Emerging Challenges in Groundwater Resource Management before Newly Created State—with Special Reference to Chhattisgarh

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Abstract: The newly formed developing states like Chhattisgarh, which is predominantly agriculture based, has unique problems of groundwater resource development and management, unlike other developed states of the country due to the under developed groundwater resource potential. Eighty seven per cent geographical area of Chhattisgarh is covered by hard rock; still the availability of potential aquifer systems in the state is quite high in comparison to the surrounding hard rock terrain of other states. Ground water in the state is being developed by individuals and therefore needs much more disciplined and scientifically acceptable pumping pattern. Along with geomorphology and aquifer disposition, the socio-economic framework of this developing tribal dominated state also governs the groundwater resource development. Proper understanding of hydrogeological and socio-economical structure of the state is key to the future sustainable development of groundwater resource in the state. The role of credit agencies, governmental policies and availability of power etc. play vital role in groundwater resource development by individuals in the state. The political and social peace and conspicuously low industrial activity in the state along with the high per capita availability of overall water resources provides opportunity for steady growth of groundwater resources. In the last two decades the change in groundwater abstraction pattern from dug well zone to bore well zone has produced few complexities. The impact of geogenic contamination in drinking water sector has increased a lot though the threat of pathogenic contamination has reduced due to adoption of hand pump and borewells.

There is a need of proper assessment of available groundwater resources and its utilization and their future prospects. Macro and micro level delineation of potential aquifer systems, adoption of newer technology for proper groundwater resource development and conservation, provision of necessary opportunities of groundwater resource development, regulation and control of groundwater resources for judicious and scientific development, prevention of groundwater pollution and identification of areas suitable for artificial recharge and human resource development for sustainable groundwater resource management in the state is urgently required.

INTRODUCTION

Unlike the developed states of India, the newly created developing state like Chhattisgarh has its unique problems in ground water resource management (GWRM) due to the under developed

groundwater resource potential. The lack of infrastructure, the socio-economic setup, higher forest density along with geomorphological conditions are responsible for the poor development of groundwater resource in the state. Sudden change in political scenario due to creation of new state has brought hope of rapid change in existing groundwater resource utilization. This along with the socio-economic and hydrogeological conditions prevailing in the region is the cause of emerging challenges in GWRM before the state.

To understand these emerging challenges in GWRM of state, proper understanding of geomorphology, hydrogeology and socio-economic structure of the state is essential. The role of credit agencies, governmental policies, and availability of power etc. play vital role in groundwater resource development by individuals in the state.

Chhattisgarh is a rich land of poor people where weaker sections constitute 43.7% of total population. Nearly 46% of the geographical area of the state is covered under forest. The annual per capita availability of water is 3000 m^3, which is much higher than the national average of 1800 m^3/annum. The state is having three major physiographic units namely northern hills, central plain and southern plateau. These three units broadly collaborate with three main river basins i.e Ganga, Mahanadi and Godavari respectively. The central plain is most fertile and densely populated part of the state covering largest area. The southern part is least developed, forested and tribal dominated while the northern part is hilly and undulating, having less development.

SOCIO-ECONOMIC FRAMEWORK

Tribal dominated Chhattisgarh is predominantly an agrarian state with 80% of its population dependent on agriculture. The net sown area of the state is 47,70,296 ha which forms 34.59% of geographical area. Paddy is the main crop and is being grown over 85% of the sown area. Chhattisgarh is a mono-crop area as double crop is practiced only in 20% of net sown area (Agri.Statistics, 2005). The cropping pattern here is mainly rain fed and agriculture often exposed to the vagaries of monsoon, since only 23% of cropped area is being brought under assured irrigation. Irrigation is mainly through surface water by means of canal water (64%) and through groundwater (24%). Groundwater irrigation mostly depends on the efforts of individuals; government's contribution is negligible (Table 1). Nearly 50% of the farmers here are marginal and another 25% are small farmers; a majority of them are from weaker section of the society (where literacy is still low) who are not in a position to grasp the opportunities provided by governmental policy or advantages offered by credit agencies in the state. The complexities further grow due to insufficient infrastructure facilities particularly the power supply. In spite of the favourable conditions, political and social peace and conspicuously low industrial activities, groundwater resource development is not as good as it should be, due to the socio-economic reasons.

GEOHYDROLOGICAL FRAMEWORK

Chhattisgarh is mainly occupied by hard rocks of Archaean to Proterozoic age, which cover 85% of the area (Table 2). Gondwana semi consolidated sediments covers only 12% area. The karstic limestone and gypsiferous shale are two most significant aquifer formations found within the Proterozoic hard rock in Chhattigarh basin and can produce large quantity of water in comparison to the crystalline basements, which cover almost 58% of the area (Fig. 1) The aquifers in hard rocks are mainly

unconfined to semi confined, while confining condition is restricted to the Gondwana rocks in northern part and in some shale areas. In general depth to water level in state remains shallow between 1 and 20 m bgl throughout the year. However in isolated patches, mainly in central plains, premonsoon level drops down to 40-60 mbgl producing threat to the sustainability of handpumps, the life line of rural drinking water supply. The seasonal water level fluctuation remains to the tune of 3 to 9 m in maximum part of the state (CGWB, 2005a). The groundwater flow directions broadly follow the surface water divides; hence the base flow are mainly through Mahanadi, Indravati and Rihad rivers. The groundwater development in the state is highly uneven. In the southern Bastar plateau it is minimum and varies from 3 to 9% whereas in the northern part it ranges from 13 to 25%. In the central plains maximum groundwater development has taken place due to favourable geographical and hydrogeological conditions and better awareness. Groundwater development here varies from 21 to 65%. In isolated patches (eight blocks) the groundwater development has reached up to semi critical condition showing declining groundwater levels trend. However large parts of central plain are still underdeveloped.

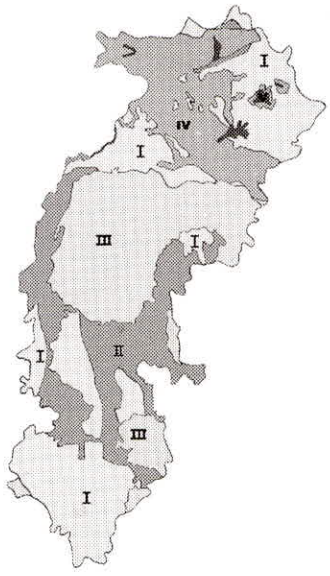

Fig. 1. Groundwater province. Index as in Table 2, column 1.

The increase in groundwater utilization in the last 15 years for agricultural activities through adoption of bore wells has increased the groundwater draft more than 4 times. During the year 1990 the groundwater draft was 60,830 ha m (CGWB, 1994) that has increased to 279,530 ha m, resulting in an overall increase in stage of groundwater development from 3.31% to 20.43% (CGWB, 2005b). The present stage of development of groundwater in the state varies from 2.36% in Dantewada to 65.41% in Durg district. The groundwater irrigated area has increased more than five times in last decade from 0.087 to 0.4.1 m ha. Overall increase in the irrigated area of state during last decade has only been contributed through groundwater.

However the development has not been uniform and steady in the state. Due to multifarious reasons, the development has been slow in certain areas but it has galloped in other places. Out of 146 blocks of Chhattisgarh, the stage of groundwater development is still less than 30% in 104 blocks, between 30-50% in 19 blocks and more than 50% only in 23 blocks. However there are only eight 'semi-critical' blocks (Gurur, Durg, Dhamtari, Balod, Dhamda, Patan, Saja and Belha) and no 'critical' or 'over exploited' blocks as per the latest (CGWB, 2005b) resource estimation [based on the modified GEC 1997 methodology (MOWR, 1997)] in the state. During 1990's all the blocks were below 33%. When compared with earlier resource estimation of 1990's groundwater development in it shows two to nine fold increase in the stage of groundwater development among those 42 blocks where presently the groundwater development is more than 30%. Significant development has been noticed in Patharia, and Takatpur blocks of Bilaspur district, Balod, Belha, Dhamda and Dondi Lohara blocks of Durg district, Champa block of Janjgir-Champa district, Pandaria and Sahashpur Lohara blocks of Kawardha district where the stage of development has increased more than seven times (Tewari and Mukherjee, 2006).

Table 1. Status of irrigation by various sources in Chhattisgarh

District	No of Canal	Canal Irr. Area in ha		No of Irr. Bore/Tube wells			Govt.BW/TW Irr. Area in ha		Priv.BW/TW Irr. Area in ha	
		Net	Gross	By Govt	By Priv.	Total	Net	Gross	Net	Gross
Raipur	103	222427	222427	454	7810	8264	993	993	30962	27261
Mahasamund	59	39835	39795	3	7467	7470	50	50	19575	16372
Dhamtari	10	78247	78247	4	11938	11942	10	9	27806	18678
Durg	294	126123	126123	957	23840	24797	3060	2815	96177	57300
Rajnandgaon	188	51783	49950	563	2255	2818	1839	1364	8083	5171
Kawardha	39	22571	19454	218	2782	3000	2216	817	18868	13506
Bastar	12	237	237	52	764	816	244	244	1536	1536
Kanker	19	6224	6224	141	2304	2445	0	0	5079	5079
Dantewada	21	4043	4043	3	59	62	58	58	142	142
Bilaspur	109	112269	111456	739	6988	7727	192	192	19135	15317
Janjgir-Champa	11	138020	133816	0	2640	2640	0	0	10468	5063
Korba	35	3332	3332	45	42	87	0	0	138	138
Sargujga	152	9381	9181	228	562	790	113	113	923	923
Koriya	77	5496	4695	55	89	144	20	20	36	36
Raigarh	58	17737	16339	417	6361	6778	475	420	26211	23651
Jashpur	50	4812	4668	0	1	1	0	0	2	2
	1237	**842,537**	**829,987**	**3879**	**75,902**	**79,781**	**9270**	**7095**	**265,141**	**190,175**

District	No of Irr. Dug wells		Dug well Irr. Area in ha				Total Irr. by all means in ha		Area of Net Ground water Irr. in ha	Percentage of all Irri area
	By Priv	Total	By Govt Net	By Govt Gross	By Priv Net	By Priv Gross	Net	Gross		
Raipur	26896	26896	0	0	5970	5828	284898	281055	37925	43%
Mahasamund	14200	14200	0	0	1553	1480	70560	67166	21178	24%
Dhamtari	4215	4215	0	0	1513	1478	110019	100751	29329	52%
Durg	6219	6219	0	0	4724	2885	259289	215430	103961	32%
Rajnandgaon	9407	9407	0	0	4451	3133	74814	67754	14373	17%
Kawardha	1886	1892	16	16	932	744	48127	37695	22032	20%
Bastar	4467	4472	0	0	907	907	6940	6940	2687	2%
Kanker	4291	4327	1	1	926	926	19716	19716	6006	9%
Dantewada	388	388	0	0	83	83	4917	4917	283	2%
Bilaspur	6193	6454	0	0	5922	4967	148361	142158	25249	31%
Janjgir-Champa	6512	6512	3	3	6359	4918	163664	151856	16830	54%
Korba	1863	1863	0	0	1207	1207	7188	7188	1345	5%
Sargujga	48186	49314	0	0	6918	6691	38673	36590	7954	7%
Koriya	6774	6915	0	0	939	779	7971	6793	995	7%
Raigarh	3794	3794	0	0	902	867	59093	54059	27588	19%
Jashpur	11462	11462	0	0	2039	2039	8146	8002	2041	3%
	156,753	**158,330**	**20**	**20**	**45,345**	**38,932**	**1312,376**	**1208,070**	**319,776**	**23%**

Source: Agri. Statistics 2005

Table 2. Hydrogeological sequence of Chhattisgarh state

Groundwater Province	*Rock type*	*Distribution*	*Characters*
Unconsolidated sediments Sub Recent to Recent (VI)	Alluvium/Laterite (Around 1%)	Isolated patches all over the state. Along major drainage.	Unconfined to confined shallow aquifer, Developed by dug/dug cum bore and Filter points. *Locally potential.*
Sheet volcanics Cretaceous to Palaeogene (V)	Deccan Trap (Around 2%)	Jashpur, Sarguja, Kabirdham, Bilaspur	Unconfined to confined aquifer, Developed by dug/dug cum bore. *Locally Potential.*
Semi-consolidated sediments Carboniferous to Cretaceous (IV)	Gondwana Supergroup Lameta beds (Around 12%)	Raigarh, Sarguja, Koriya, Korba, Bilaspur, Jashpur	Unconfined to confined deeper aquifer, Developed by dug wells and deep tube wells. Iron problems common wide. *Widely Potential.*
Purana rocks of Chhattisgarh Meso to Neo Proterozoic (III)	Chhattisgarh Super group Indravati, Sukma, Khariar and Pakhal groups (Around 27%)	Bastar, Raipur, Durg, Dhamtari, Champa, Mahasamund, Rajnandgaon, Raigarh, Kabirdham, Bilaspur, Korba, Dantewara.	Unconfined to semi-confined aquifer, Developed by dug/dug cum bore wells. *Most potential.*
Plutonic, volcanic and meta sedimentary rocks Palaeo Proterozoic (II)	Dongargarh granite and equivalents, Kotri, Chilpi, Nandgaon, Abhujhmar, Khairagarh groups (Around 20%)	Bastar, Kanker, Raipur, Mahasamund, Dhamtari, Rajnandgaon, Kabirdham, Durg, Bilaspur, Raigarh, Sarguja, Dantewara.	Unconfined to semi-confined aquifer, developed by dug/ dug cum bore wells. *Moderately potential.*
Basement crystalline and gneisses Archean to Palaeo Proterozoic (I)	Granulites, Bengpal, gneisses of Bastar & Chotanagpur and Bilaspur-Raigarh-Sarguja belt, Bailadila and Sonakhan group (Around 38%)	Dantewara, Bastar, Kanker, Raipur, Raigarh, Bilaspur, Mahasamund, Rajnandgaon, Sarguja, Jashpur, Kabirdham, Champa, Korba, Durg, Koriya.	Unconfined shallow aquifer, developed by dug/dug cum shallow bore wells. *Least potential.*

CAUSE OF EMERGING CHALLENGES IN GROUNDWATER RESOURCES MANAGEMENT IN STATE

The causes of emerging challenges in groundwater resources management in state are mainly of two types. Firstly those causes that inherently prevail in the state due to geographical, hydrogeological and socio-economical conditions in state. Secondly those created due to creation of new state and related rise in expectation. In addition, there are some more causes due to anthropogenic activities. All these causes pose challenges for the groundwater resources management in the state.

Inherent Cause

Inherent causes which produce challenges in groundwater resources management are mainly natural. The varied hydrogeological condition of the state along with physiography produce unequal opportunities for groundwater resources development. In the northern districts, except Gondwana covered areas all other areas are covered by gneissic complex which are poor aquifers and are not able to sustain even the domestic needs in summer due to very limited storage space restricted mainly in the weathered zone. Secondly the potential aquifers in the Gondwana rocks occuring at 200 m below ground level are presently not being used due to weak economic background of the individuals and poor technical knowhow. This area needs proper management to improve the Groundwater Resources Department. In southern part of the state (Kanker, Bastar and Dantewada district) large part of the area is hilly and forested. Except the Indravati, Sabri and Pakhal basins area, a large area is covered by igneous and metamorphic rocks having low groundwater potential. Further whatever potential is available is not used. Natural groundwater discharge bodies like ground water pond, springs etc are plenty in this area (Fig. 2). The central part which covers maximum area of state is having some groundwater development, wherein isolated patches have semi critical stage of groundwater development. However in remaining parts thrust has to be given to improve the groundwater resources development in a sustainable and equitable manner which need both regulation and encouragement.

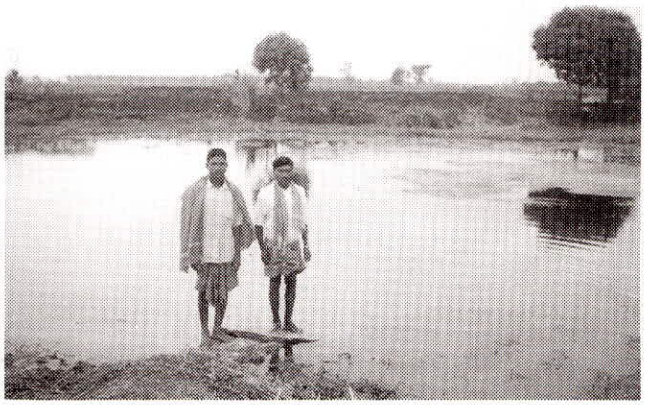

Fig. 2. Ground water pond at village Kamanar, Bastar.

Groundwater Quality

Quality of groundwater is not a matter of serious concern in the state so far. The geogenic contamination due to presence of Fe, SO_4, As, and F has been identified in ascending order of abundance i.e. Fe>> SO_4>As>F (Hunse et al., 2003). Fe problem in drinking water tapped through handpumps is the largest issue in the state which effects almost all the districts and is a serious problem in Dantewada, Bastar and Raigarh district. Thousands of villages are affected with Fe contamination. Higher SO_4 problems are restricted mainly in district/blocks having Gypsiferious shale as in Bilaspur, Durg, Kawardha, Janjgir Champa and Raigarh districts. In few villages the problem is very severe, affecting all the abstraction structures, however in other parts it partially affects the drinking water needs. Arsenic and fluoride problems are restricted to village level and are not very serious except in a few villages.

Karst aquifers in many townships are the only source of drinking water in the state. Karst formation is highly sensitive towards pollution. The waste disposal practice in the urban areas covered by karstic limestone/dolomites is of major concern including the capital city of Raipur. Lack of infrastructure to monitor the effect of waste disposal, especially through bio and organic pollutant has not yet unfolded to identify the level of pollution in groundwater in this area. Proper hydrogeologically acceptable waste management plan has to be developed for the state.

The industrial pollution to groundwater has not so far been detected on the regional scale, though sporadic reports say it is increasing day by day. Strategies for protection of groundwater resources through these anthropogenic pollutions have to be evolved by carrying out detailed studies.

Socio-Economic Causes of Uneven Groundwater Development in State

The majority of farmers in Chhattisgarh state are marginal or small. To alleviate rural hunger and poverty and to face recurrent droughts, it calls for re-evaluation of strategies to improve access to water utilization techniques.

Tribal and backward population constitutes more than 43% of the total population of the state. They have their own traditions, culture and beliefs. The economic status of this section of population is extremely poor. The tribal people have still not moved into the mainstream and are therefore not exposed to the advantages of the health, social and financial benefits of the development schemes. There is therefore an inherent need to educate the population through mass awareness programmes for accepting the benefits of many government developmental schemes like Jaldhara, Indira Khet Ganga Yojana, Swajaldhara, Hariyali and others for utilisation of groundwater resources. Because of the illiteracy and ignorance of this section of society, their exploitation in the hands of rich and influential people goes on unchallenged.

Size and Nature of Land Holdings: The average size of the land holdings in Chhattisgarh state varies from 1.1 ha to 2.3 ha and therefore falls in the small holding category (as per Government of India norms). 45% land holding of state belongs to SC/ST farmers and out of them more than 70% are small to marginal farmers (NABARD, 2005). Consolidation of land holdings may therefore have to be restored to make these holdings financially viable. The financial status of not only the tribal but the remaining population hinders the proper development of groundwater resources. Construction of an abstraction structure, installation of pump and development of the field like its fencing costing between Rs. 0.05 to 0.1 million is a big deal for majority of farmers.

The electricity supply has still not reached in many of the villages in the state and even in villages where it has reached, the supply of electricity is erratic. The problem of low voltage and its non-availability during agricultural activities are some of the major problems faced by the cultivator. Full benefits of few of the government developmental schemes do not immediately reach the intended beneficiaries. In many cases for example if a farmer is somehow able to construct a dug well or a bore well, for want of electricity, he is unable to install a pump since it will entail a lot of investment.

Other Causes

Chhattisgarh, the 26th state of India was carved out of Madhya Pradesh on 1st November 2000 to fulfill the long cherished dream and aspirations of the local people. The newly formed government has to work diligently to fulfill the high expectations of the 20 million people of the state. The state has plenty of water resource to meet demands for rapid growth. The government policies are made accordingly.

1. Government is trying to attract large number of industrial investment which will affect the groundwater regime.
2. The state is rich in mineral resources; Govt policy for rapid extraction of the mineral wealth is obvious for economic development of state, which is bound to disturb the groundwater system.

3. The state after its formation have concentrated its focus to improve the irrigated area. Massive surface water projects were launched within a short period. This is going to change the groundwater balance in the command area where water levels are already shallow in most part (Fig. 3).
4. Government policy to make the state power hub in the region will enhance coal mining, fly ash dumping and construction of large reservoirs will change the groundwater scenario in the area.

DISCUSSION AND CONCLUSION

The discussions in previous paragraph show that the challenges in groundwater resources management in the state is mainly due to low development on one hand and sustainability of resource in lean period on the other hand. Groundwater pollution though is not alarming at present but due to shallow water levels and further industrilization it can lead to serious problems if not properly managed. Similarly in the command area, the existing shallow water level can reach water logged condition if not treated properly.

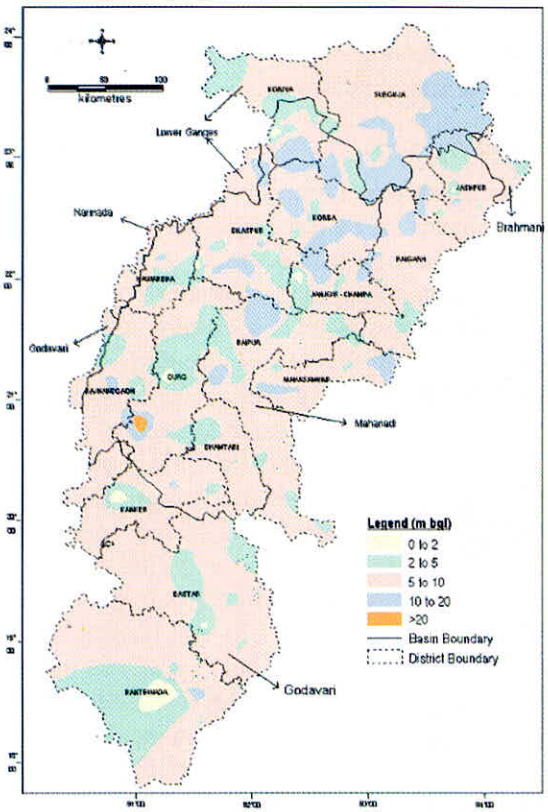

Fig. 3. Pre monsoon depth to water level map of Chhattisgarh (May 2005).
Source: State Report 2006.

There is a need of proper assessment of available groundwater resources and its utilization, macro and micro level delineation of potential aquifer system, and adoption of newer technology for proper groundwater resources development. In the last two decades the change in groundwater abstraction pattern from dug well to bore well has produced few complexities. The aquifer tapped using bore wells are mostly semi confined and it takes more time to naturally recharge these semi confined aquifers than phreatic aquifer. This practice tends to decline the water level in this zone. There is a need of proper artificial recharge technique to replenish groundwater at a higher rate than natural recharge.

All this clearly points towards regular and intensive monitoring and sampling along with macro to micro level studies to generate huge database for proper management of the resource and tackle the emerging problems of groundwater resource management in the newly created state.

From the above discussions it can be said that the following points summarize emerging challenges in groundwater resource management before the newly created state.

1. To tackle the problems arising from low groundwater development.
2. Enhance the existing groundwater development in area where development is low.
3. To regulate the draft in isolated pockets of Groundwater development.
4. Take adequate measures to replenish the aquifer in the declining groundwater level area.
5. Protection of shallow groundwater from pollution.

6. Develop hydrogeologically acceptable waste disposal pattern, particularly in Karstic terrain.
7. In view of prevailing socio-economic status of the farmers, development of suitable role of credit agency and Govt. policies to promote the groundwater resource development
8. To promote the use of diesel pumpsets for groundwater draft as the government is promoting bio diesel in the state to solve the low voltage and power deficiency problem.
9. To enhance the storage capacity of aquifers through proper rain water harvesting practice. The financial provision towards various "assured income schemes" of government can be utilized for this purpose, such as Rojgar Guaranty Scheme etc.
10. Adoption of new technology and scientific methods for groundwater development.
11. Human resource development for sustainable groundwater resource management in the state.

ACKNOWLEDGEMENT

Authors are thankful to Chairman, Central Ground Water Board for allowing us to present and publish the paper. Guidance provided by Dr. A. Srisailanath, Regional Director, CGWB NCCR Raipur while preparing the manuscript is thankfully acknowledged. Thanks are due to Smt. Rumi Mukherjee, Sc. "B", CGWB, NCCR for careful editing.

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