ISSN: 2456–5474 RNI No.UPBIL/2016/68367 Vol-2* Issue-10* November- 2017
Innovation The Research Concept

Hydrogeomorphological Assessment of Southern Aravalis: A Geographical Study of Udaipur District (Rajasthan)

Abstract

It is an astonishing fact that surface and sub-surface water sources have contaminated because of indiscriminate disposal of solid and liquid wastes generated from domestic and industrial activities. Moreover, the situation has further worsened due to habitual practices of population and their mind-sets. The hydrogeomorphology exercises tremendous control on the groundwater regime of an area. The relief, slope, depth of weathering, type of weathered material, thickness of deposition, nature of the deposited material and the overall assemblage of different landforms play an important role in defining the groundwater regime especially in the hard rock and the unconsolidated sediments. The present paper is primarily aimed at the preparation of various maps pertaining to hydrogeomorphology, drainage and slope.

Keywords: Indiscriminate Disposal, Hydrogeomorphology, Groundwater Regime.

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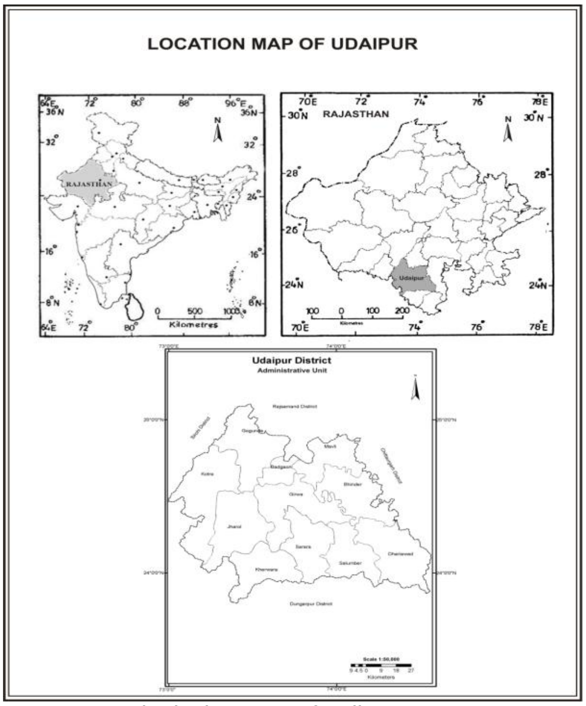
Introduction

Water is an important natural resource and sustains life on this planet. It is synonymous with existence and is the very embodiment of life. Without water the planet would be dry and lifeless. But now scarcity of water is increasing day by day. The average annual availability of water per capita in our country was 5000 m^3 in 1950, which has decreased to 1869 m^3 in the year 2000 and if the similar conditions of water consumption continue, it is feared that it shall further reduce to about 1000 m^3 by 2025, which shall be a serious situation. The data gathered by Ministry of Water Resource reveal that situation of water crisis has arisen in areas belonging to eight river basins of our country is indeed critical.

The advent of remote sensing has new vistas in geomorphological and structural mapping for the groundwater exploration. Satellite images with their synoptic view facilitate better appreciation of geomorphology and help in identification and mapping of different landforms and their assemblage. The imagery in combination with topographic maps and limited field checks at appropriate places help in accurate geomorphic analysis and mapping of landforms.

Study Area

The district extends from $23^0$46’15” to $25^0$05’10” north latitude and from $73^0$10’ 20” to $74^0$40’15” east longitude by covering 13,419.14 sq km of area. In administrative terms, the district is divided into 4 blocks, 11 panchayat samitis, 10 thesils and 5 municipalities and 10 townships. The district lies in the established monsoon macro-climatic region, experiencing extra and sub-tropical characteristics of seasonality and marked reversal in wind system resulting in a hot to warm rainy season, succeeded by a warm to cool season of almost no rains.



Source: Geological Survey of India

Objectives of the Study

It is aimed to prepare hydrogeomorphological maps and delineate the groundwater potential zones of the study area

Hypotheses

1. The study area is considered to be a densely forested region and experience heavy rains, and the major source of water is groundwater.
2. The geological nature of beds assures that there would be no significant loss of storage of water through seepage.

Methodology

The basic data being used in present study are IRS-1C LISS-III FCC imagery and topographical sheets of 45G, 45H, 45L, 46E and 46I series. Geological and groundwater maps prepared by Geological Survey of India, Central Groundwater Board and State Groundwater Board are also used. The data and information have been collected from Department of Economics and Statistics, Udaipur; Meteorological Department, Udaipur; Central Groundwater Board, Jodhpur; State Groundwater Board; JRNRV University, Udaipur, Institute of Development Studies, Jaipur; MLS University, Udaipur; and Regional Remote Sensing Application Centre, Jodhpur. The satellite data have been converted into thematic maps to prepare base map, delineation of watershed up to watershed level, hydrogeomorphological map and water resource action plan.

Review of Literature

Basically, hydrogeomorphological mapping is a key word in resource management approach. It implies water resource management, which is both economically viable and environmentally sustainable. In the long run it emphasizes optimal management of both land and water resources in such a way to maintain a balance between productivity and conservation measures through identifying and monitoring of problem areas that require alternate. This calls for a holistic view of the entire district and integrated approach through understanding various resources, their potentials and integration with socio-economic data to solve the problem.

During recent year, a few attempts have been made for assessment and management of water resources using integrated approach for hydrogeomorphological mapping of a region. One of the earliest and most extensive of such attempts was initiated by the Department of Space under the National Natural Resources Management System (NNRMS) programmes under Integrated Mission for Sustainable Development (IMSD), for generation of action plan package on watersheds at block, tehsil and district basis. So far, a large number of districts have already been covered in various states of India where integrated studies have been carried out. Their respective reports and maps have been digitized and are available with the National Remote Sensing Agency.

Abraham Thomas, P.K. Sharma, Manoj K. Sharma and Anil Sood (1999) have conducted the study in Lehra Gaga Block, Sangrur District in Punjab. The area being an alluvial plain has good groundwater prospects but the quality of water is marginal in general except the south-eastern part of the area on both sides of Ghagar River and along the major canals, where it is good. The inter-relationship of hydrogeomorphological units and other topographical features with the groundwater is brought out clearly in this study.

Akram Javed and Mushtaq Hussain Wani (2009) have demonstrated the utility of remote sensing and GIS techniques in delineating groundwater potential zones in highly variable terrains representing various geomorphic landforms. The study reveals that valley fills possess good to very good groundwater prospects, followed by alluvial plains and buried pediments which seem to possess moderate to good groundwater prospects. Lineaments that are present on the hilly terrain (plateau) and cut across some of the tributaries may also prove to be moderately potential zones as they allow surface water to infiltrate through weak zones, otherwise the plateau has poor groundwater potential. Linear ridges and residual hills act as run off zones only. The hydrogeomorphic units in the area support well with the existing groundwater conditions and geomorphology of the area. The groundwater prospects map generated through the integration of hydrogeo-morphological, geological and lineament mapping may be useful for planners and decision makers for initiating groundwater development in the area.

A.K. Saraf and P.R. Choudhary (1998) have enabled an evaluation of the capabilities of IRS-LISS-II data for comprehensive understanding of the groundwater condition of a hard rock area. Digital analysis of LISS-II data has permitted identification of groundwater recharge due to reservoirs in the study area. This is further augmented by analysis of thematic information derived from DEM and groundwater data in a GIS environment. Integrated analysis provides a further in sight into the hydrogeological regime of the area which can be utilized for site selection for artificial recharge. GIS facilitates conjunctive analysis of multi-parameter thematic data and decision making for efficient planning for groundwater management. The spatial database developed during this study is being improved by adding further information layers and a modeling approach may be adopted in future using integrated GIS.

Arora and Goyal (2003) have highlighted the use of geographical information system (GIS) in development of conceptual groundwater model. Various layers of information such as canal network recharge zones, subsurface geology and digital terrain model (DTM) of Hanumangarh and Sriganganagar districts were developed in GIS and were then transferred to finite difference grid for developing mathematical groundwater flow model of the area. Binay Kumar, Uday Kumar (2010) have described that by integration of all the maps (lithology, structure, geomorphology, hydrology, lineaments) and further analysis of data on type of well, water table and water depth, ground water potential zones were delineated and classified. The groundwater prospect map is a systematic effort and has been prepared considering major controlling factors, which influence the water yield and quality of ground water. The map depicts hydrogeomorphological aspects, which are essential as basis for planning and execution of groundwater exploration. Since rainwater is not adequate and uncertain, it was essential that drinking water supply to the town is augmented by bringing in water from Mansi Wakal (Dr. P.L. Agrawal, 2002). He has listed few other steps which are essential to conserve water resource. These are: completion of sewage system including sewage treatment plant, make adequate arrangement for solid waste, watershed development, tree plantation, rainwater harvesting and to educate people to conserve water.

Hydrogeomorphologically the Gurgaon district has very diverse conditions due to its location, geology and topography. The northern part of the district is occupied with quaternary alluvium while south and south-eastern part was occupied by Precambrian meta-sediments of Delhi Super Group. Availability of groundwater in alluvial plain and alluvial plain with sand cover is not a problem but quality of the groundwater is saline due to inadequate drainage network, regarding this aspect many studies carried out by HARSAC (Department of Science & Technology Hisar, 1998).

The study on geomorphology and underground hydrology in Phagi Tehsil, Jaipur has been done by M.L. Sharma (1992). He empirically examined the rock strata, geomorphological features and the scanty rainfall as well as drought in succession has all contributed cumulatively to the dearth of underground water potentialities in the area of Phagi tehsil. Therefore, a few pockets of aquifers are explored for future water catering.

Outcomes of the Study

Geomorphhological Condition

The height of the Aravali ranges gradually decrease from south-west to north-east from 1000-1500 m or more around Udaipur-Gougunda stretch, forming the western flank of Udaipur or Mewar area are locally called ‘Magra and Magri’. The plateau of Gogunda and Bhorhat and their surrounding hills form the next highest elevations of the Aravali range, their heights varying between 1050-1200 m.

These Aravali escarpments disperse in a number of spurs having gentle gradient. In contrast, towards west, the gradient is steep and the fall is more abrupt. The series of spurs and curved ridges stretching in south, south-west and south-east, lie separated from one another by the north-south flowing river valleys of Sai, Sabarmati, Wakal and Som while minor valleys of Pamari, Jhontri, Tidi and Manas separated such ranges locally. The configuration of relief in the area restricts the availability of cultivated land in the western part of the district where within comparatively shorter distance from the valley-bottoms and their neighbouring terraced fields, ranges, attain steep rise, forming narrow, steep-sided and picturesque valleys. The Wakal-Som watershed at 1000 m above msl, gives rise to a radial drainage pattern with a resultant broken landscape in its vicinity.

The Baghpura plateau and region around Jaisamand lake, locally known as ‘Chhappan’ is a wild and dissected area with numerous low hills and narrow flat-bottomed valleys in between, having average elevation of 650-800 m. Farther eastward lies the hummocky and irregular tableland of low relief (310-620 m elevation), greatly dissected by Jakham and its tributary streams, draining finally into river Som- the main artery of the region and an important tributary of the Mahi drainage system further southward. The saucer-shaped Udaipur basin in northern central part of the district stands separated from similar and wider Jaismand basin in south by several west to east running spurs and divides of 500-600 m elevation which act as a major watershed between the Bay of Bengal and Arabian Sea drainage systems. The western hilly region of the district gradually merges north-eastward into higher plain, through a transitional belt of spurs, isolated hills of circum-denudation and patches of level plain

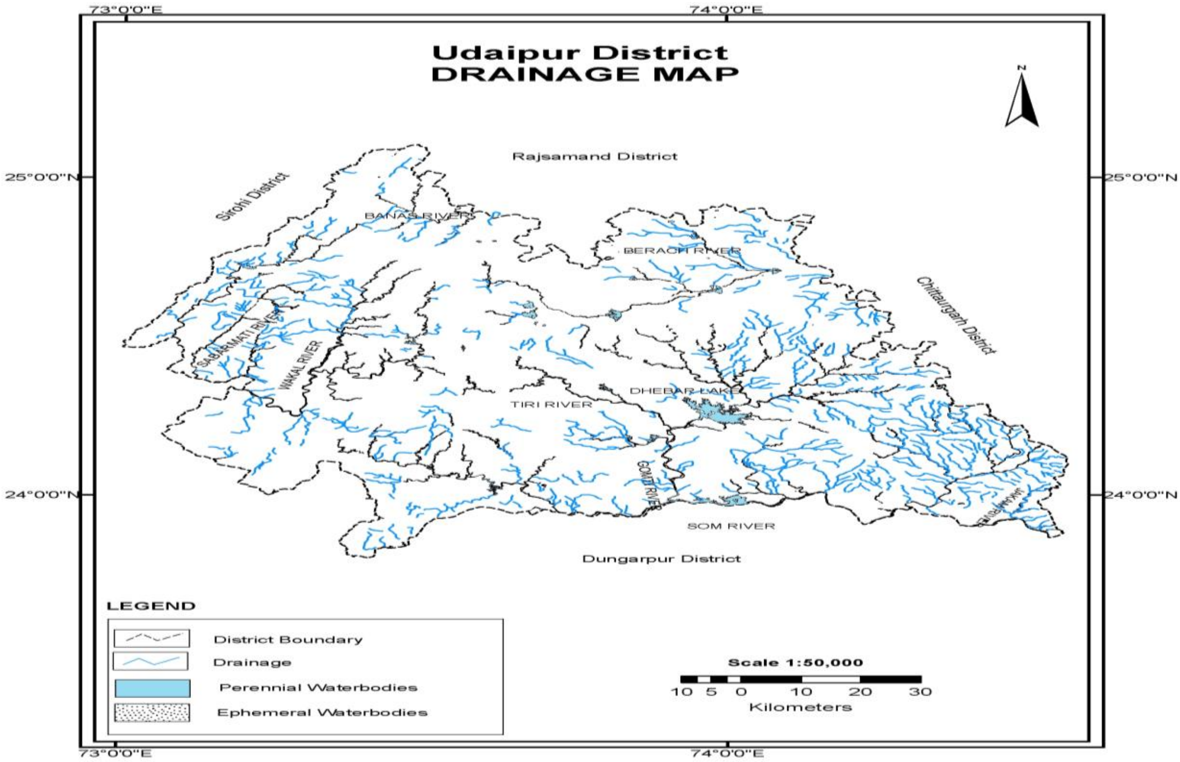
Drainage Pattern

The district has a well developed drainage system. The main rivers of the district are Jakham, Som, Wakal, Sei, Sabarmati, Gomti and Berach. These are monsoon fed rivers and flow more rigorously in rainy season. Jakham, Gomti and Som drain in the south-eastern plains of the district whereas Wakal, Sabarmati and Sei rivers flow through the valley region of Aravali ranges in the south-west of the district. These rivers have been dammed at various sites and thus several artificial lakes have been created. Important among them are Jaisamand, Udaisagar, Pichhola, Fatehsagar, Som Kagdar and Jakham. Drainage density in most part of the district varies from 0.5 to 0.7 km/km^2. Rainfall and surface water alongwith groundwater shape the available drainage pattern and contribute towards watershed areas in any given region.

Watersheds

Watersheds are natural hydrogeomorphological entities that cover a specific areal extent of land from which all rainwater flows to a defined gully, stream, or river at any particular point. A watershed, or a drainage basin, is an area of ground in which any drop of water falling anywhere in it, will live in the same stream or river assuming that the drop is not consumed by the biosphere, evaporated, stored or transported out of the watershed by sub-surface flow (Bofkin *et al.,*1982). According to Davis (1961), the river is like the veins of leaf, broadly viewed it is like the entire leaf. It can also be defined as an area from which run-off resulting from precipitation, flows past a point into a large stream. The term catchment area so drainage basins are very often used in the same sense. Thus watershed forms an ideal unit for detailed study of an area in respect to total environment and consequently for integrated area development plans.

Watershed demarcation in Udaipur District has been done with the aid of Survey of India toposheets and geo-coded IRS LISS-III FCC on 1:50000 which are of great help not only in delineation of ridge lines but also take into account of any marked changes which may have occurred in the stream courses during the past few decades.



Source: Map is drawn on the basis of interpretation of satellite imageries (IRS-1C-LISS-III-2005,2006)

Table 1: Udaipur District- Watershed Area

Watershed	Area (sq km)	Area (%)	Watershed	Area (sq km)	Area (%)
2D2E5	2.97	0.02	2D2E7	733.73	5.82
2D2F5	214.93	1.71	2D2F6	261.28	2.07
2D2F7	1803.15	13.43	5E2B7	130.89	1.04
5E2B8	20.04	0.16	5E3A1	5.22	0.04
5E3A2	650.62	5.16	5E3A3	407.72	3.04
5E3A4	864.22	6.86	5E3A5	1245.5	9.28
5E3A6	925.91	7.35	5E3A7	435.96	3.25
5E3A8	865.37	6.87	5E3B1	489.54	3.89
5E3B2	418.70	3.32	5F1B1	268.53	2.13
5F1B3	344.32	2.57	5F1B4	917.03	7.28
5F1B5	1110.32	8.81	5F1B6	810.07	6.43
5F2C7	87.67	0.70	5F2D5	92.69	0.74
5H3C8	9.26	0.07	6A2A9	33.95	0.27
6A2B7	50.26	0.40	6A2C2	1.24	0.01
Total Area 13419.14 sq km (100.00%)					

Source: Calculated on the Basis of Watershed Atlas, Published by State Remote Sensing Application Centre, Government of Raj, Jodhpur, 1999

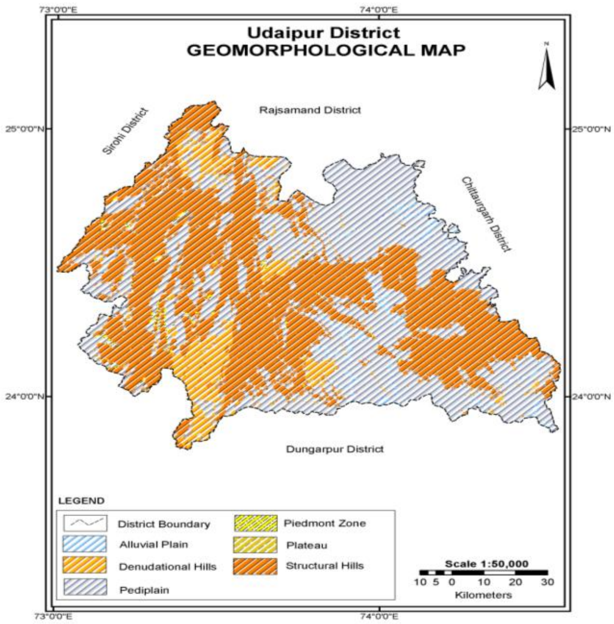
Hydrogeomorphological Units

The classification of hydrogeomorphological units is essentially based on the base geology in combination with geomorphic units. The district is characterized by undulating topography. Towards the western part of district, series of Aravalli hills run along NE-SW direction. A typical plain of gneisses and granites without any alluvium cover is observed to the east of Aravalli Ridges. The landform of the study area has dominance of structural hill and plateaus (47.92 per cent), followed by pediplain weathered (26.92 per cent) and pediment-inselberg compleex landforms.

Table 2: Udaipur District- Geomorphic Units

Geomorphic Units		Area (sq km)	Area (%)
Fluvial Origin	1. Alluvial Plain Younger	349.53	2.60
	2. Alluvial Plain Older	88.55	0.66
Denudational Origin	3. Pediplain Weathered	3612.07	26.92
	4. Pediment-Inselberg Complex	1675.96	12.49
	5. Denudational Hill	959.69	7.15
	6. Piedmont Slope	95.41	0.71
Structural Origin	7. Lower Plateau	3.78	0.02
	8. Structural Hills	6430.07	47.92
Total		**13,419.14**	**100.00**

Source: Drawn on the basis of Satellite Imageries



Source: Map is drawn on the basis of interpretation of satellite imageries (IRS-1C-LISS-III-2005,2006)

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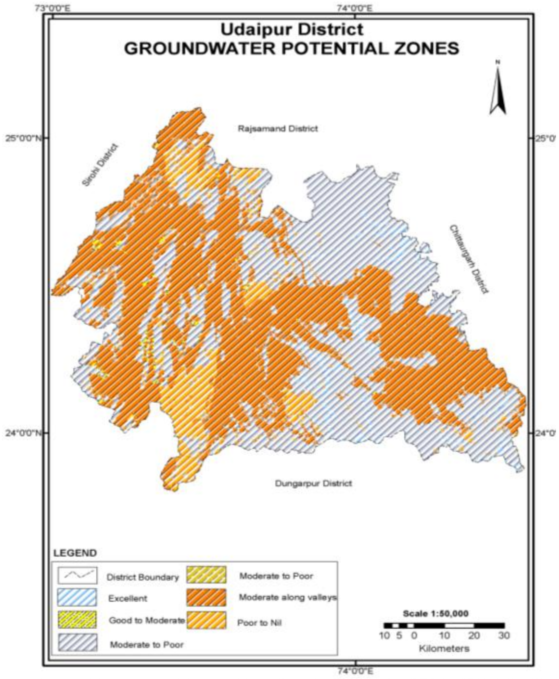

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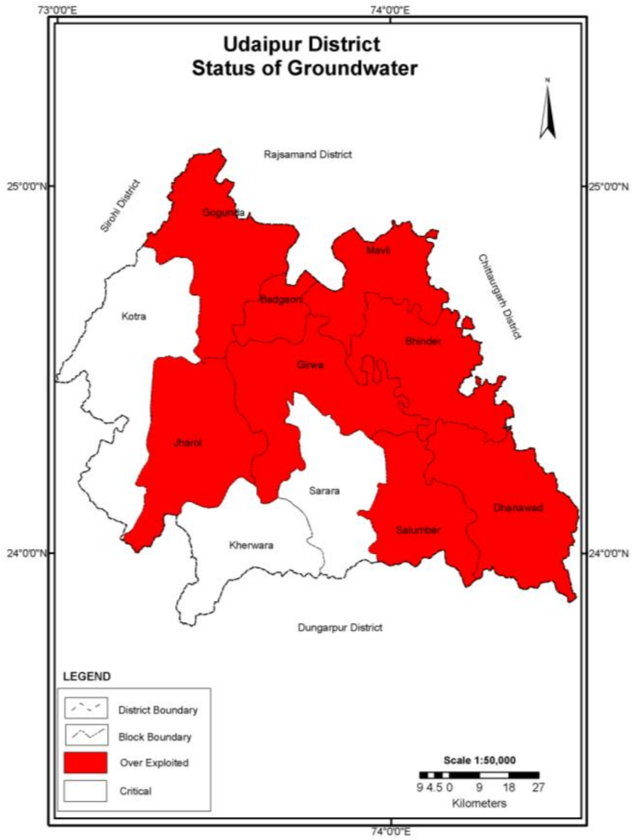

Source: Map is drawn on the basis of interpretation of satellite imageries (IRS-1C-LISS-III-2005,2006)

Geological Sections and Groundwater Availability

In the hard rock areas, geological structures exercise definite control on the aquifer characteristics of different rock types, as the structurally weak planes act as conduits for movement and occurrence of groundwater, thereby introducing an element of directional variation in hydraulic conductivity. The geological structures that can be identified on satellite imagery are divided into two categories: (i) Primary structures- associated with specific rock types and (ii) Secondary structures- which cut, deform and otherwise affect the rock units themselves. Mainly western part of the district is covered by the geological sections comparison to eastern part such as lineament, fault, fold, strike structural trends etc.

The stage of groundwater development in the district is 114.42 per cent, which indicates that the scope of groundwater development is already exhausted in 8 blocks where groundwater development has already exceeded 100 per cent and categorized as over-exploited and only three blocks fall under critical category where groundwater development is approaching 100 per cent. There is no scope for further development in the district for irrigation or industrial use. Gneiss, granites, schist, phyllite, quartzite, calc-schist and calc-gneiss and alluvium form the aquifer in different parts of the district. Alluvium area is restricted to riverbeds. Ground water occurs under unconfined to semi-confined condition. Depth and diameter of the dug well depends on formation and geomorphology. However, general depth of dug- well ranges from 15 to 30 m.

Conclusion and Suggestions

The groundwater regime depends more on the recharge conditions, than any other factor. However, the recharge conditions in turn depend on many other factors. By providing integrated lithologic, structural, geomorphologic and hydrologic data, the satellite imagery facilitates better appreciation of the recharge condition. Based on geomorphic and hydrologic analysis the areas can be classified into runoff, recharge, storage and discharge zones.

The integrated study carried out in the Udaipur district, including all natural and human attributes, suggest that the district has not shown development as it could looking at the resources available. There is enough scope to increase the level of economic conditions and consequently better living, provided an integrated approach. Therefore, for preventing further depletion of groundwater and in future development the first priority is for recouping it -

1. Artificial recharge through many water harvesting structures have been suggested, e.g. nala bund, percolation tanks, recharge pit, de-silting of existing structure etc.
2. Change of cropping pattern and selection of low water requiring crops.
3. Adoption of better irrigation system like the sprinkler and drip irrigation system.
4. Explore the short and long term viability of inter basin water transfer of surplus water viz. Jhakham to Jaisamand, Sabarmati to Udaipur basins, etc.
5. Involving total prohibition of direct defection and discharge of solid wastes by humans in water bodies.
6. Awareness programmes should be implemented effectively. Afforestation and plantation should be made for minimizing water run-off.

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