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GIS BASED STUDY ON GROUNDWATER QUALITY OF SIKAR DISTRICT, RAJASTHAN

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Abstract: *Water is an eternal wonder, a lifegiving force, a powerful agent of progress and a scarce resource, supporting biological existence of our global system. As the population increases, the need for water availability and accessibility will continue to grow dramatically and will exert additional stress on limited resources exacerbated by depletion and pollution. With rapid growth in population, urbanization, industrialization, competition for economic development, groundwater has now become an invisible Resource. The study aims to understand the distribution of groundwater quality in Sikar district. The study is very significant as it will help in determining the spatial distribution of water quality which helps in sustainable management of water resources. This study will generate the spatial water quality maps for different parameters which will help the planners to evaluate groundwater quality at micro level (block) as well as at district level.*

Keywords: Ground Water, Water level, Water Quality, GIS, IDW

Introduction

Water, the essence and sustenance of life, is among the biggest and the most crucial natural resources both in terms of quantity and quality. It has many distinct properties that are critical for the proliferation of life that set it apart from other substances. It is one of the most critical, scarce, precious and replenishable natural resource which cannot be created (Prasad 2008). Thus, water is a finite resource that has limits and boundaries to its availability and suitability for us. Rapidly growing population, increased economic activity coupled with improved living standards has led to enhanced competition for and conflicts over the limited water resources. In the contemporary society, water is a major theme of scientific, economic, political, social and human debate. The total volume of water in the hydrosphere is estimated to be about 1.36 x 10^9 km^3, of which 97.3 percent is locked up in the oceans and sea water and other 2.1 percent in ice caps and glaciers. Freshwater, critical for sustenance of terrestrial life (plants, animals and humans), constitutes about 0.6 percentof the total water inventory. The intensive use of groundwater for irrigation and other purposes has resulted in sharp decline in groundwater table and change in the natural geo-chemistry of groundwater. Groundwater can be optimally used and sustained only when the quality and quantity are properly assessed (Kharad et al., 1999). Unfortunately, groundwater is being adversely affected both in terms of quality and quantity by human activities. Geographic Information Systems (GIS) are an effective tool for storing, analyzing, managing and displaying spatial data often encountered in water resource management. GIS has been put to effective use in many earlier groundwater studies and found to be extremely successful (Barber et al.,1996; Burrough and McDonnell,1998; Ahn and Chon,1999; Ducci,1999; Lo and Yeung, 2003; Babikar et al.,2007)

The state of Rajasthan is one of the driest states of the country and the total surface water resources in the state are only about one percent of the total surface water resources of the country. In the last 50 years, a threefold increase in the human population and a doubling of the livestock populations have put tremendous pressure on the fragile water and land resources of Rajasthan. This study is very significant as it will help in determining the spatial distribution of water quality which helps in sustainable management of water resources. The problems of water quality have become more important than the quantity. Therefore, the present study focuses on the water quality analysis of Sikar district. The study area is located in the north-eastern part of Rajasthan state and extends between north latitudes 27°07' & 28°12' and east longitudes 74°41' and 76° 05'. It encompasses an area of 7732 sq.km.

The overexploitation of groundwater and its deteriorating quality are a matter of great concern. has been a lot of research done in this field at global and national level. Ducci (1999) produced the maps of groundwater quality and contamination by using GIS in southern Italy. Mouser et al. (2006) used geo-statistics approach to spatial representation of groundwater contamination. Nas and Berktay (2010) have studied and identified that the Konya city have optimum groundwater quality level. They used ArcGIS 9.0 and ArcGIS Geostatistical Analyst for generation of various thematic maps. Gupta (1991) conducted a study on groundwater quality in Nagaur district of Rajasthan. Das et al (1992) studied the quality of groundwater in the areas around steel plant at Rourkela. Shankar and Muthukrishanan (1994) observed higher concentration of TDS, Total hardness, chloride and calcium in groundwater of Madras city. Kamaraju (1997) evaluated groundwater potential of west Godawari district using GIS. Singh and Khan (2011) assessed the groundwater quality of Dhankawadi ward of Pune by using GIS. Shankar et al. (2011) mapped the spatial distribution of groundwater quality in Paravanar river sub basin, Cuddalore district, Tamil Nadu and found that most of the quality is in poor zone. Hassan (2014) studied the groundwater quality of Sheikhupura tehsil using geo-statistics.

Objectives

The study has been undertaken with the objectives to determine the spatial distribution of groundwater quality, to prepare GIS based maps from hydro-chemical study of groundwater, to point out qualitatively stressed and problematic areas within the study area and to suggest measures for better management of available groundwater resource.

Methodology

The methodology adopted (Fig. 1 and table 1)) comprised the following steps:

1. Desk Research: thorough search and review of published literature in related field from various books, periodicals, published papers, journals on the subject was conducted. The books and periodicals are listed under ‘References’ and ‘Bibliography’.
2. Data Collection: Secondary data from various departments and agencies was collected to get the latest information on the subject.
3. Data Analysis: Various methods are applied to conduct the present research.
4. Cartographical techniques for preparation of spatial maps (GIS is used as a tool) and diagrams.

Figure 1: Flow Chart of Methodology

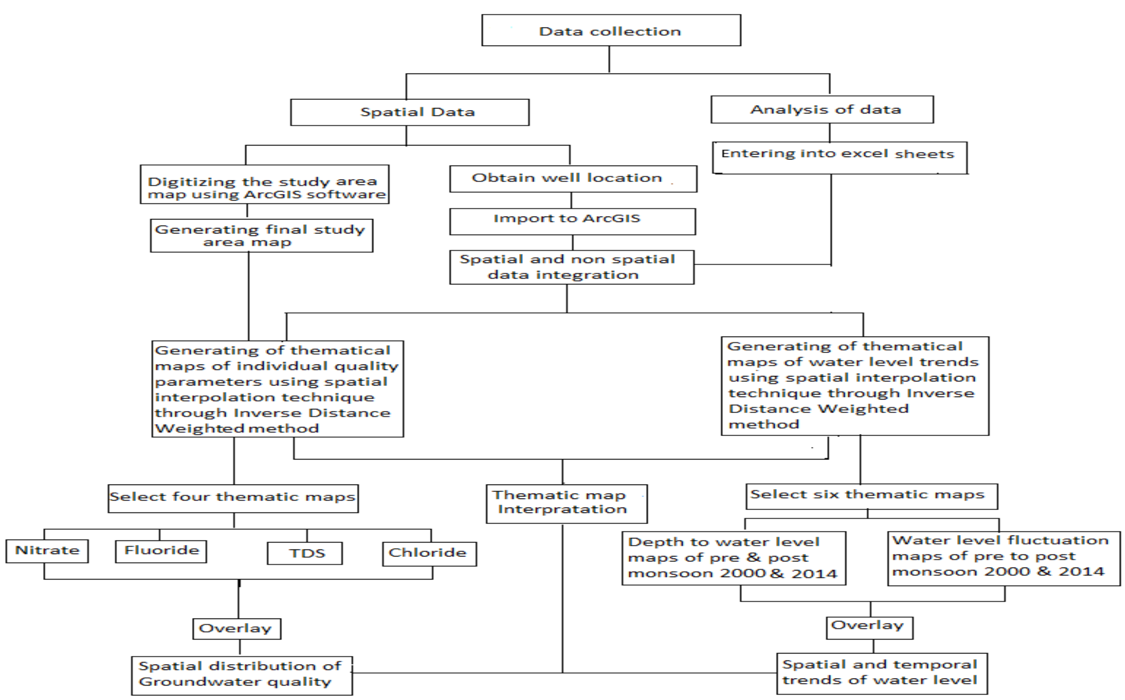

Table 1: Drinking Water Standards (IS 10500:2012)

#	Parameters	Indian Standards	
		Acceptable limit	Permissible limit
1	Total dissolved solids (TDS) (in mg/L)	500	2000
2	Nitrate (as No_3) (in mg/L)	45	No Relaxation
3	Chloride (as Cl^-) (in mg/L)	250	1000
4	Fluoride (as F) (in mg/L)	1.0	1.5

Source: Bureau of Indian Standards

Status of Groundwater Quality in Sikar district

The study has been carried out to evaluate the spatial and temporal variation in groundwater quality in the Sikar district. Total 317 different locations in eight blocks comprising the whole district are selected for the study and analyzed for determination of four selected parameters and evaluated the groundwater quality in compliance with National standards (BIS 10500:2012) for its designated use. The data is collected for the years 2000 and 2014. All the samples are classified in three different categories i.e. samples having value less than acceptable limit, within acceptable limit and above permissible limit. The analyzed result of selected parameters from the district is given below.

Fluoride: BIS has recommended an upper acceptable limit of 1.0 mg/l of F as desirable concentration of fluoride in drinking water which can be extended to 1.5 mg/l of F in case no alternative source of water is available. At district level, 25 percent (80) of the samples in 2000 and with an increase of 20 percent, 96 samples are above permissible limit in 2014. 53 percent of the samples in 2000 and 39 percent samples in 2014 are below the limit in the study area. Details are shown in table 2. There are 21 percent samples in 2000 and 30 percent samples in 2014 within permissible limit in the district. The occurrence of high concentration of fluoride in groundwater of Laxmangarh is found as 68 percent samples are above permissible in 2014. Spatially, concentration of fluoride increases from the east part towards the western part of the study area (Fig 2).

Table 2: Water Quality Sampling for Fluoride in Sikar District

#	Block	Samples	Below Acceptable Limit		Within Permissible Limit		Above Permissible limit	
			2000	2014	2000	2014	2000	2014
1.	Danta Ramgarh	41	28	23	05	07	08	11
2.	Dhod	42	29	22	06	16	07	04
3.	Fatehpur	30	06	04	06	06	18	20
4.	Khandela	37	18	08	10	12	09	17
5.	Laxmangarh	41	11	12	12	11	18	18
6	Neem-Ka-Thana	49	24	13	17	21	08	15
7.	Piprali	39	33	24	03	10	03	05
8.	Sri Madhopur	38	20	18	09	14	09	06
	Total	317	169	124	68	97	80	96

Source: Public Health and Engineering Department, Sikar District

Nitrate (NO_3^-): The nitrate content of 317 samples were categorized and the result exhibits that 58 percent samples from the study area are above permissible limit in 2000 whereas 60 percent of the samples are above permissible limit in 2014. Laxmangarh and Fatehpur blocks have majority of samples above permissible limit. Details are given in table 3. Map (Fig 3) indicates that south eastern parts of the district show higher concentration of Nitrate in the ground water.

Chloride: The table given below (table 4) provides us information on chloride levels in groundwater in Sikar district. Only three samples in 2014 and eleven samples in 2000 were above permissible limit in the whole district. Map (Fig 4) shows most parts have chloride within permissible limits.

Figure 2: Concentration of Fluoride in Ground Water

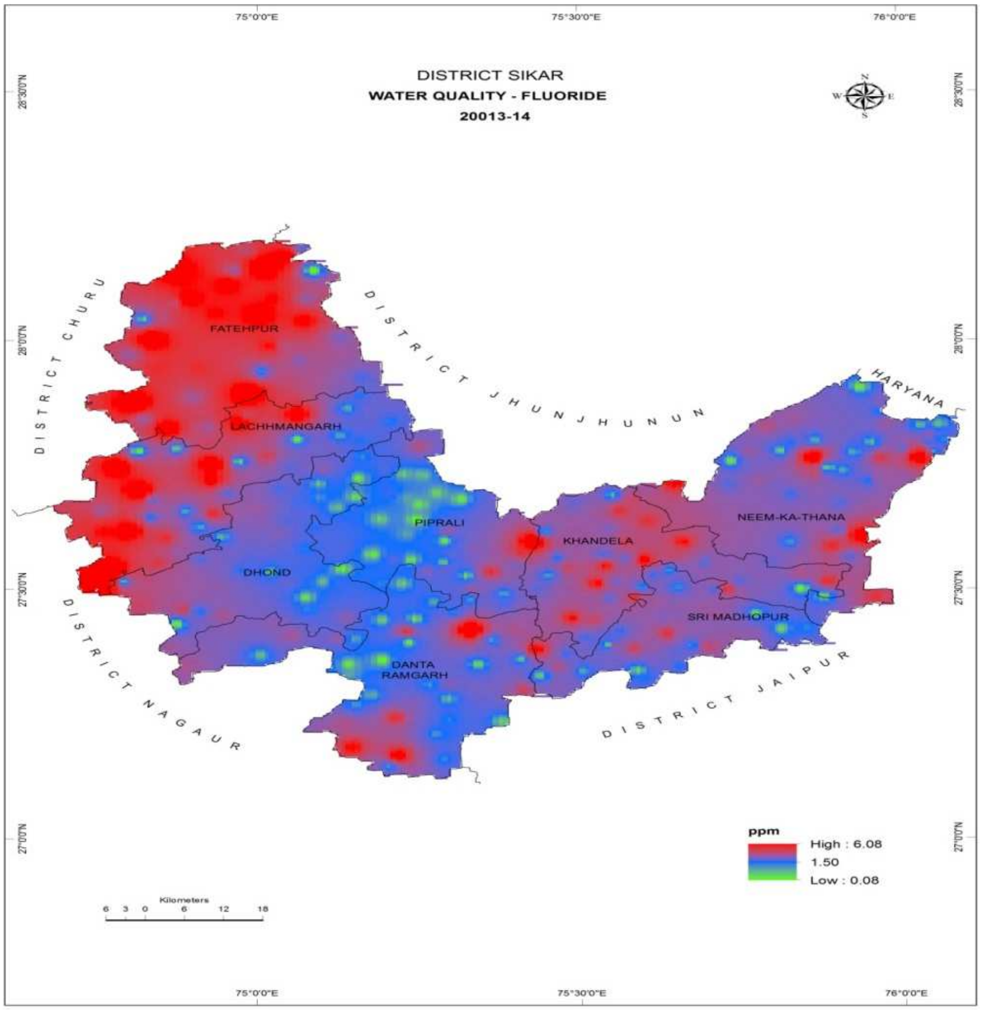

Table 3: Water Quality Sampling for Nitrate in Sikar District

S.N.	Block	Samples	Below Acceptable Limit		Within Permissible limit		Above Permissible Limit	
			2000	2014	2000	2014	2000	2014
1.	Danta Ramgarh	41	15	25	NIL	1	26	15
2.	Dhod	42	12	12	NIL	NIL	30	30
3.	Fatehpur	30	06	03	2	1	22	26
4.	Khandela	37	17	12	1	NIL	19	25
5.	Laxmangarh	41	07	06	NIL	1	34	34
6.	Neem-Ka-Thana	49	26	18	NIL	1	23	30
7.	Piprali	39	19	20	1	NIL	19	19
8.	Sri Madhopur	38	26	25	1	1	11	12
	Total	317	128	121	5	5	184	191

Source: Public Health and Engineering Department, Sikar District

Figure 3: Concentration of Nitrate in Ground Water

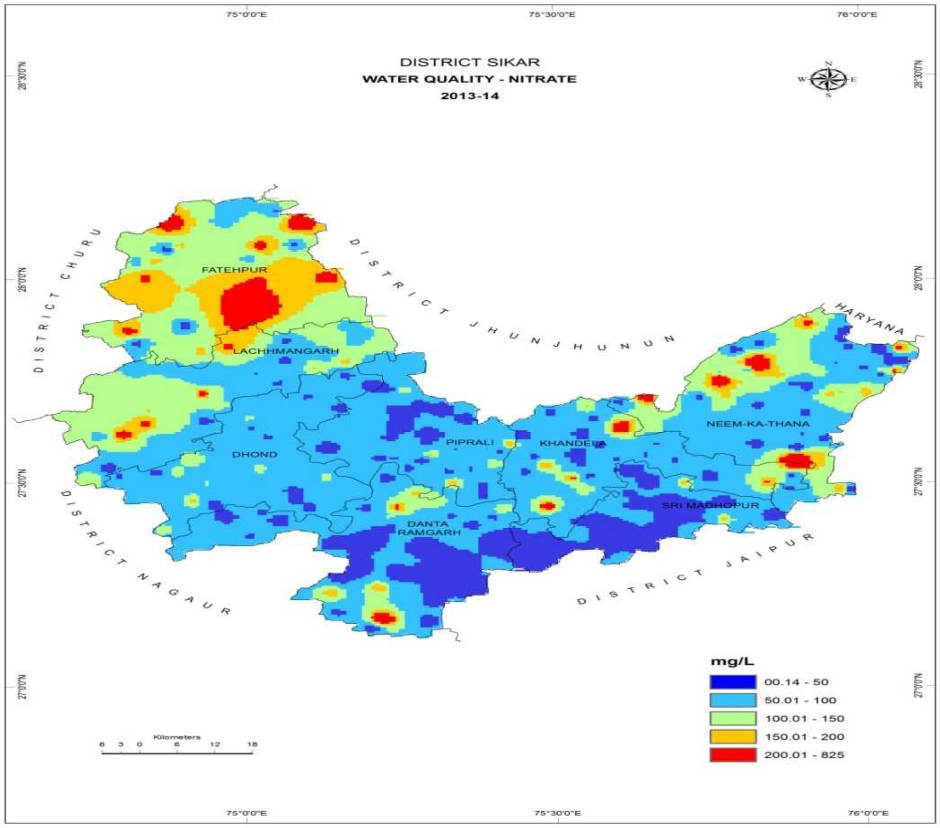

Table 4: Water Quality Sampling for Chloride in Sikar District

#	Block	Samples	Below Acceptable Limit		Within Permissible limit		Above Permissible Limit	
			2000	2014	2000	2014	2000	2014
1.	Danta Ramgarh	41	31	30	04	10	06	01
2.	Dhod	42	35	37	07	05	NIL	NIL
3.	Fatehpur	30	07	11	22	19	01	NIL
4.	Khandela	37	22	28	14	08	01	01
5.	Laxmangarh	41	23	23	17	17	01	01
6	Neem-Ka-Thana	49	30	27	17	22	02	NIL
7.	Piprali	39	34	35	05	04	NIL	NIL
8.	Sri Madhopur	38	38	34	NIL	04	NIL	NIL
Total		317	220	225	86	89	11	3

Source: Public Health and Engineering Department, Sikar District

Total dissolved solids (TDS): Sri Madhopur and Dhod blocks have more than 95 percent of the samples within permissible limit in 2000. At the district level, 7 percent of the samples are below limit in 2000 whereas 8 percent of the samples are below desirable limit in 2014.GIS based map of the district prepared for spatial distribution of TDS shows that few pockets of Fatehpur, Laxmangarh and Neem Ka Thana blocks have above permissible limits of TDS in 2000 while central part of the district in 2014 shows moderate amount of TDS (Table 5).

Figure 4: Concentration of Chloride in Ground Water

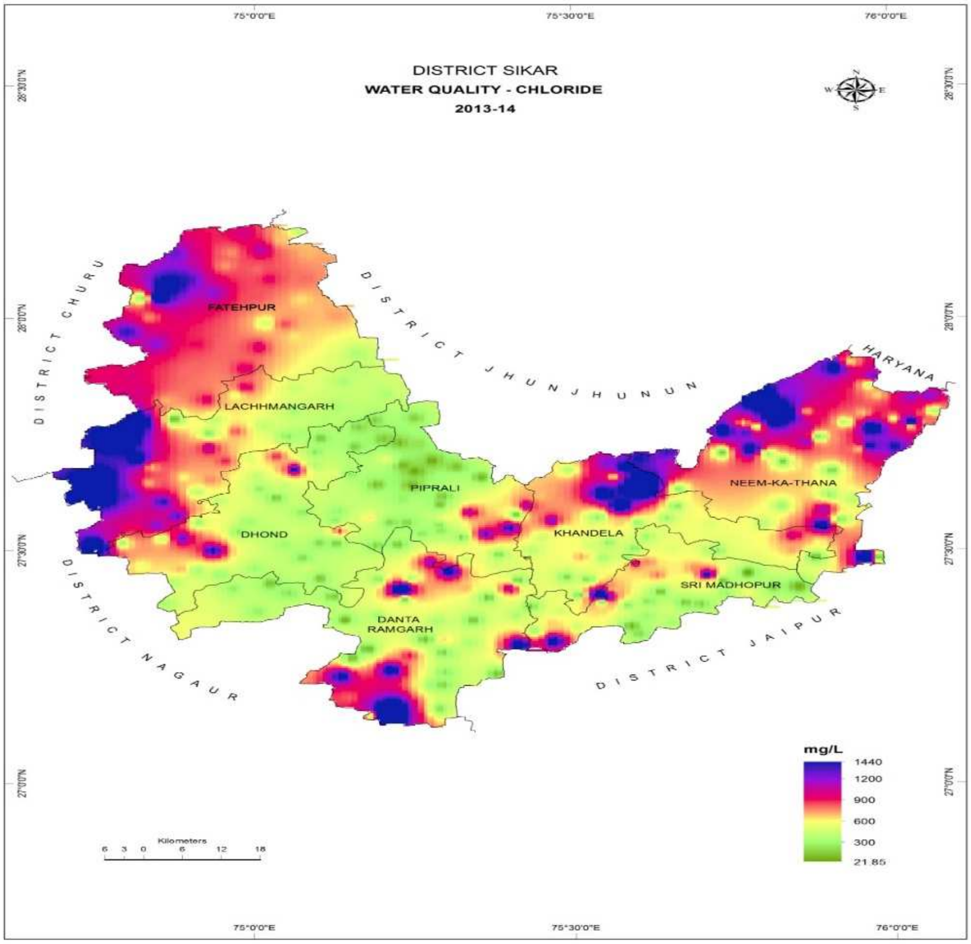

Table 5: Water Quality Sampling for TDS in Sikar District

#	Block	Samples	Below Acceptable Limit		Within Permissible Limit		Above Permissible Limit	
			2000	2014	2000	2014	2000	2014
1.	Danta Ramgarh	41	06	03	26	36	09	02
2.	Dhod	42	01	03	40	39	01	NIL
3.	Fatehpur	30	NIL	01	08	22	22	07
4.	Khandela	37	01	02	28	34	08	01
5.	Laxmangarh	41	NIL	NIL	27	39	14	02
6	Neem-Ka-Thana	49	01	NIL	37	46	10	03
7.	Piprali	39	14	14	24	25	02	NIL
8.	Sri Madhopur	38	01	04	37	34	NIL	NIL
Total		317	24	27	227	275	66	15

Source: Public Health and Engineering Department, Sikar District

The study is mainly concerned with spatial and temporal trends of water table and groundwater quality in the Sikar district. Data related to selected parameters and different time periods have been collected and analysed. In general, groundwater depth and quality in Sikar district showed a considerable deterioration from 2000 to 2014, possibly due to over-exploitation and natural factors. The water quality in the area is also deteriorating. Few areas of the district are affected by various chemicals in water. As wells are drilled deeper in pursuit of the falling water table, the water which is extracted frequently displays higher levels of fluoride and other harmful chemicals. Falling water tables can also induce leakage from a contaminated external source, such as surface water polluted by sewage, agricultural fertilizers and industry. Few pockets of Danta Ramgarh, Fatehpur, Khandela and Neem ka Thana are showing increasing trends of fluoride concentrations from 2000 to 2014. High fluoride concentration in groundwater has been reported from Dukia, Rajpura, Abhaipura, Gangyasar, Rookansar, Udansar, Moordunga, Puranpura, Bibipur, Kishorpura and Dahar ka bas villages in south central, northern and western parts of the study area. The increasing concentrations have resulted in concerns about human health impacts. In almost all the blocks of the study area, the TDS values are within permissible limit in both the years except at few places in Fatehpur and Laxmangarh blocks. Higher values of TDS in groundwater occur at Biraniya, Dadunda, Dhandhan, Palas, Rohalsahabsar, Rosawa, Jaitpura, Kumas Jagir, Mangloona and Kankara in the study area. Chloride content in groundwater in excess of the permissible limit is found at Kankara, Chaukri and Mangloona. Some parts of Khandela, Neem Ka Thana and Fatehpur blocks are displaying increased level of nitrate content from the year 2000 to 2014. Spatial interpolation technique through Inverse Distance Weighted approach in GIS has been used in preparing the maps that are self-explanatory in nature. The maps generated by IDW method show the areas where the level of groundwater parameter is above the desirable standards of BIS for drinking water quality. The results of the study thus provide basic information needed for groundwater management in the study area.

Suggestions

- Construction of check dams and subsurface dykes at appropriate places across the *nallahs* and streams in the water table depleting areas, and the areas where water quality problem exists may be taken on priority basis.
- Over-exploitation may disturb the hydro chemical balance of fresh and saline water interface leading to contamination of saline water ingress. Therefore, proper care should be taken to avoid over-exploitation. Clustering of tube wells should also be avoided.
- Change the irrigation and cropping pattern of agriculture. Instead of growing water intensive crops Green Revolution Wheat and mustard, introduce dryland farming which consume less water. Local varieties should be encouraged and a minimum price/ market and marketing systems developed for these. Crop choice plays an important role to mitigate water scarcity in arid and semi-arid regions.
- Proper water conservation measures should be used. People should be made aware and trained on the techniques of water conservation. Restore the conventional methods of water conservation like *Baories, Johads* and Tankas.
- Roof top rainwater harvesting should be made mandatory in all cities and towns. Even though the district receives good rainfall, considering the water scarcity in some pockets during peak summer, a comparative programme should be formulated to harvest the rain water through roof top, check dams, surface tanks, and bunds to enhance the recharge to groundwater.
- Constant monitoring of groundwater quality should be carried out in the fluoride contaminated areas and industrial and mining belts to prevent further deterioration and related problems. The determination of trace elements and organic compound be done to help in categorizing the quality of water.
- Reduction of unnecessary water usage on the industrial scale needs to be monitored. Increasing water efficiency is pivotal in reducing water demand. Some of the methods that can reduce water footprint, include changes in technology from water cooling to air cooling, replacing of water intensive equipment and fixtures, waste water recycling and reuse into industrial process.
- Remote sensing and GIS technologies be adopted in monitoring the changes in various GW parameters and forecasting flood and droughts
- Pricing water at its real value makes people use it more responsibly and efficiently and reduces water wasting.

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