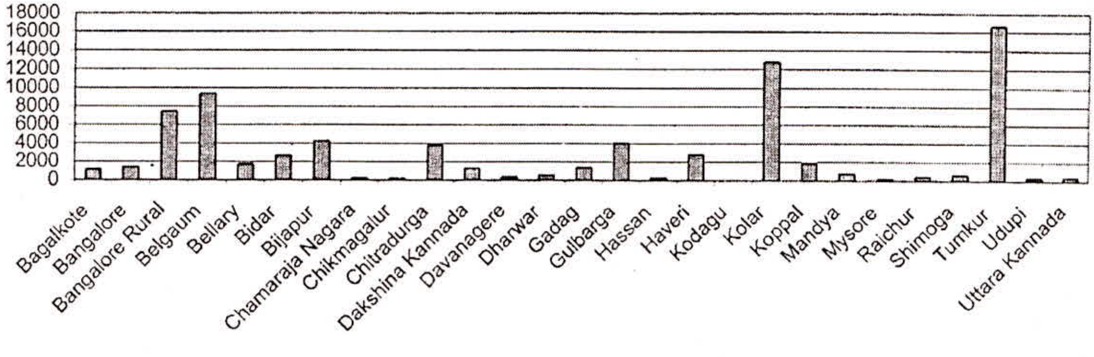

Fig. 2. Dug wells dried as on 2001.

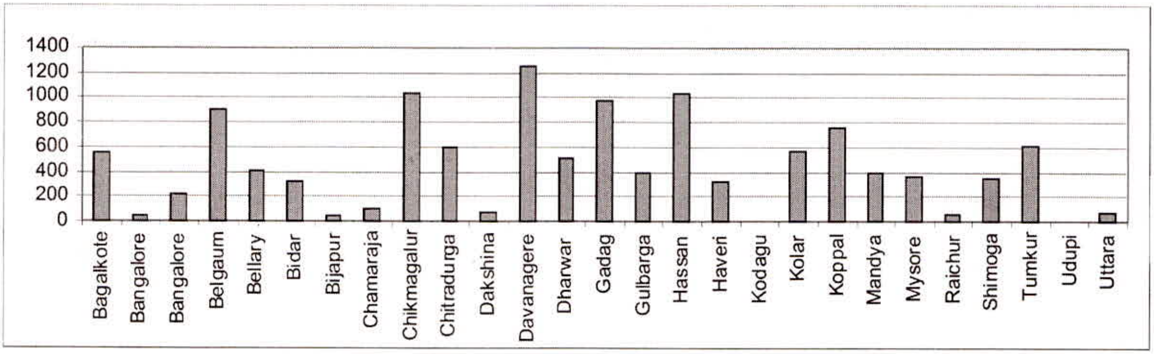

Fig. 3. Shallow bore wells dried as on 2001.

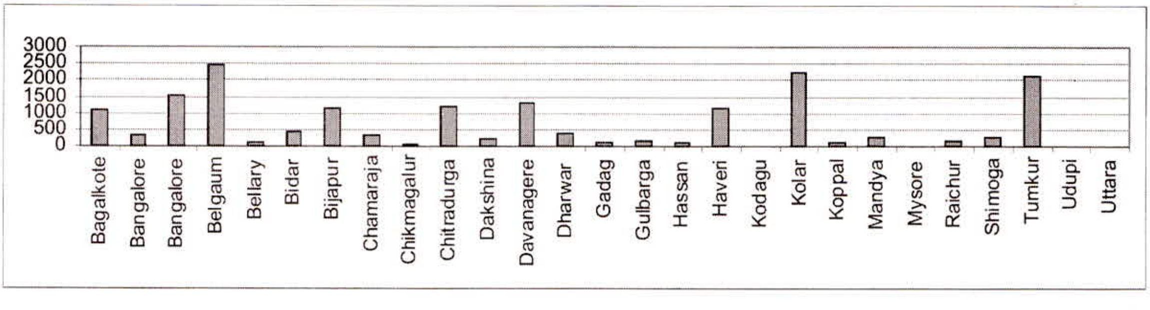

Fig. 4. Deep bore wells dried as on 2001.

Water Level Trend

Long-term trend in water level brings out the status of groundwater development vis a vis the recharge. In Karnataka about 71% of the observation wells showed decadal declining trend during pre-monsoon and 75% during post- monsoon with an average fall of 0.24 m per annum. In Kolar district all the wells have shown declining trend resulting in drying up of phreatic aquifer. However 2005 happened to be an excessive rainfall year wherein copious quantity of water could be collected in tank, surface water bodies and recharge structures and other water conservation structures resulting in remarkable improvement in groundwater scenario and groundwater quality. Selected hydrographs of phreatic aquifers of Kolar district are shown in Fig. 5.

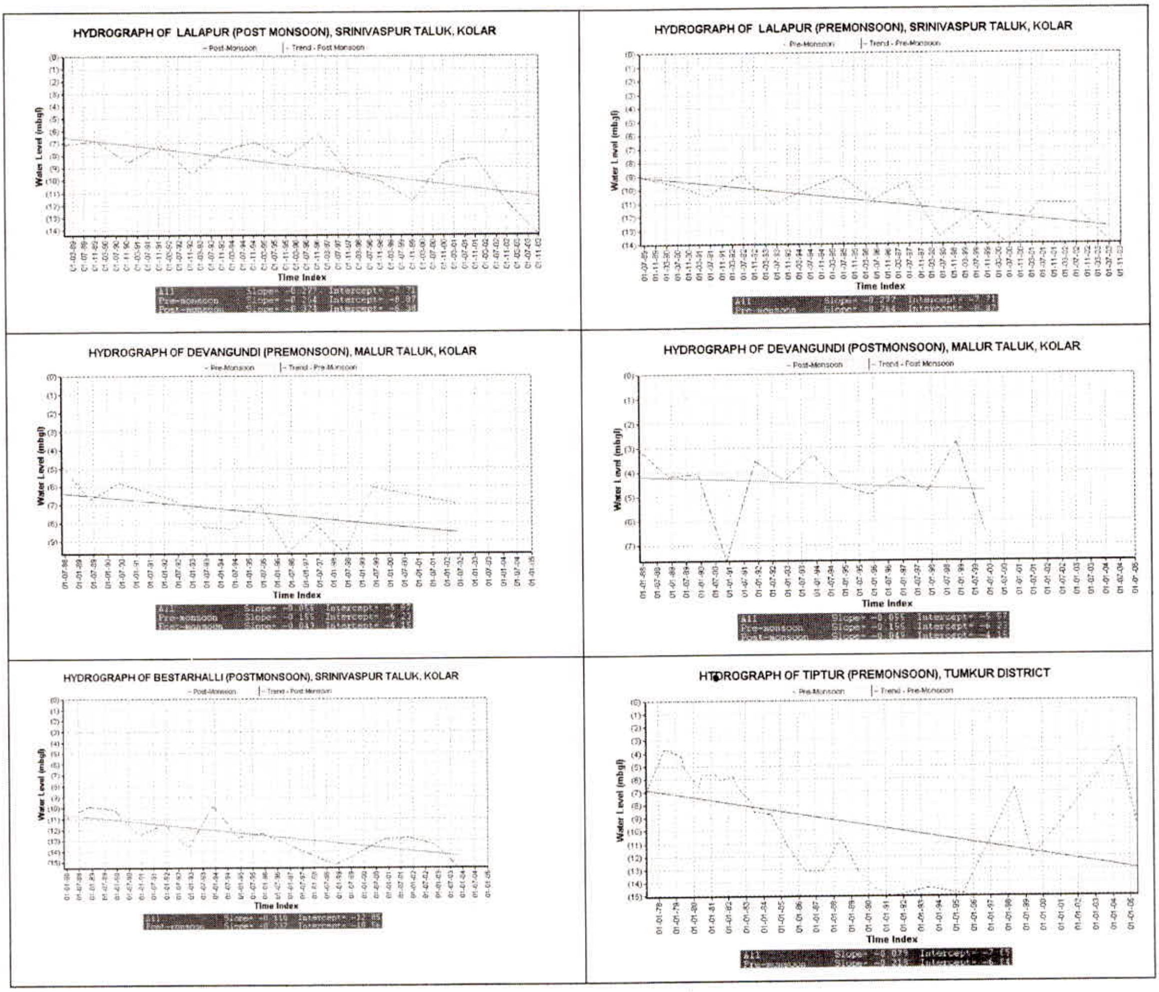

Fig. 5. Trends of groundwater limits.

FINANCIAL IMPLICATIONS OF OVER-EXPLOITATION

Falling water levels have created a severe impact on the economy of the rural population. The farmers were forced to go in for deeper and deeper bore well, or to change the cropping pattern and in certain cases even leading to suicide of the farmers. The financial implication on the available data of the drying of groundwater structures is assessed to be about 580 crores in the state and 91 crores in Kolar as per cost norms of the NABARD. The financial loss due to the dried up groundwater structures as on 2001 is given in Table 3. After 2001 there were three consecutive drought years and on a conservative estimate about 80% of the groundwater structures in some of the over-exploited districts like Kolar, Bangalore, Davangere, Tumkur and Bagalkote have gone dry. This is in addition to the loss from groundwater based agricultural income. Due to non-availability of the data on this account quantification of loss in terms of financial implication could not be done. The increased cost of lift due to the decline in water level also is considerable and it is estimated to be 15.92 crores as on 2000 (Keerthiseelan et al., 2006). Thus the total loss amounts to be 596 crores as on 2001.

Table 3. Calculation of loss due to drying of wells in Karnataka state

Structure	*Average unit* cost (Rs)*	*No. of wells dried as on 2001*		*Loss of Investment (Lakh Rs)*	
		Karnataka	*Kolar*	*Karnataka*	*Kolar*
Deep bore wells	31000	17316	2256	5367.96	699.36
Shallow bore wells	20,000	11934	562	2386.8	112.4
Dug wells	65,000	77279	12820	50231.35	8333
Total		106529	15638	57986.11	9144.76

*as per NABARD norms.

Effect of Over-exploitation on Groundwater Quality

It is reported that there is deterioration in the quality of ground water in bore wells tapping the deeper fractures. Fluoride concentration in deeper bore wells has gone up to 6 ppm as against the permissible limits of 1.5 ppm. Continued consumption of this will create health hazard over the entire population unless its remedial measures are taken up.

Reasons for Over-exploitation

The study on over-exploitation of groundwater resources in the state with special reference to Kolar district brings out the fact that lack of scientific management of the resources are the main culprit. They are

1. Excessive Water Usage for Crops

In Karnataka state the groundwater draft for agricultural purposes is almost double the crop water requirement (Fig. 6). If the ground water is used for irrigation strictly as per the crop water requirements then the stage of groundwater development in the state can be brought down from the present 70% to 60% for the state. In Kolar district the actual draft is twice the available resource. At the same time it is 4.4 times the crop water requirement. If irrigation is followed as per crop water requirement, it is possible to manage draft within the available resource and 85,593 ham of ground water can be saved to recharge the dried aquifer annually in the district (Fig. 7).

2. Unscientific Development

In several parts of the state especially in Kolar the groundwater development is not supply-based but demand-based thereby causing irreparable damage to the groundwater regime. The potential fracture zones down to the depth of 250 m is already exploited and in parts getting dried up. But the farmers

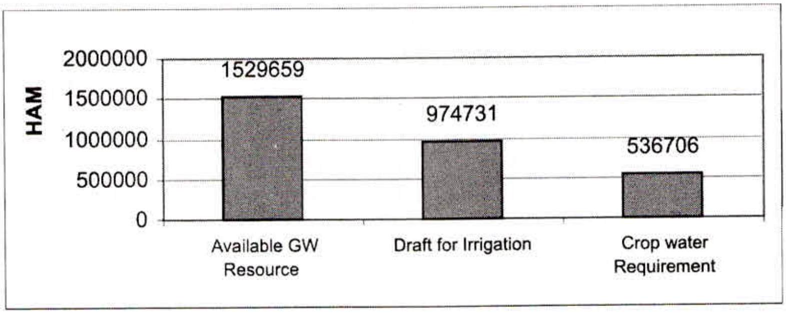

Fig. 6. Groundwater resource vs draft in Karnataka as on 2004.

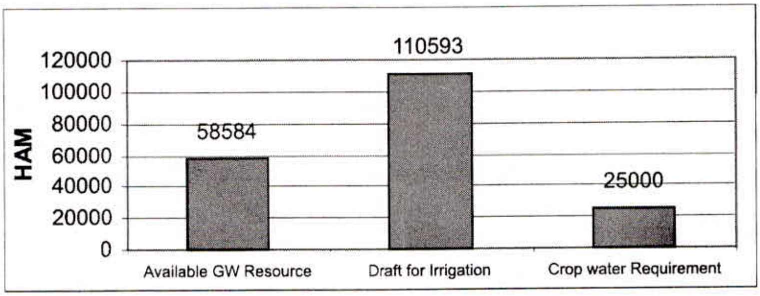

Fig. 7. Available groundwater resource vs draft in Kolar district as on 2004.

instead of reducing the draft invest more to drill deeper bore wells to sustain the crop. In the process the spacing norms and the pumping schedule are thrown out of gear.

3. Traditional Irrigation Practices

The irrigation practice followed in several parts of the over-exploited taluks are same old traditional flooding method which leads to wastage of a large quantity of water.

4. Unsuitable Cropping Pattern

In several parts of the over-exploited taluks of the state it is common to have water intensive crops like paddy and sugar cane. These crops are being irrigated from bore well water.

5. Free Power to Farmers

The subsidized or free power to farmers have resulted in the wastage of water by over-pumping as the farmers resort to continuous pumping whenever power is available. In the process there is an usage of water for the crops.

Remedial Measures

There is an urgent need for sustainable management of groundwater resource so that the requirement of present generation is met without compromising the ability of future generations to meet their own needs. Hence it is required to control declining trend of water levels, drying of wells and deterioration of quality. These objectives can be achieved by following measures.

1. Artificial Recharge

The average annual rainfall of the state is 1189 mm and that of Kolar is 641 mm. Based on the geology and topography large area is identified for construction of artificial recharge structures in the state, especially in the over-exploited areas. The studies in Kolar indicated that construction of percolation tanks and check dams have tremendous influence not only on the sustainability of bore wells but also in improving the quality of ground water. Realising the benefits of these structures in improvement of quality and sustainability of bore wells, the administration of Kolar advised the farmers not to use the tank water for irrigation. Even though there was initial resistance from the farmers two years back, now the farmers vouch for it after reaping the benefit.

2. Restricting Free Power

The free power supply to the farmers is a political necessity and may not be able to do away with. However the same can be restricted based on the land holding and the recommended cropping pattern thereby controlling the excessive draft.

3. Change in Irrigation Pattern

It is observed that actual draft in the state is 1.8 times more than water requirement of crop grown as per crop water requirement. The crop water requirement (CWR) is only 35% of annual groundwater availability. If CWR is followed it is possible to manage the draft within the dynamic zone and 44,000 ham of draft can be saved to recharge already dried aquifer. To achieve this flood irrigation should be avoided and water conserving irrigation systems may be adopted.

4. Change in Cropping Pattern

Water intensive crops like paddy, banana and sugarcane should be avoided as far as possible in groundwater irrigated areas. Paddy requires about four times more water as compared to other crops like ragi, wheat, jowar, bajra, pulses and ground nuts etc.

GROUNDWATER PRICING

Though groundwater withdrawal is through the individual's bore well located in his land, its impact on groundwater regime is beyond his land and results in water level decline, quality deterioration and change of environment in surrounding areas also. As it is a matter of common interest and comes in the way of sustainable management of this resource, it cannot be left for individuals to use and misuse it the way they want. Government should have control over its withdrawal and quality aspect. Free availability of this resource without any control has lead to unmindful pumping without bothering for actual quantity required. Hence there is need to price it to achieve the following:

- To control wastage
- To improve water use efficiency
- To invite innovative practices of irrigation and in water conservation
- To arrest over-exploitation

- To protect the environment
- To generate revenue towards watershed management and artificial recharge

Method of Pricing

In over-exploited areas, there is need to invest money to maintain the hydrogeological conditions by way of scientific management through water conservation techniques. This has to be supplemented with other management practices as mentioned above. The investment can be equated with the dynamic resource available and the additional input required. The revenue collected from the pricing of ground water will partly meet the investment required for artificial recharge to ground water and construction of water conservation structures. Further the pricing should also act as a deterrent for wastage of the precious resource. To effect this the pricing should be such that it pinches the high end users while leaving the marginal users less affected. Water for drinking purposes should be free. There are three prevalent methods of pricing of drinking water supply viz. slab tariff, volumetric tariff and linear tariff.

1. Slab Tariff

Under this users falling under low draft category (Slab 1) can be charged nominally while the users falling under slab 2 can be charged slightly higher and as we progress towards higher slabs the unit cost should go higher and higher. For pricing of groundwater the slab tariff is recommended. Many experts have shown their preference for this tariff because it contributes to equity, conserves the water resource and provides incentive to consumers to effect savings on water use. Further, there should be separate slab tariffs for different sectors like domestic, irrigation and industrial. Drinking water sector should get free access to ground water whereas its rate for industries should be more than that for irrigation purposes.

2. Volumetric Tariff

Under this tariff structure the charge is based on the volume of water drawn from the ground water and unit rate is uniform irrespective of the quantity consumed.

3. Linear Tariff

The tariff under this plan is similar to that of slab tariff but for the slab being that of monetary unit instead of quantity of water drawn.

Pricing should be done annually taking watershed as a unit depending up on the dynamic resource of that year. Cost of net groundwater resource available in a watershed in a particular year should be equal to annual investment arrived from the total investment towards field investigations, groundwater exploration, watershed treatment and construction of artificial recharge structures, their maintenance and monitoring, taking life of structures as 20 years. Pricing should be done only in critical and over-exploited blocks and there should be different rates for different sectors.

Viability of Groundwater Pricing

The viability of groundwater pricing entirely depends on public acceptance of the policy and is difficult to implement. While progress towards this goal has been made in a few water-scarce countries such as Jordan and Israel (Marcus Moench, 2001), the situation is more complex in India with varied hydrogeological conditions with tens of millions of wells distributed throughout. In over-exploited areas, when groundwater regulations are enacted as a part of legislation, the development of resources has to take place under watch. In such a case, public are bound to accept the pricing policy deemed fit for the area and for the sector concerned for various slabs. Public awareness will help in this regard.

CASE STUDY OF BASAVAPURA WATERSHED FOR COMPUTATION OF PRICE

Basvapura watershed, Gauribidanur taluk, Kolar district, Karnataka, where watershed treatment was done and artificial recharge structures were constructed by CGWB during 1994-95, is taken as a case study to estimate the groundwater price. The Basavapura micro watershed is a typical example for the area having intensive groundwater development. Bore wells are the prevailing structures of the abstraction of ground water and is mainly for agriculture. Dug wells in the area have gone dry due to lowering of water table, with the decline being in the order of 10 to 25 m in the last two decades. The prevailing well density is about 35 wells per sq. km.

The area is underlain by granite gneisses. The thickness of overburden varies from less than a metre to about 20 m. The area is covered by sandy to sandy loamy soil. Watershed treatment works in 3.75 sq. km area covering Basavapura and parts of Kallinayakanahalli villages have been implemented under experimental artificial recharge studies by the Central Ground Water Board. Check dams are the predominant structures implemented in Basavapura watershed. The water stored in these structures is mostly confined to stream courses and the height of the check dam is normally less than 2 m. Three piezometers were constructed by CGWB to monitor the phreatic and piezometric water levels in the area. One staff gauge was established to monitor the run-off at the outlet of the micro watershed.

Details of the structures constructed in Basavapura micro watershed:

Structure	*Unit/Coverage*
Check dams	18
Pecolation tank	1
Earthen bund	1
Boulder Checks	93
Rubble checks	35
Vegetative checks:	460 sq.m
Gully revetment:	700 sq.m

Impact Assessment by CGWB

Considering the run-off from the watershed, as per the studies, it was observed that the flow recorded at the outlet of the watershed has been reduced considerably. Correspondingly, the built-up in storage is in the order of 3 to 7 m in comparison with the pre-treatment period. Cost benefit ratio works out to be 1:2.7.

Impact Assessment by Sri Bisrat Alemu Mangesha and M.G. Chandrakanth (2001)

An impact assessment study through Participatory Rural Appraisal mapping of watershed was carried out on "Economic Access to Groundwater Irrigation in Watershed Development in Basavapura watershed" (Bisrat Alemu Mengesha and M.G. Chandrakanth 2001) six years after artificial recharge structures were constructed. According to studies the percentage increment of net area irrigated for large and small farmers was 23 and 36% respectively and net area irrigated increases by 26 per cent. The life of the bore wells were increased by five times in Basuvapura watershed due to the influence of artificial recharge scheme. The proportion of working wells increased from 71% to 85% as the proportion of failed wells declined from 29% to 15%. The irrigation intensity and cropping intensity increased by 8 and 19 per cent respectively after the water conservation programme indicating that dependence on groundwater source is enhanced by the influence of recharge through artificial recharge structures. Outside the watershed development area, the net area irrigated decreased marginally by four per cent.

Price Computation

Annual investment for watershed treatment	= Rs. 172200
Dynamic resource (Net groundwater availability)	= 68.9 ham
Cost of dynamic resource (Annual cost/dynamic resource)	= Rs 2498/ham
Cost of one m^3 of dynamic resource	= Re 0.25 = Rs 0.25
Cost of ground water to irrigate one hectare of non-paddy crop	= Rs 850
Cost of ground water to irrigate one hectare of paddy crop	= Rs 3172

The groundwater rates will vary from watershed to watershed and from year to year depending upon cost of feasible artificial recharge scheme and available dynamic resource of that year which depends upon rainfall.

CONCLUSIONS

- The unplanned and indiscriminate pumping of ground water has resulted in steep decline in water levels in several parts of the state resulting in over-exploitation in 22 taluks.
- Loss due to drying of wells and increased pumping cost in the state is Rs 596 crores as on 2001.
- Adopting irrigation as per crop water requirement will bring the stage of development from 70 to 60% and 4000 ham of ground water can be saved from present draft due to flood irrigation practices.
- Water intensive crops may be avoided in groundwater commands. Non-paddy crops require only 25% of water as compared to paddy.
- Suitable water conservation and artificial recharge methods based on geology may be adopted in over-exploited areas having declining trend.
- Groundwater pricing may be adopted in critical and semi-critical areas to improve water use efficiency.
- Pricing should be fixed based on investment towards watershed treatment and artificial recharge structures
- Drinking water should be free.
- Cost should be effective to have desired effect of water conservation.

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