International Journal of Social Science and Economic Research

ISSN: 2455-8834

Volume:03, Issue:12 "December 2018"

Exploring Ground Water Status and Development in Baghelkhand Region of Madhya Pradesh

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ABSTRACT

Ground water is main source for drinking and irrigation in the region. About 90 per cent of irrigation in the districts is from ground water sources; though level of irrigation in the district is very low i.e. only 23 per cent of net sown. There are 40.48 per cent tube wells and 28.80 per cent of dug wells for irrigation in total irrigation sources in the districts. Effort was done to exploring ground water status and development in Baghelkhand region of Madhya Pradesh. Regional variation of average rainfall was calculated. Temporal analysis of ground water, water level fluctuation was also calculated. Assessment of ground water quality was done to understand the suitability for drinking and irrigation purposes. Stages of ground water development in Rewa and Satna district are highest in the region which is 42 and 69 per cent respectively. Shahdol district stands very low (7 percent) in groundwater development uses while Umaria district (9 percent) is consequently increasing. These districts are under developed in region in terms of irrigation and water supply. Ground water for drinking, industrial and other uses exhibits more than 138.6 Million cubic meters (MCM) in the region. Umaria, Shahdol and Sidhi district have maximum potential of ground water availability but due to backwardness of the region the development of ground water is unsatisfactory.

Keywords: Ground water, temporal analysis, ground water development, regional variation

1. Introduction

The geo-environmental implications of agricultural growth on physical environment in general and water resource in particular, it is worthwhile to mention that the quality of water is as important as quantity, because quality determines the usefulness of water for any particular use. Along with the natural sources, anthropogenic activities are also influencing water quality. Increasing population, expanding urbanization, construction activities, rapid industrialization and modernization of agricultural operation during recent years have threatened the environment with consequences of severe pollution (Valdiya, 1987). The main source of water contamination can be categorized into two groups i.e. point source and non- point source. The overwhelming

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majority of water quality problems are now caused by diffuse "non-point" sources of pollution from agricultural land, urban development, and forest degradation etc. The non-point pollution sources are more difficult to control and evaluate than point sources because they have many diffuse and wide spread origins. The amount of pollution delivered by them varies from hour to hour and season to season, making it difficult to quantify the sources. The use of land for agriculture and the practices followed in cultivation greatly affect the quality of groundwater. Intensive cultivation practices cause chemical fertilizers and pesticides to seep into the groundwater a process commonly known as leaching. Routine applications of fertilizers and pesticides for agriculture and indiscriminate disposal of industrial and domestic wastes are increasingly being recognized as significant source of water pollution. Besides the leaching of agriculture chemicals in groundwater is also contaminated by farm irrigation runoff from agricultural fields where these chemicals have been used indiscriminately. Factors that affect the rate and magnitude of agricultural groundwater contamination will vary greatly with the structure and depth of the material that lies between irrigated fields and the groundwater surface.

Groundwater plays a critical role in supporting the lives and livelihoods of both rural and urban population. Groundwater resources are ubiquitous in most regions and available in large volumes and of a quality that is generally good or sufficient for its intended use. This has contributed immensely to poverty alleviation, food security, livelihood and wider socio-economic development. According to an estimate, it accounts for nearly 80% of the rural domestic water needs, and 50% of the urban water needs in India (Kumar and Shah, 2003). Groundwater is generally less susceptible to contamination and pollution when compared to surface water bodies. Also, the natural impurities in rainwater, which replenishes groundwater systems, get removed while infiltrating through soil strata. Groundwater is extensively used in Delhi, U.P., M.P., Bihar and W. B. for irrigation and industrial purposes.

Lack of water harvesting structures like Check dams, Enikuts, etc. has resulted to depletion of ground water table. The problems of water resource management are lack of adequate and timely efforts in planning and design of irrigation works from headwork's to fields channels suited to agricultural crops as per irrigation practices, inefficient use of water, lack of policy on- farm development works, groundwater depletion, inadequate or absence of watershed management, deficiencies in command area development agencies. In domestic and industrial water supply, there is inadequate attention towards preparation of perspective plans for domestic and industrial water supply, by river basin or by sources, inadequate safe water supplies in rural and urban areas, surface and groundwater pollution. It is undeniable that a large part of the problem can be solved by revival of local and traditional water storage structures, innovative method of harvesting and integrated watershed development.

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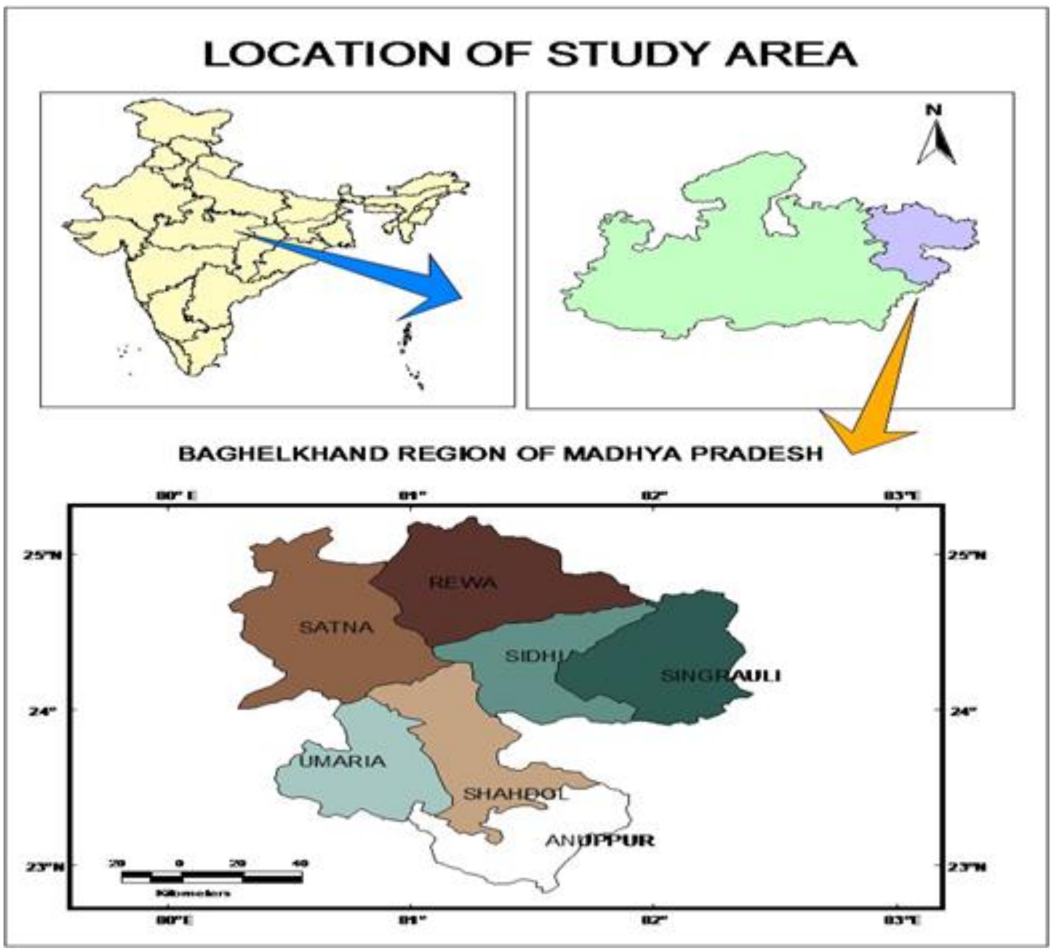
2. Data source and Methodology

2.1 Position and Extent

Baghelkhand region of Madhya Pradesh extends between the latitudes 22° 50' to 25° 28' North and the longitudes 80° 20' to 82° 58' east. It is in the central part of the peninsular 'foreland' and situated between the alluvial stretch of the northern Great Plains and the Deccan. It naturally presents a transitional zone incorporating the Vindhyanchal (fig.1). The very name of the region is derived from the combination of physical and cultural complex. The region's northern boundary touch with Allahabad and Chitrakoot district of Uttar Pradesh and north-east part touch with Mirzapur district. Sarguja (Baikunthpur), Jabalpur and Dindori district come to east and south of the region. Western limits of the region touch through Panna district (Singh, 1971).

Figure 1.: Map of the study area



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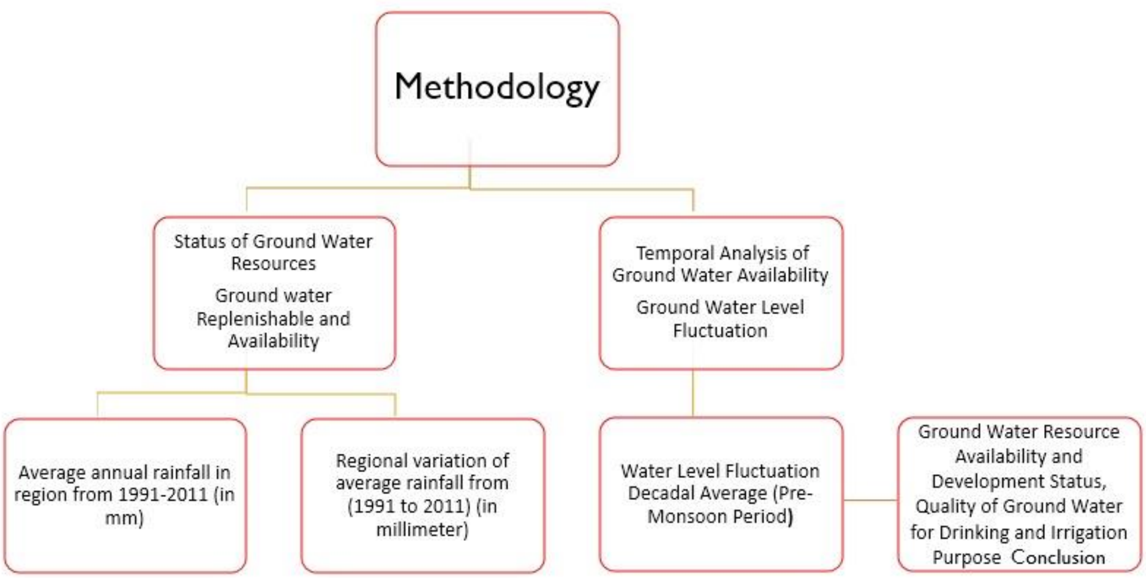
2.2 Source of data and study design:

The present study of status of ground water has been taken up on two villages of all districts of region and five households from each villages mean total sixty households has been selected for questionnaire based survey. Secondary data sources have also been used from Ground water board, Water Aid India and other Government offices for assessing the position of ground water resource which come under Baghelkhand region.

Figure 2.: Flow diagram representing position of ground water resource in Baghelkhand region



3. Result and Discussion:

3.1. Status of Ground Water Resources

Ground water resource estimation of all districts which come under Baghelkhand region has been collected from central ground water board, government of India. The annual ground water replenishable in region is 3045.49 MCM in rainfall season while 228 MCM ground water recharge through other sources. In recharging of ground water through other sources refers canal seepage, return flow factor, seepage from water bodies etc. There is a total 4137.76 MCM annual ground water recharge in monsoon and non-monsoon season while 207 MCM natural discharges during non-monsoon season.

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All districts of region come under safe zone (except Satna district) and development of ground water is very low. Satna district (Rampur-Baghelan block) comes under semi- critical zone at present because over exploitation of ground water resource has been gone up in this district. More than 69 percent of ground water has been developed in Satna district. As per Ground water resource data figures, Net Ground Water availability in region is 3930.84 Million Cubic Meter (MCM)and Ground Water Draft for all uses is 1019.54 MCM, making stage of Ground water development 26.00 percent as a whole of region. 277.54 MCM is available for future domestic and industrial supply for next 25 years and balance available ground water for future irrigation would be 2797.54 MCM, at 50 per cent stage of ground water development's safe limits, in all districts (except Satna district) of region (Table 1).

Table 1.: Ground water Replenishable and Availability (Million Cubic Meters)

Districts	Annual ground water Replenishable (2004-05)					Natural discharge during Non-monsoon season	Net annual ground water availability
	Monsoon season		Non-monsoon season		Total		
	Recharge from rainfall	Recharge from other sources	Recharge from rainfall	Recharge from other sources			
Anuppur	403.93	1.54	54.91	4.97	465.34	23.27	442.07
Rewa	470.82	7.24	0	55.52	533.58	26.69	506.89
Satna	563.01	13.77	0	70.35	647.13	32.36	614.77
Shahdol	90.18	2.34	0	7.97	911.49	45.57	865.92
Sidhi	826.66	6.7	0	40.52	873.87	43.7	830.16
Umaria	690.89	2.48	0	12.99	706.35	35.32	671.03
Region	3045.49	34.07	54.91	192.32	4137.76	206.91	3930.84

Source: Ground water board, 2004

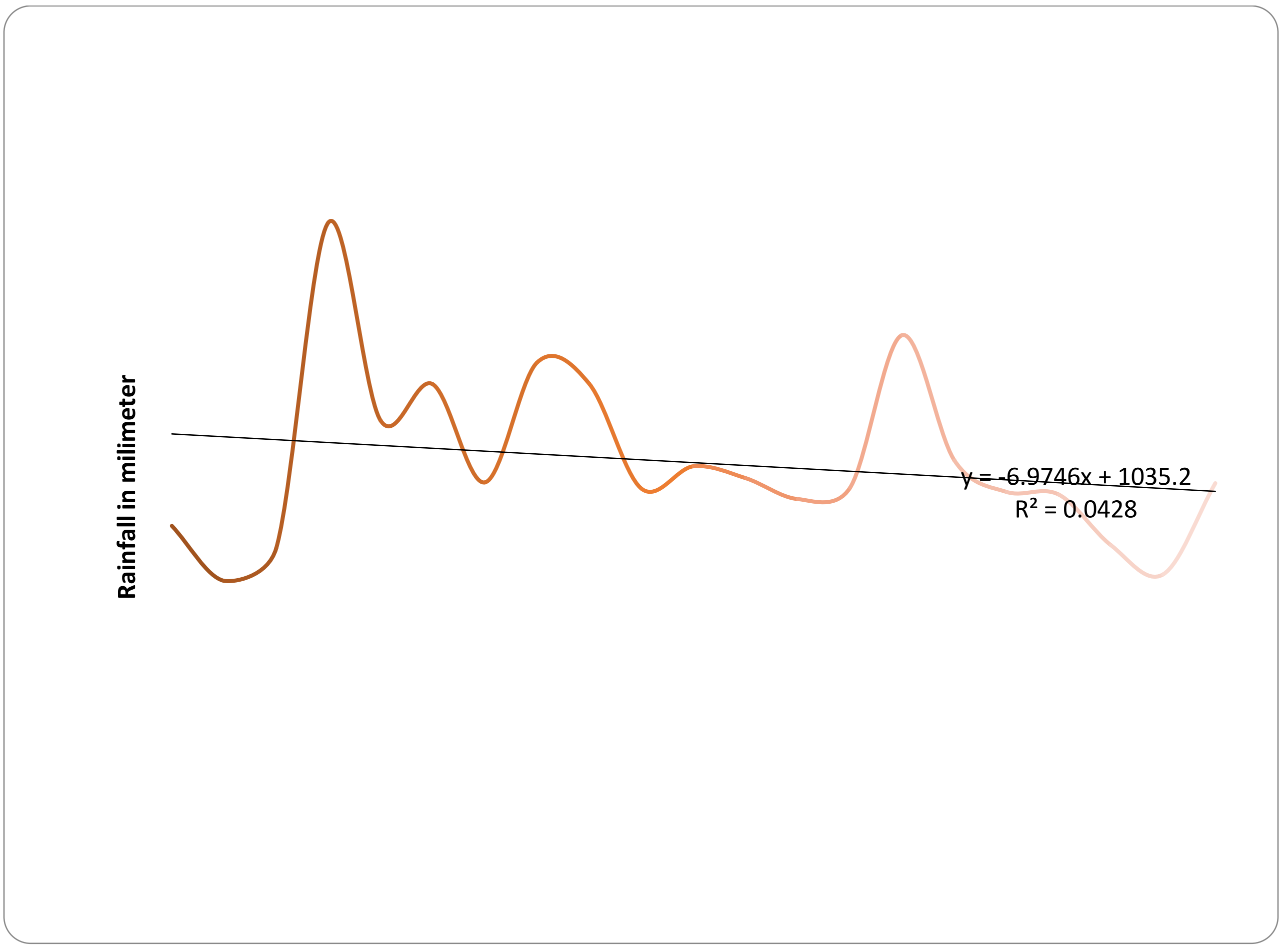
3.2 Temporal Analysis of Ground Water Availability

In temporal analysis, the precipitation data has been taken from 1991 to 2010. Ground water fluctuation and depth analysis data is from 1996 to 2006 and ground water fluctuation and depth of water level has been discussed in this part, while comparison of ground water availability has also been discussed from different decades. This analysis has been done with the help of data provided through central ground water board, ministry of water resource, Government of India.

3.2.1 Precipitation

In Baghelkhand region, rainfall is evenly distributed spatially but not temporally. The average annual rainfall of the country for 2011-12 is around 954 millimetres against the Normal rainfall of 1197 mm (Departure of 20 per cent less than the Normal). Rainfall is sufficient in region but (figure 2.5) the average annual rainfall is declining from 1991 to 2010. A review of annual ground water availability, contribution from monsoon rainfall recharge and annual ground water draft in

Figure 3.: Average annual rainfall in region from 1991-2011 (in mm)



Source: Indian Metrological Department, Pune and India water portal, 2010.

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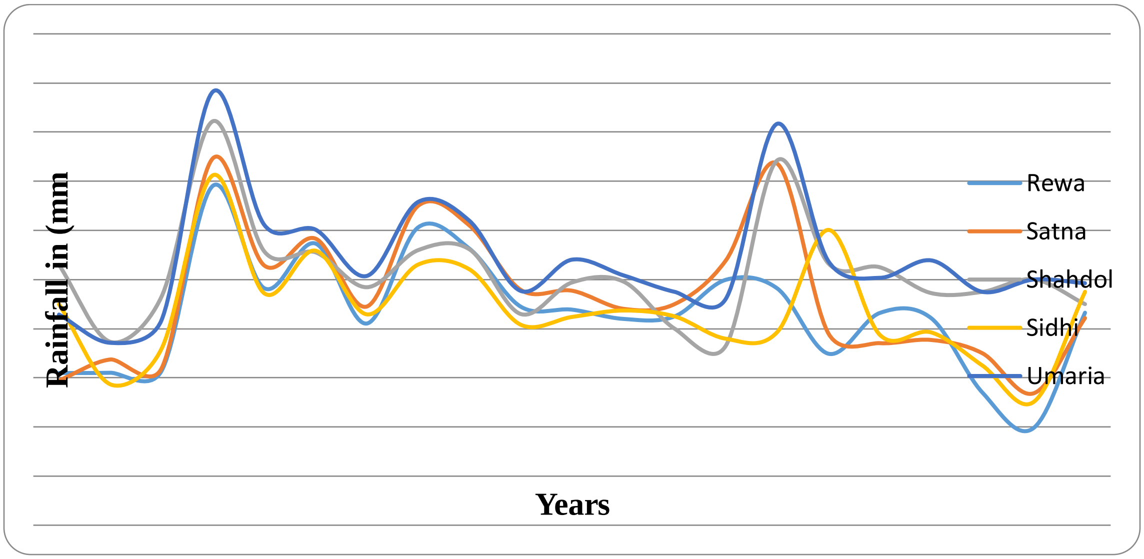
Figure 4.: Regional variation of average rainfall from (1991 to 2011) (in millimeter)



Source: Indian Metrological Department, Pune and India Water Portal, 2011

different districts falling safe category and the rainfall distribution in space brings a paradoxical situation in the sense that, withdrawal of ground water is not solely responsible for declining trends, the scantly and low rainfall resulting in meagre monsoon recharge is equally important. Majority of the ground water stress areas categorized as overexploited and critical units also lies in these states (fig. 3).

In the region, the annual rainfall exhibited 1032.16 mm in 2004 and it decreased to 878 mm five years later. The highest rainfall was recorded in year of 1994 followed by 2005 (figure 2.5 and 2.6). In 2005 region marked highest rainfall but the Sidhi and Rewa district recorded lowest rainfall. The (figure 2.6) demonstrates that the Shahdol and Umaria district has highest annual rainfall comparison to other districts. The region witnessed lowest rainfall in the year of 2009 followed by 1991-93, which faced deficiency of water related facilities. The less precipitation takes water deficiency water depth further down in region ultimately affecting water supply in domestic, small industries and irrigation sectors (fig. 4).

3.2.2 Ground Water Level fluctuation

Water Level Fluctuation Decadal Average (Pre- Monsoon Period)

The depth to water level data of May 2006 have been compared with average water level data of May 1996 to May 2005 and the map so prepared reveals the following details. The ground water levels were influenced by pre-monsoon rainfall received in the area in mid-May this year. In

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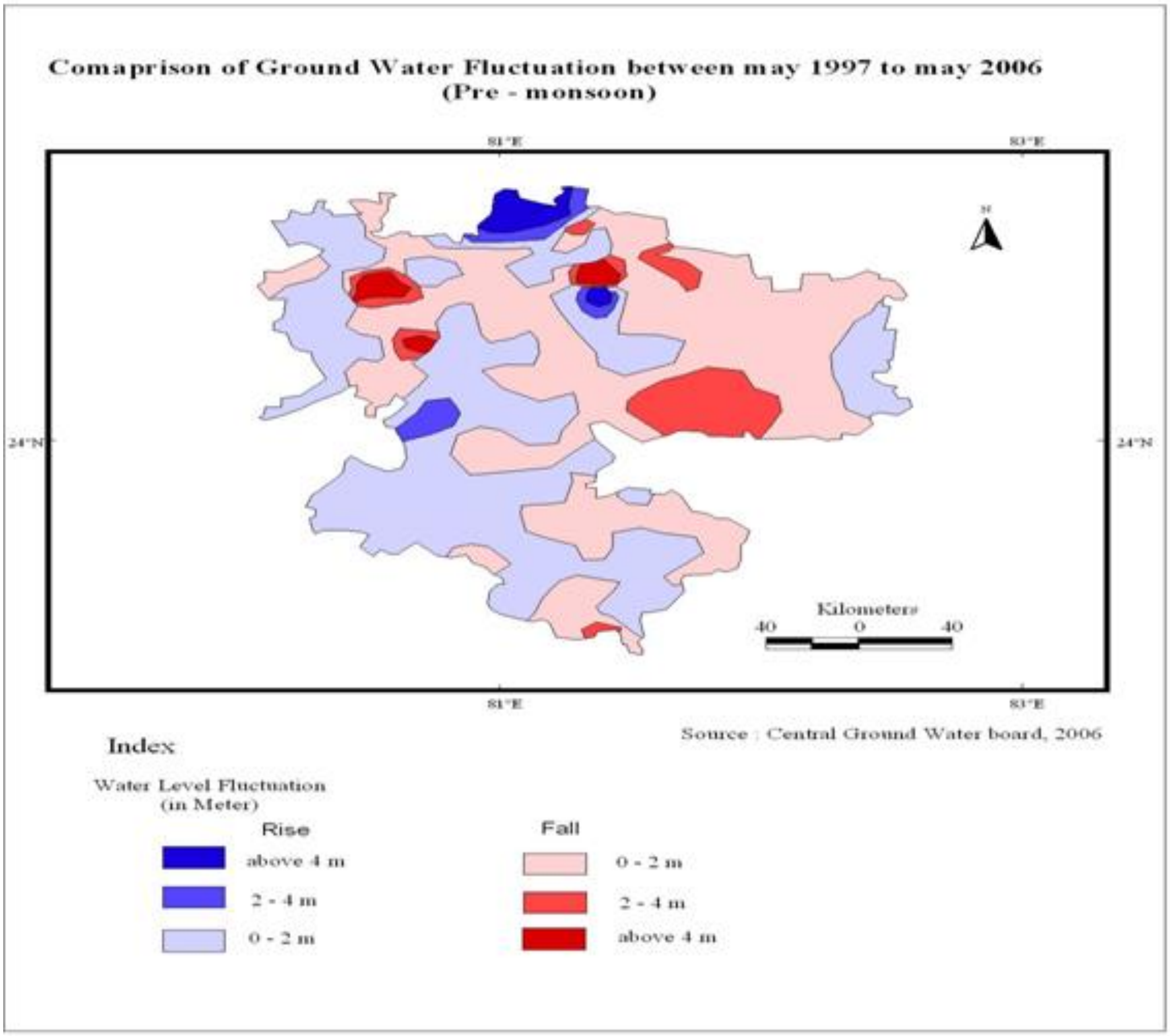
general, there is a fall / rise up to 2 m in groundwater level during May this year in most parts of the region in relation to average of last 10 years (1996 to 2005) pre- monsoon (May) groundwater level.

Figure 5



There is fall upto 4 m in water levels, observed in the entire regional area of the region and noted in 39.6 per cent of monitoring network wells. A fall between 2 and 4 m in water levels is observed in some small pockets in parts of Rewa, Satna, Anuppur, Sidhi districts and recorded in 11.99 per cent of monitoring network wells. A decrease of more than 4m in water levels is observed in pockets in parts of Rewa districts and few wells in parts of many Satna districts and

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noted in 6.4 percent of monitoring network wells. Rise up to 2m in water levels is observed in large areas, mostly in northern and western of region as also spread in eastern. Rise between 2 and 4 m in water levels is observed in small pockets in Umaria and Rewa district network wells. Rise more than 4m in water levels is observed in pockets in parts of Rewa and district. In 2009 ground water level has fallen as compared to 1998-2009 decadal average, the entire region water level fell approx. 2m bgl. While the northern and eastern part of region follows 4m bgl some of small patches in Anuppur and Satna districts water level rise upto 2m bgl. The cause of water surplus is due to heavy rain from western disturbance (fig. 5).

4. Ground Water Resource Availability and Development Status

4.1. Dynamic fresh ground water resource

The Annual Replenishable Ground Water Resource for the entire region is 4138 Million cubic meter (MCM). The ground water assessed is the dynamic resource which is replenished each year. The Annual Replenishable Ground Water Resource is contributed by two major sources – rainfall and other sources that include canal seepage return flow from irrigation, seepage from water bodies and artificial recharge due to water conservation structures. The overall contribution of rainfall to region in Annual Replenishable Ground Water Resource is 74 per cent and the share of other sources taken together is 26 per cent (CGWB, 2011).

4.2. Status of Ground Water Development

Ground water is main source for drinking and irrigation in the region. About 90 per cent of irrigation in the districts is from ground water sources; though level of irrigation in the district is very low i.e. only 23 per cent of net sown. There are 40.48 per cent tube wells and 28.80 per cent of dug wells for irrigation in total irrigation sources in the districts. Apart from private sources, Hand Pumps are main source of rural water supply in the region. There is total of 3 lakh 80 thousand hand pumps in the district for water supply. As far as urban water supply is concerned there are 52 towns in the region, namely Anuppur, Kotma, Jaithari, Bijuri, Pasan and Amarkantak. Urban water supply of Anuppur and Amarkantak towns are based on bore wells/ tube wells. Water supply of Kotma and Jaithari towns are from Kewai and Tipan rivers. Bijuri and Pasan towns are getting water supplies from Coal Mines water/ tube wells (Table 2).

In Baghelkhand region major geological formation is a soft rock (Gondwana) and hard rock (Vindhyan) and major irrigation project is a GovindSagar multipurpose project. Net ground water availability is 3930.84 MCM/yrs while gross ground water draft is 1019.54 MCM/yrs. Dug well status in region is a quite good in terms of depth. The depth of wells is approx. 10-20m in soft rock aquifer while bore well in hard rock aquifer depth is 100-200 m.

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Table 2.:Status of Groundwater Development (Million Cubic Meters)

Districts	Net ground water availability 1998 (MCM)	Net ground water availability in 2004 (MCM)	Stage of development (In percent)				Categories of district		
			1988	1990	1998	2004	1988	1990	1998
Rewa	483.121	506.89	17.5	20.5	42.08	42	safe	safe	safe
Satna	598.304	614.77	16.5	18.9	56.43	69	,,	,,	Semi critical
Shahdol	1307.494	865.92	2.35	2.64	6.24	7	,,	,,	,,
Sidhi	762.893	830.16	21.7	24.9	19.58	25	,,	,,	,,
Umaria	655.751	671.03	2.16	3.9	6.17	9	safe	safe	safe
Anuppur	-	442.07				8			

Source: Water Aid India, 2005 and CGWB, 2010

Note. MCM = Million cubic Meter

The groundwater resources of the all districts in region are under-developed (except Rewa and Satna) districts and under-utilized. 120324 tube wells and 85622 dug wells facilitate the irrigation of an area of 3,349 sq.km of agricultural land as against 19,235 sq.km cultivable area and 14,702 sq.km of net sown area in the region. Total annual Replenishable groundwater resource of the district is 4137.76 MCM and after deducting unaccounted natural discharge, the net available ground water resource is 206.91 MCM, while total groundwater draft in the region is only 1019.54 MCM. The stage of ground water development of the region is only 26 per cent. All districts come under safe category from ground water development point of view. Net Groundwater Availability for future irrigation development is 2797.54 MCM for the whole region. There is ample scope for development of groundwater for irrigation, industrial and domestic purposes.

Stages of ground water development in Rewa and Satna district are highest in the region which is 42 and 69 per cent respectively. Shahdol district stands very low (7 percent) in groundwater development uses while Umaria district (9 percent) is consequently increasing. These districts are under developed in region in terms of irrigation and water supply. Ground water for drinking, industrial and other uses exhibits more than 138.6 Million cubic meters (MCM) in the region. Umaria, Shahdol and Sidhi district have maximum potential of ground water availability but due to backwardness of the region the development of ground water is unsatisfactory.

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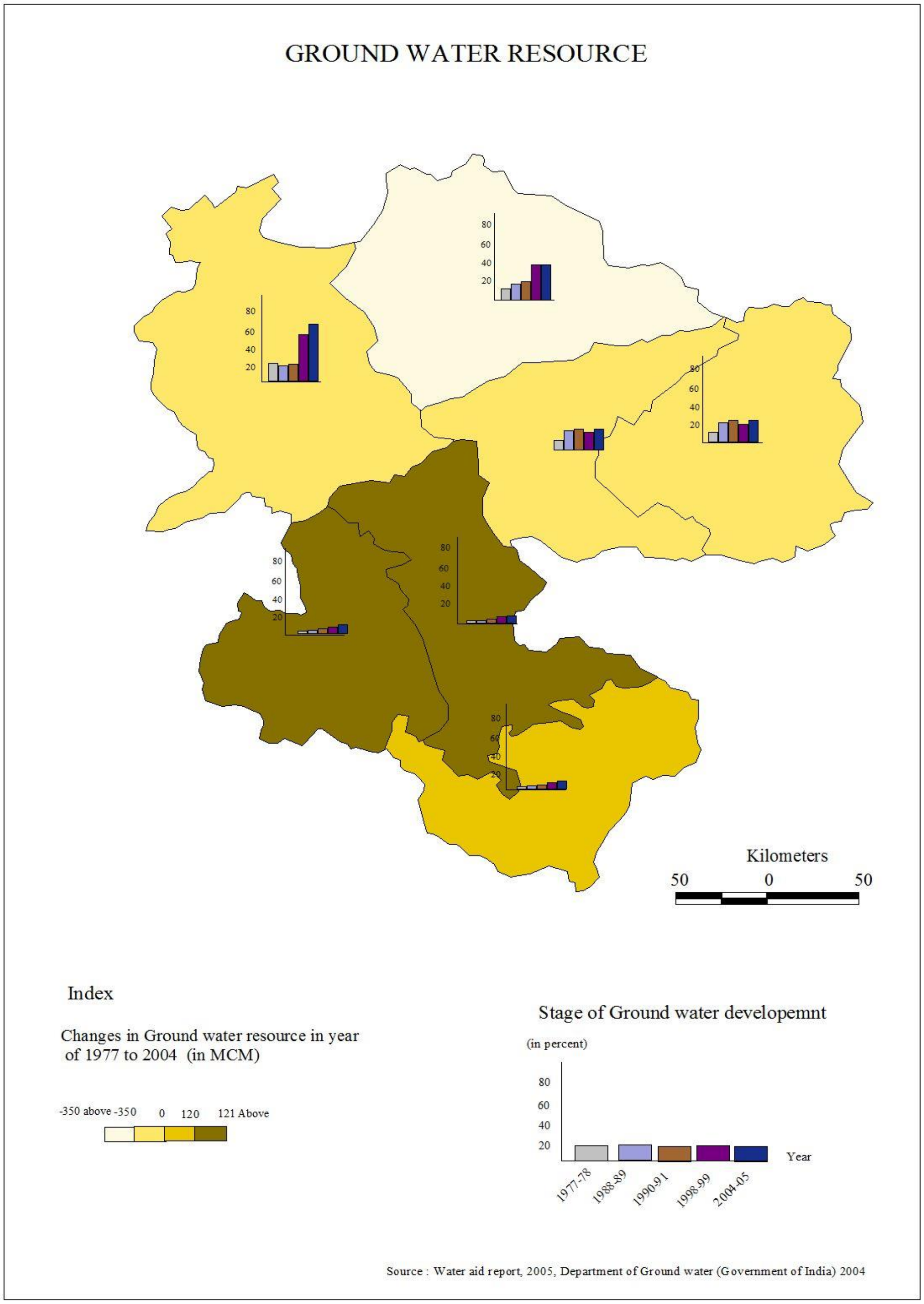
Figure 6



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pesticides or sewage may contain excessive quantities of chloride. Water having high chloride content is highly corrosive. In fact, majority of wells (96 per cent) show the chloride content below 200 ppm which is within the safe-limit for agriculture, domestic and other purposes. The chloride content ranged from 5 to 341 ppm. Flouride in ground water is less common than chloride. When more than 2 ppm fluoride occurs in water, it leads to the dental defect known as *mottled enamel* (Fluorosis). Water containing between 0.2 and 1.40 ppm of fluoride has been found to reduce greatly the incidence of dental cavities in the teeth of children (fig. 6).

Nitrate in water is considered to be a part of the final oxidation product of nitrogenous organic matter. According to WHO permissive of nitrate is 11.3 ppm and Maximum allowable limits is 22.6 ppm. Studies have shown that nitrate (NO3) in excess of about 44 ppm in drinking water may be a contributing factor or the cause of 'Methemoglobinema' (blue babies) among infants. The nitrate content of ground water samples (Table 2.9) ranged from zero to 272 ppm. The highest concentration of nitrate is in Umaria district contain 272 ppm while six villages have zero nitrate concentration. About 42 per cent of villages have above 20 ppm nitrate content. Dissolved solids represent the approximate total quantity of dissolved mineral constituents in the water. Water with less than about 500 ppm of dissolved solids is considered satisfactory for domestic and generally for other uses. Hardness of water is related to its reaction with soap. Since soap is precipitated primarily by Ca and Mg ions, hardness is defined as the sum of the concentration of these ions expressed as mg/1 of CaCO3. Water for domestic use should not contain more than 600 ppm total hardness. The present analysis shows these villages are under the permissive limit.

The degree of acidity or alkalinity of the water as indicated by the hydrogen-ion concentration is expressed on the pH scale between 0 and 14.The numbers on the pH scale are the negative logarithms of the hydrogen ion concentration in moles per litre of solution (Walker, 1978). In region 114 villages pH value have been investigated by CGWB. Six per cent of villages dug well showed the pH value below 7.0. These villages are Jhiriyatola, Amarkantak, KanadiKhurd in Shahdol district and in Umaria district Nowrozabad while Badhaora, Chilheri Kalan villages from Sidhi district. Region consists 92.8 per cent village estimated the pH value within the permissive limit and water is slightly alkaline in Dhangaon in Shahdol district.

4.3 Quality of Ground Water for Drinking Purpose

The quality of ground water in district is being assessed by the analysis of groundwater samples from 960 villages. The analysis of water samples for year 2006 indicate that the pH values of all water samples varies as in 7.37 to 7.91 showing alkaline nature of water in the Baghelkhand districts.

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4.4 Quality of Ground Water for Irrigation Purpose

The chemical quality of groundwater is an important factor to be considered in evaluating its suitability for irrigation purpose (Rai, 2004). The parameters such as EC, Sodium Absorption Ratio (SAR), per cent sodium (Na) are used to classify the water quality for irrigation purpose. It is clear that more than 82 per cent groundwater samples from the district fall under (medium salinity and low sodium) which means that these waters can be used for all type of crops on soils of low to high permeability, without causing problem of salinity. The ground water representing the wells of Shahdol district blocks Jaisinghpur, Gohparu and Beohari are grouped under (high salinity and low sodium) class, indicating that groundwater from these areas can be used for irrigation purposes on well drained soils or used for salt tolerant crops like groundnut, safflower etc.

4.5 Present Status of Tap water scheme in rural areas.

A number of Tap water schemes have been launched by central and state government by the help of panchayats and women groups. Rajiv Gandhi drinking water scheme is one of the important schemes for rural drinking purpose and sanitation. Before independence, starting year's rural areas had water deficiency but they survive by the help of accumulating water in ponds and wells. Although, this method is better for life sustain but whole year availability of water in ponds and wells are not same. So the after independence up to 1990s government had built many medium and small projects as well check dam for recharging the ground water. Many schemes have started to provide drinking water because in Satna and Umaria many villages are far away from water sources. In summer period water sources being dried so, some of the village's water location are far about 450 meters from their resident place (according to water aid 2005 report).

Table 3.: Present Status of portable water scheme in northern part of region

Districts	Total No. of completion of tap and surface water programmes	No. of works regarding to village water and sanitation samiti delivered to women group	Tap water works which are started from 2010 to present while before it was closed	No. of Present started scheme	No. of scheme which are stopped at present time
Rewa	169	70	60	146	23
Satna	148	12	12	135	13
Sidhi	168	5	20	151	17
Singroli	34	0	5	31	3

Source: Office of Commissioner, Rewa Division, 2011.

After 1990s tap water supply has become important because firstly, villagers get water from near houses which reduces human effort to travel for search for water. Second, water security and

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third, is water safety that can decrease water borne disease as comparatively the supply from ponds and wells in rural areas. Northern part of region consists Rewa, Satna, Sidhi and Singroli districts (Table 3). Rewa and Sidhi districts had started 135 and 151 programme works respectively for tape and surface water for drinking purpose. While Rewa and Sidhi district has more than 17 schemes has stopped working at present. Reason for cut off or stopped water taps construction:

- Power disruption.
- Close to the source drying.
- Do not run off with grace by Panchyat.
- Due to malfunction Pump.
- Off-line due to the barrel disruption.
- Another reason to quit (Power pole breakage, wire theft, etc.)

Rural drinking water target of the 2011-12 in Region by government incentive:

- The goal is to make more than 300 households in districts.
- Mined under the wells to all program within end of month.
- Provision to construct portable water supply in water quality affected households.
- Provide portable water supply in hostels.
- Maintenance of tap water supply schemes (schemes close to the source drying in the source build).
- Renovated program of traditional drinking water sources.
- Hand pumps maintenance.

Table 4.: Action plan to tackle water crisis in the villages 2009-10

District	No. of portable water transport villages	No. of portable water transport villages	No. of potential villages that have water crisis in summer	No. of potential villages that have portable water transport	Total no. of villages at present that have portable water transport
Rewa	5	17	600	103	71
Satna	12	26	450	50	40
Sidhi	3	2	300	3	2
Singroli	0	0	300	15	0

Source: Office of Commissioner, Rewa Division, Madhya Pradesh, 2011

5. Conclusion

Large amount of rainwater is wasted in form of surface water flow resulting into less ground water recharge. Furthermore; the condition of ground water level is secured by its excessive utilization causing more ground water fluctuation in the region.Geological structure of the region i.e., presence of calcium carbonate rocks, dolomite, other minerals and salts along with human interventions, are together responsible of degrading ground water quality.In Rewa district there are 12 urban bodies and city municipality, Mangwan, Hanumna, Gurh, Naigarhi, Sirmour, Bakunthpur, Govindgarh, Mauganj, Chakghat, Teonthar and Semaria urban council. Present conditions of daily water supply in these urban councils are quite good except Semaria urban council. In Semaria there is alternative water supply system; means during water deficiency period water transportation facilities is available in this urban body. Availability of water in this region is up to June month of year while in Naigarhi urban council has water availability is till the month of May of a year. In 2009-11 many villages of northern part of region is in a state of water deficiency during summer seasons. In Satna district there are 11 urban councils, except Maihar urban council each have daily water supply system while Maihar has alternative water supply system. The water availability in region is up to end month of May but Chitrakoot urban council has water availability till June end of a year. Amarpatan, Kothi, Kotar, Rampur-Baghelan, Jaitwara urban councils have water transport system to full fill their demand in dry seasons.

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