Evaluation of ground water conditions of Mahesana, Gujarat, India using Geoinformatics Technology

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Abstract— Mahesana district is facing presently acute ground water problem. Day-by-day ground water level is going down requiring systematic study for the delineation of aquifers in the area. It has been observed that ground water level of unconfined aquifer has gone below 400m depth at most of the places. Ground water table is going down by 2 to 4 meters per year. Mahesana area is almost flat and it is occupied by mainly alluvial soil consisting of sand, silt and clay. Sub surface geohydrological conditions have been evaluated with the help of drilling data in GIS environment using Remote Sensing and Geoinformatics technology. Various thematic layers like Landuse, Geology, Soil, Drainage etc. have been prepared and integrated with the subsurface groundwater data for the assessment and evaluation of ground water conditions of the area.

Keywords: Aquifer, Remote Sensing, Geoinformatics, GIS

I. INTRODUCTION

Ground water is a major source for all purposes of water requirements in country and it plays a vital role to human life and economic activity. The occurrence and distribution of groundwater varies significantly from place to place depending on surface and sub-surface geology, geomorphology and rainfall. Mahesana district is one of the important district of Gujarat state as for as agriculture is concerned. Irrigation in the area is dependent not only on canals and rains but also on groundwater. The unplanned and non-scientific development of ground water resources has led to sharp depletion of the resources and also degradation of quality of water at many places. For optimum use of the groundwater resources in conjunction with rain water a systematic study is required to assess the nature and behaviour of aquifers. Using geoinformatics technology various thematic layers have been prepared and integrated with the sub-surface groundwater data with the objective of developing aquifer model.

II. STUDY AREA

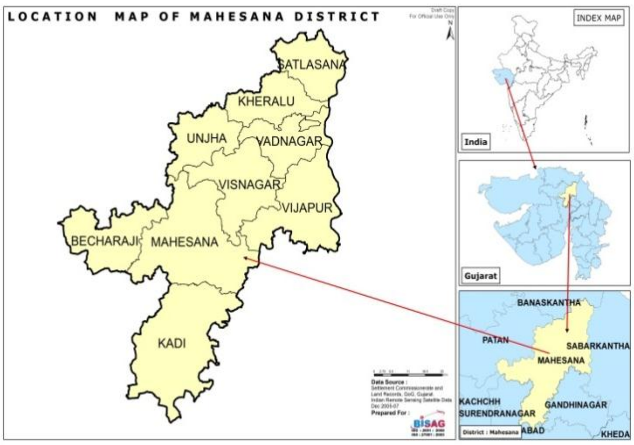

Fig.1: Location Map of the Study Area

Mahesana district is situated in northern part of Gujarat from latitudes 23⁰15' to 23⁰53' north and longitudes 72⁰07'to 72⁰26' east (Fig. 1). It has common boundaries with five other district of Gujarat states. The District is surrounded by Banaskantha District in North, Ahmedabad and Patan District in South & West respectively and Sabarkantha and Gandhinagar District in East. The geographical area of the Mahesana district is 4393.74sq.km. The district is divided into nine Taluka.

A. *Ground Water Condition of Mahesana:*

In the Mahesana district ground water occurs in confined, unconfined and semi confined conditions. Groundwater is exploited in the area by deep tube wells going beyond 400 m depth. Day-by-day groundwater condition is deteriorating in the area due to over exploitation.The withdrawal of ground water is 350 crore cubic meters per annum thereby creating an average annual deficit of ground water as 125 crore cubic meters. North Gujarat is the most stigmatic for the over withdrawal of ground water with water lift in many talukas particularly in Mahesana district having approached critical level of over 500 m.

Due to over withdrawal of ground water, ground water table is going down by 2 to 4 meters per year.

B. *Rainfall:*

Mahesana falls in semi-arid region having rainfall varying from 600 mm to 700 mm.Average rainfall in the district is about 642 mm. Less rain fall especially in North Gujarat is creating problem in agriculture and drinking water. Therefore, major source of irrigation is ground water.

Only 15 % of the rainfall percolates in the soil there by storing over 225 crore cubic meters of rain water annually as ground water. The rest flows away as runoff every year.

In 1991 to 2014 the average normal rainfall of the district is about 737 mm. Rainfall in different parts of Mahesana District varies from 281 mm to 1421 mm with average number of 45 to 50 rainy days (Fig. 2).

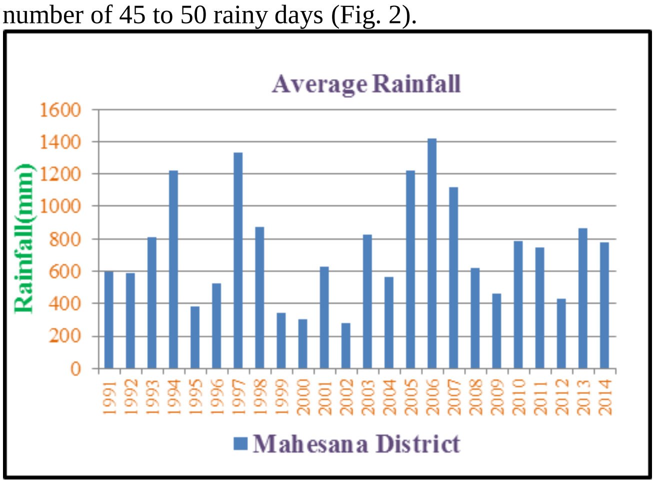

Fig. 2: Year Wise Average Rainfall of Mahesana District from 1991 To2014

C. Topography of the Area:

Topographically area is almost flat covered by alluvial soil except in Kheralu and Satalasana area which is hilly (Table 1).Topography controls the flow of surface water and its direction and its infiltration in sub-soil.The slope in major part of the Mahesana region ranges from 0 to 1% that is almost flat.

Class	Percentage	Slope Category	Area(Km^2)
1	0 – 1	Nearly Level	4242.29
2	1 – 3	Very gentle Slope	57.61
3	3 – 5	Gentle Slope	9.27
4	5 – 10	Moderate Slope	19.15
5	10 - 15	Strong Slope	3.84
6	15 – 35	Moderate steep to steep slope	5.24
7	35 – 50	Very steep slope	42.26
	Total		4379.69

Table 1: Categories of Slope in the Study Area

III. METHODOLOGY

The methodology adopted for the present study includes:

1) Development of thematic layer such as land use map, topography, geology, soil etc. with the help of LISS-III and Cartosat images using remote sensing and GIS software.
2) Collection and integration of collateral Data such as Administrative boundary, District Boundary, Taluka Boundary, Hydrological Data with the thematic layers (Fig.3).
3) Study and plotting of lithologs (Subsurface drilling data).
4) Synthesis and integration of various thematic layers, and hydro geological data for the assessment and evaluation of ground water condition in GIS environment for the development of aquifer model.

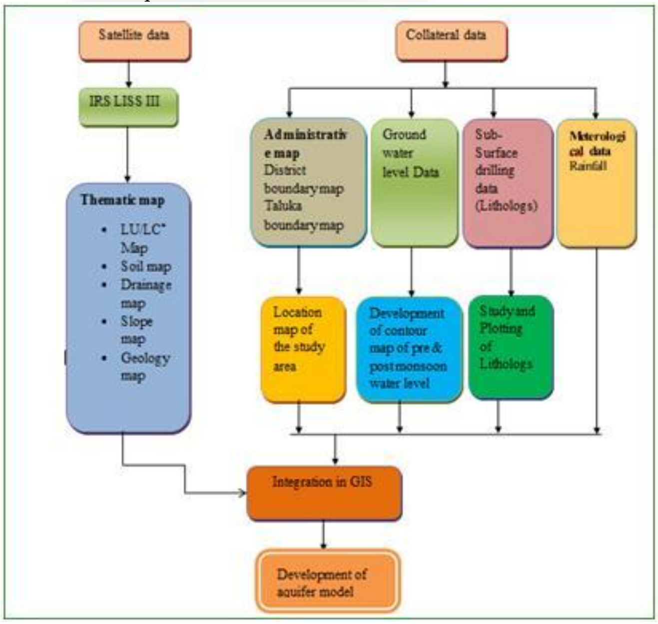

Fig. 3: Flow Chart of the Adopted Methodology

A. Drainage of the Area:

The entire area is drained by the Sabarmati and the Rupen. The river Sabarmati flowing on the boundary of the district is the third largest river in the state after Narmada and Tapi. It originates from the Arawallis in Rajasthan, and in its course of about 300 km, flows through Kheralu (Satlasan), Vijapur, and Kalol taluka. The river flows 90 km in Mahesana district and then enters in Gandhinagar district. The river Rupen rises from the western side of the Taranga hill in Satalasana taluka and flows through Satalasana, Kheralu, Visnagar and Mahesana taluka before entering in the Patan district.

These are two main rivers in the district but none of them is navigable. Sabarmati was Perennial River in the past but turned seasonal after construction of Dharohi dam.

IV. THEMATIC MAPS

A. Landuse Map:

Land use can be defined as the use of land by humans, usually with emphasis on the functional role of land in economic activities. This map also indicates surface reflection of the ground water conditions. The land use/land cover map has been generated using IRS-1C LISS III image. Supervised classification has been done and various classes have been identified such as Agriculture, Built up, Forest, Wastelands, and Water bodies, Others (Prosophis) (Fig. 4). Study reveals that major area about **89%** is covered under agriculture. Thus most of the ground water exploitation is in this area for irrigation requirement.

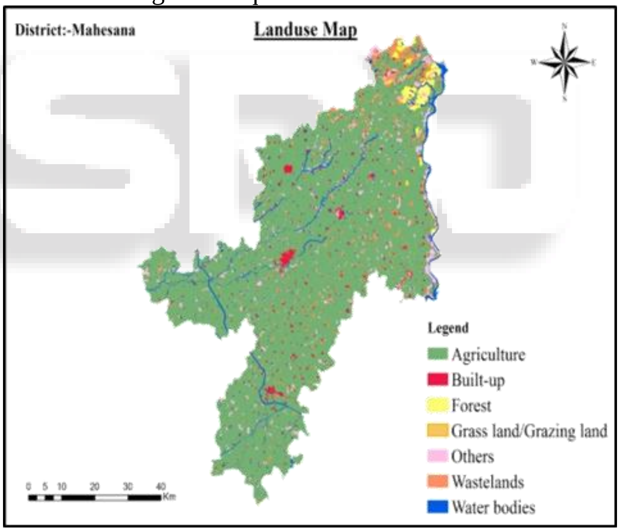

Fig. 4: Landuse Map of Study Area

B. Soil Map:

The infiltration rate of the soil depends on the soil texture of the area. Soil texture depends on the relative proportion of Sand, Silt and Clay. In Mahesana area predominant soil group is of Loamy soil (Fig. 5). 54% of the area is covered by coarse loamy soil and 42.27% area is covered by Fine Loamy soil.It has been observed that infiltration rate in the loamy soil is high

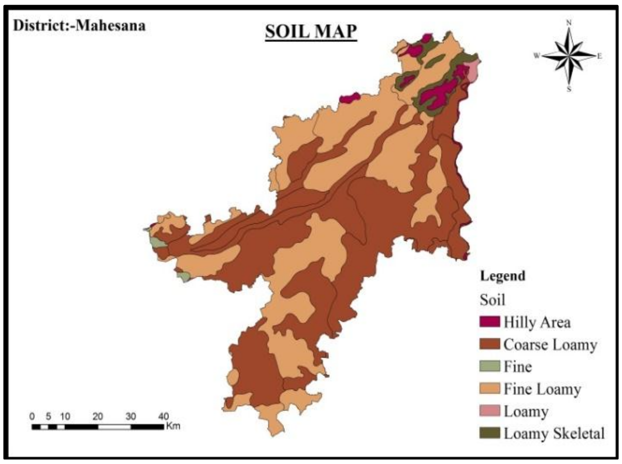

Fig. 5: Soil Map

C. Geology-Geomorphology Map:

Major part of the Mehsana district is occupied by Quaternary Sediments of Sabarmati and Rupen Rivers. About 56% area covers under alluvial plain and 35% Eolian (Fig. 6). Geology plays important role in the movement of surface water in ground through permeable rocks and geological structural features and type of soils. Good aquifers are formed due to occurrence of porous and permeable sub surface zones depending on the geology.

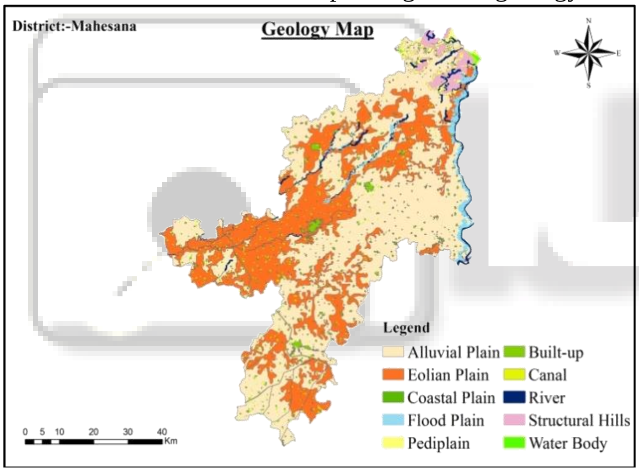

Fig. 6: Geology-Geomorphology Map

Sub surface geological cross-sections have been prepared based on the sub surface exploration (Fig. 7). These sections indicate that clay occurs in the form of lenses in sandy and loamy soils as well as in layers (Fig. 8).

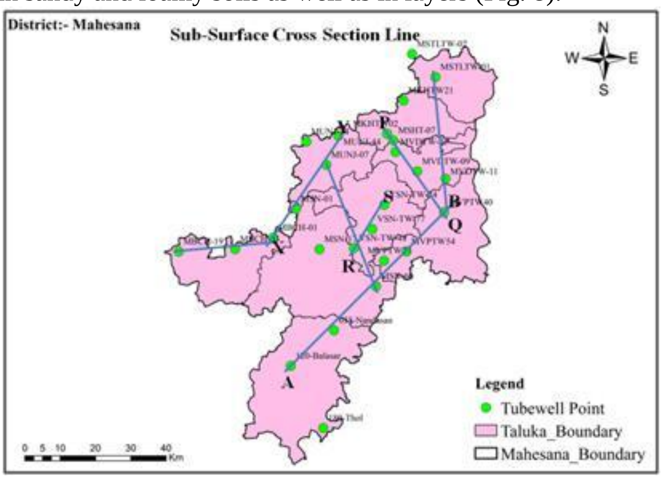

Fig. 7: Location of Borehole and Section Line

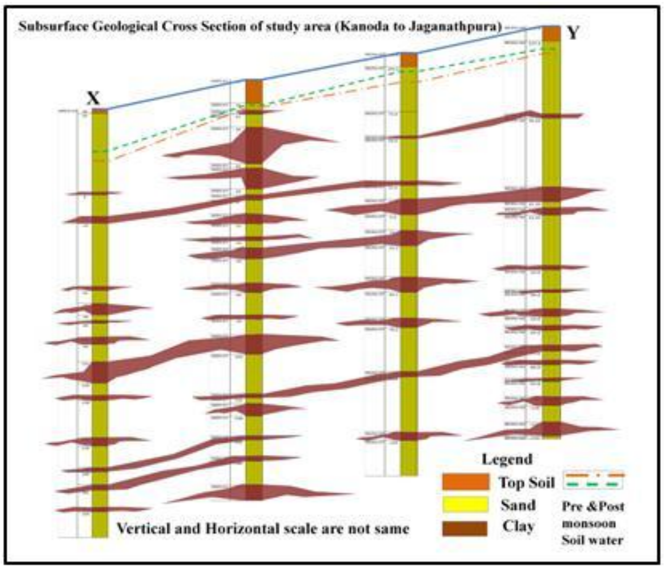

Fig. 8: Sub Surface Geological Cross Section From Kanoda to Jaganathpura

D. Water Table Map:

1) Top Soil Water Level Map:

Available sub surface water level data has been synthesized for the period 2011-2014 and depth wise Top soil water level maps have been developed in GIS environment which show slight increase in pre monsoon and post monsoon water levels in the study area except in some part of Unjha, Vadnagar, Kheralu and Visnagar Talukas (Fig. 9 to 12).

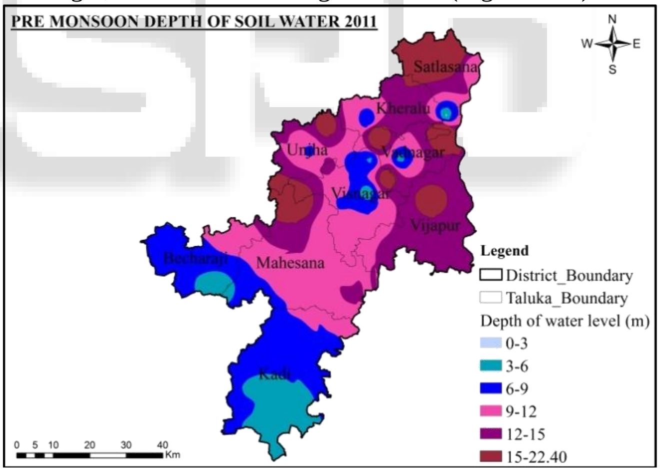

Fig. 9: Pre Monsoon Depth of Soil Water

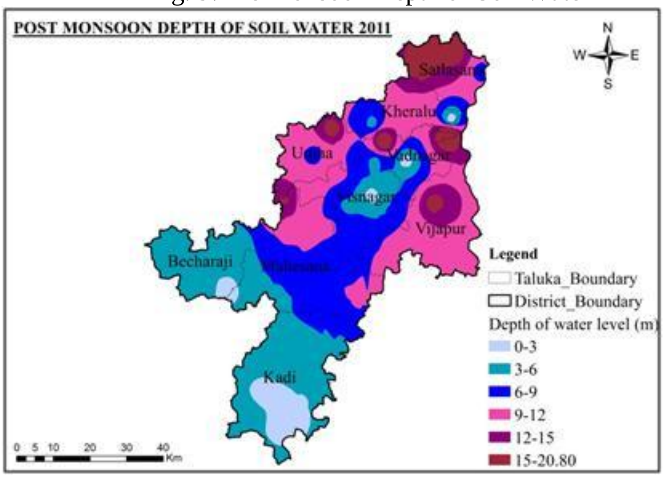

Fig. 10: Post Monsoon Depth of Soil Water 2011

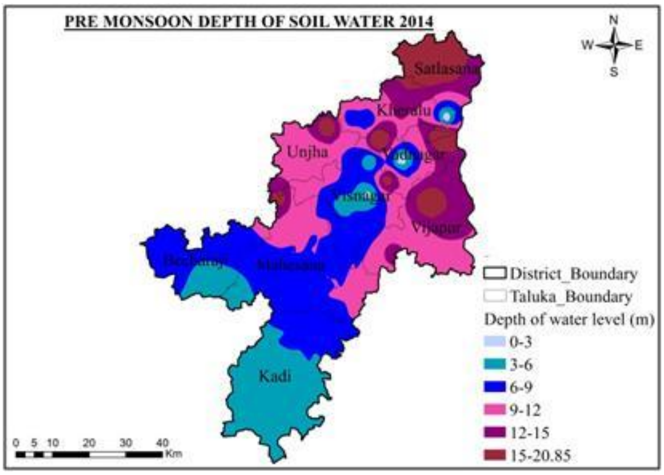

Fig. 11: Pre Monsoon Depth of Soil Water 2014

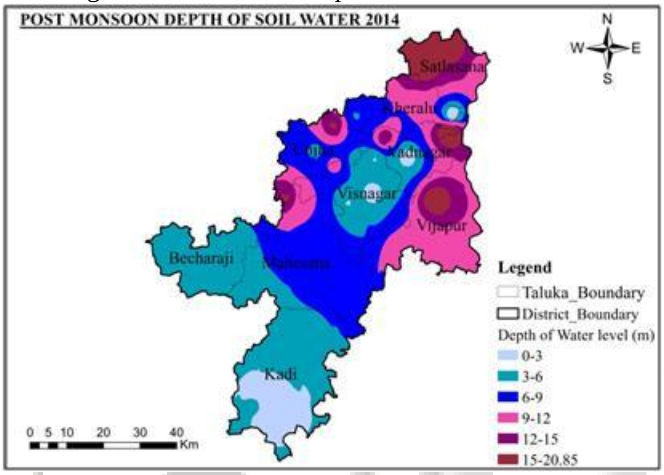

Fig. 12: Post Monsoon Depth of Soil Water 2014

2) Confined Aquifer Water Level Maps:

These maps indicate that water levels in the confined aquifer increases during the post monsoon period. Depending the configuration of the confined aquifers water level varies between (–30)m and (– 75) m at various locations

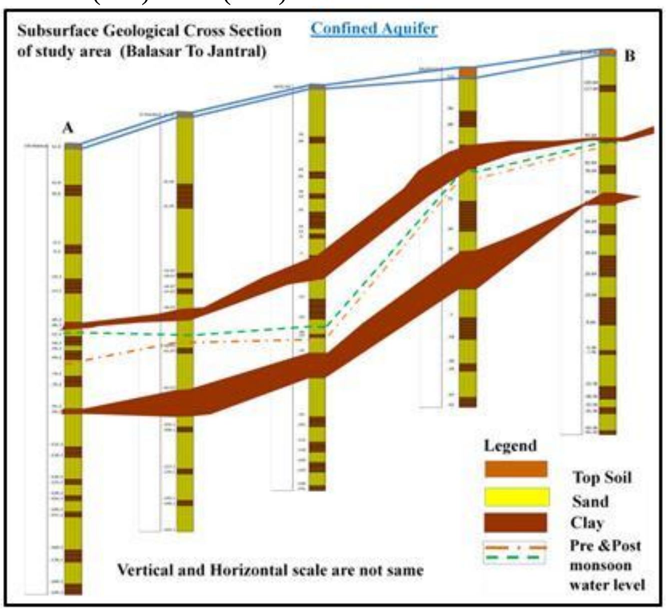

Fig. 13: Sub Surface Geological Croos-Section from Balsar To Jantral Showing Configuration of Confined Aquifer

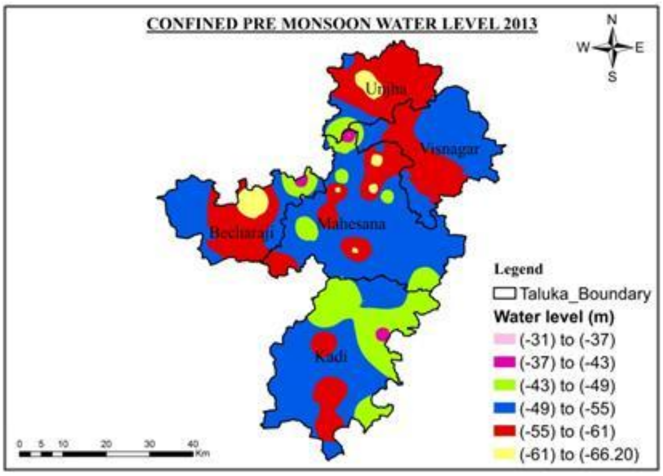

Fig.14: Confined Pre Monsoon Water Level Map (2013)

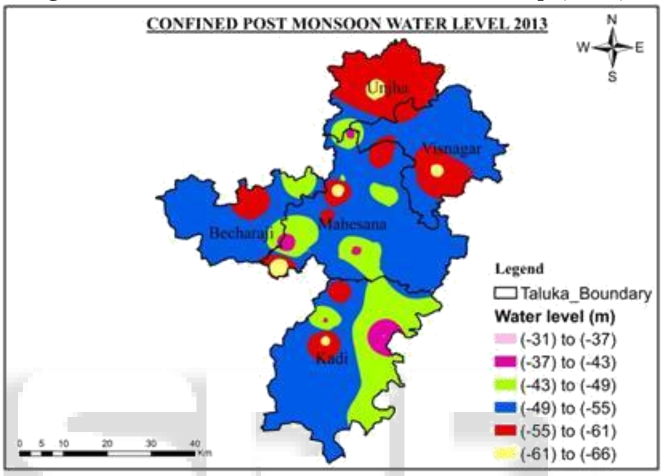

Fig.15 Confined Post Monsoon Water Level Map (2013)

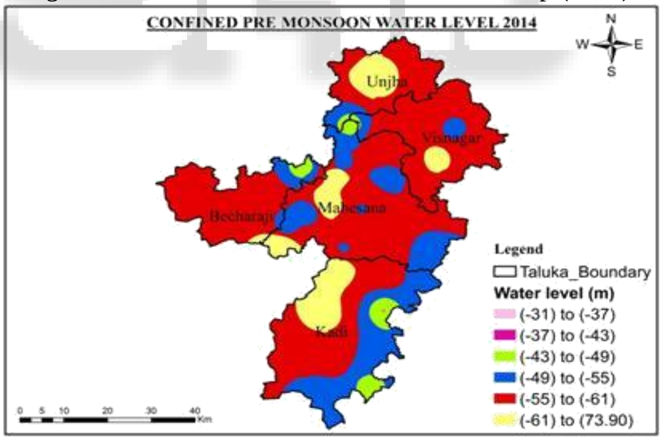

Fig. 16: Confined Pre Monsoon Water Level Map (2014)

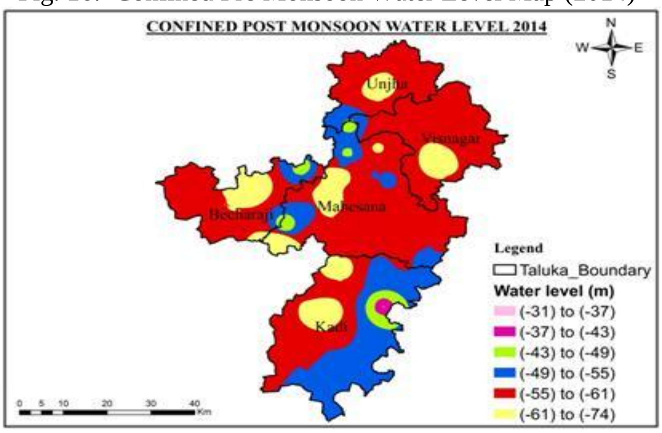

Fig. 17: Confined Post Monsoon Water Level Map (2014)

V. RESULT AND CONCLUSION

Major part of Mahesana district is almost flat except Kheralu and Satalasana area. Area is occupied mainly by Alluvial soil consisting of Loamy, Sandy and clayey. Various thematic layers have been prepared and integrated with geohydrological and hydrological data using GIS technology to understand surface hydrology and subsurface occurrence of ground water and behaviour of aquifer. There are multiple aquifers in the area but unconfined water table has gone much below the ground at places beyond 400m depth.Ground water table is going down by 2 to 4 meters per year. A few confined aquifers exist at relatively higher levels whose recharge source is beyond Mahesana.

For irrigation purpose district depends on groundwater sources. With time this resource has been used without considering adverse effect of over exploitation of ground water. The present study is part of the project for the development of ground water model of the entire district. This model will help in understanding of correct disposition of aquifers, characteristics and nature for the proper groundwater management.

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