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Research Article

Groundwater Modeling of Huzur Tehsil, M.P Using GIS Techniques

Vimal Shukla*, Jyoti Sarup

Department of Civil Engineering, Center of Remote sensing and GIS, Maulana Azad National Institute of Technology Bhopal, Madhya Pradesh

Correspondence should be addressed to Vimal Shukla, *vimalshukla.nitbpl@gmail.com*

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Abstract Huzur Tehsil, district Bhopal city in the Madhya Pradesh state of India has faced the problem of groundwater availability in recent times believed largely due to rapid urbanization coupled with the presence of increasing Population and the urban sprawl increase the number of bores well in earth, which is the reason to the declination of groundwater level. That means water is very important for the sustained use of natural resources and is vital for the existence of mankind. Groundwater used for a variety of purposes, including irrigation, drinking, and manufacturing. For assessing the groundwater Level suitability zones through GIS techniques, this study was undertaken in the Huzur Tehsil, Bhopal district, Madhya Pradesh. Artificial recharge is expected to become increasingly necessary in the future as the growing population requires more water and thus, more storage is required to conserve water for use in times of shortage. Geospatial techniques employing Geographical information systems (GIS) are increasingly being used in the field of hydrology and water resources development. This is the greatest advantage of using GIS techniques for Groundwater level (bore well) investigations and monitoring is its ability to generate information in water level behavioral conditions, which is provided very critical for successful analysis, prediction, and validation. In the present study, the Kriging technique was used to interpolate the groundwater levels. Interpolation of pre and post-monsoon groundwater levels was carried out for the year 1996-2017. Finally, we generated the fluctuation maps were showing the fluctuation in the pre-post monsoon period between the years, 1996-2000, 2001-2005, -2010 and 2011-2017 and Long term trend fluctuation maps were generated showing, and finally, Feature Projected Groundwater Level map are generated 2018-2051 period, and showing the Groundwater Level trend (1996-2051) since. For visualization groundwater level depth (mbgl) and Fluctuation, in the pre and post-monsoon period, showing the 3D Surface modeling using Matlab tools.
Keywords *Groundwater level mapping; groundwater fluctuation; Geospatial Techniques; Kriging; 3D surface; GIS*

1. Introduction

Groundwater is subsurface water that occurs beneath the earth's surface. In a hydrologic water cycle, groundwater comes from surface waters (precipitation, lake, reservoir, river, sea, etc.) and percolates into the ground beneath the water table. Groundwater is a significant part of the hydrologic cycle, containing 21% of earth water. Growth in population, urbanization, and standards of living has resulted in increased demand for water. Groundwater has an important role in the environment: it replenishes streams, rivers, and wetlands and helps to support wildlife habitat; it is used as the primary source of drinking water and also in agricultural and industrial activities. Around the world, groundwater resources are under increasing pressure caused by the intensification of human activities and other factors such as growing population and very fast Urban Sprawl. Many states in India use the water right process to manage groundwater quantity and to ensure that over drafting does not occur. Groundwater is the major source of drinking water in rural India. It is estimated that approximately one-third of the world's population use groundwater for drinking purpose (Nickson et al., 2005). In addition to rural households, public water supplies in various parts of the world depend on wells and groundwater. But due to increases, the number of population that means urban sprawl increases and demand for water are is required more in an urban area and which increasing number is of bore well every house holding in an urban area, which is the reason to decline the Groundwater Level. As we know groundwater is an important source of water supply throughout the world, its uses in irrigation, industry, municipality and domestic areas continue to increase. Therefore, greater emphasis is being laid for a planned and optimal utilization of water resources. Owing to the uneven distribution of rainfall both in time and space, the surface water resources are unevenly distributed. This has resulted in an increased emphasis on the development of groundwater resources. The simultaneous development of groundwater especially through bore wells a will decline water table. In such a situation, a severe problem is created resulting in the drying of bore wells. Modern techniques like GIS (Geographical information technology) are increasingly becoming important day by day in all real-world problems of geospatial nature. The field of hydrology and water resource development is also the area having an extensive scope of deriving benefits from these tools of geoinformatics (Krishna et al., 2005). One of the greatest advantages of using GIS for hydrological investigations and monitoring is its ability to generate information in groundwater fluctuation and condition of groundwater, which is very crucial for successful analysis, prediction, and validation (Kumar M.G. et al., 2008). GIS technology is becoming an important tool as a platform to efficiently manage large and complex information organized around its core. It also provides suitable alternatives for efficient management of large and complex databases.

1.1. Problem Identification

In see few years the Groundwater Level decline in Huzur Tehsil, district Bhopal, Madhya Pradesh, India. Due to increases in the high population and more urban sprawl that means increasing the number of bores well, which are affected by the groundwater level. And few bore well dry in the pre-monsoon period. This condition produces a continuous decline groundwater level in Huzur, Tehsil district Bhopal, Madhya Pradesh, India.

1.2. Objectives of the Study

The analysis of the declining groundwater levels and the factors responsible for it is the immediate need of the hour to assess the overall scenario concerning groundwater. The study includes the analysis of groundwater fluctuation (1996-2017) pre-post monsoon. The study includes the analysis of Long term trend groundwater fluctuation (1996-2017) pre-monsoon. The study includes the analysis of feature projected groundwater level fluctuation (2018-2051) and shows the trend pattern in Groundwater level fluctuation. With the help of MATLAB showing the groundwater level fluctuation visualization.

2. Study Area

Huzur Tehsil, Bhopal district, spanning over an area of about 1361.77 sq. km lies in the central part of the state of Madhya Pradesh. Before the independence of India, it was a part of the Bhopal state, which was founded by Nawab Dost Mohammad Khan in the year 1722. The reorganization of states in November 1956, made Bhopal the capital of Madhya Pradesh State, but it remained the part of Sehore district. In the year 1972 Bhopal became the new district under the Bhopal commissioner's division.

The district is bounded by Guna district on the north, Vidisha district on the northeast, Raisen district on the east and Sehore and Rajgarh district on the southwest and west respectively. There are 245 villages in the Huzur These, Bhopal District. Bhopal urban area is about 296 sq km. Bhopal city is the district as well as state headquarter. Bhopal is well connected with all parts of the country by Air, Rail, and roads. The location of the study area is shown in the map below (Figure 1). The area falls between North latitude 23^{0} 04’18” and 23^{0} 25’46” and East longitude 77^{0} 10’07” and 77^{0} 37’32. Show the Location map of Huzur Tehsil is given in (Figure 2).

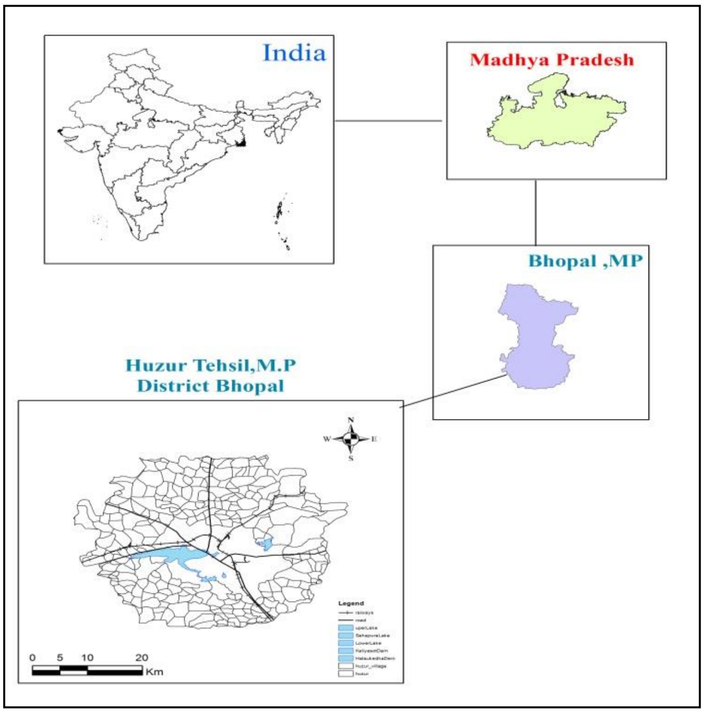


Figure 1: *Location of the study area*

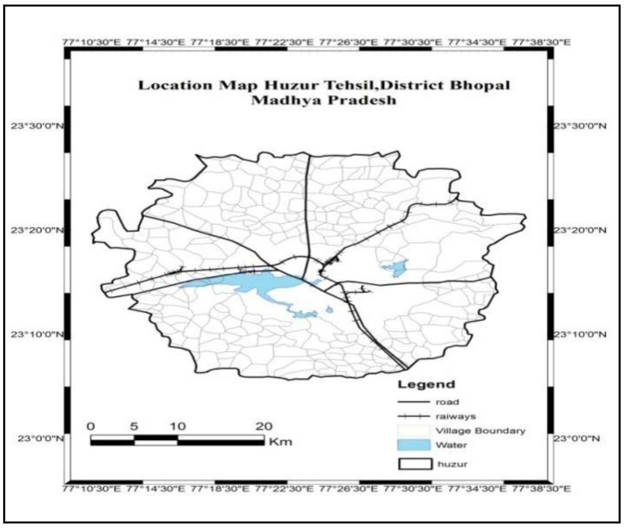


Figure 2: *The Location Map of Huzur Tehsil, District Bhopal, Madhya Pradesh, India*

2.1. Climate

Bhopal has consisted of the humid subtropical climate, with mild, dry winters, hot summer and a humid monsoon season. The summers start in late April and go on till mid-June, the average temperature is around 30 °C (86 °F), with the peak of summer in May, when the highs regularly exceed 40 °C (104 °F).

2.2. Rainfall

The monsoon starts in late June and ends in late September. IMD normal annual rainfall of Bhopal city is 1260.2 mm. The average temperature is almost around 25 °C (77 °F) and the humidity is quite high. The temperatures rise again up to late October when winter starts, which lasts up to early March. The winters in Bhopal are mild, sunny and dry, with average temperatures around 18 °C (64 °F) and little or no rain. The winter time peaks in January when temperatures may drop close to freezing on some nights. The daily normal temperature of Bhopal in May - 40.70 C and minimum - 26.40 C. rainfall analysis the monsoon time last June to September time Groundwater level is good Condition in the study are . The annual variation of rainfall is shown below (Figure 3).

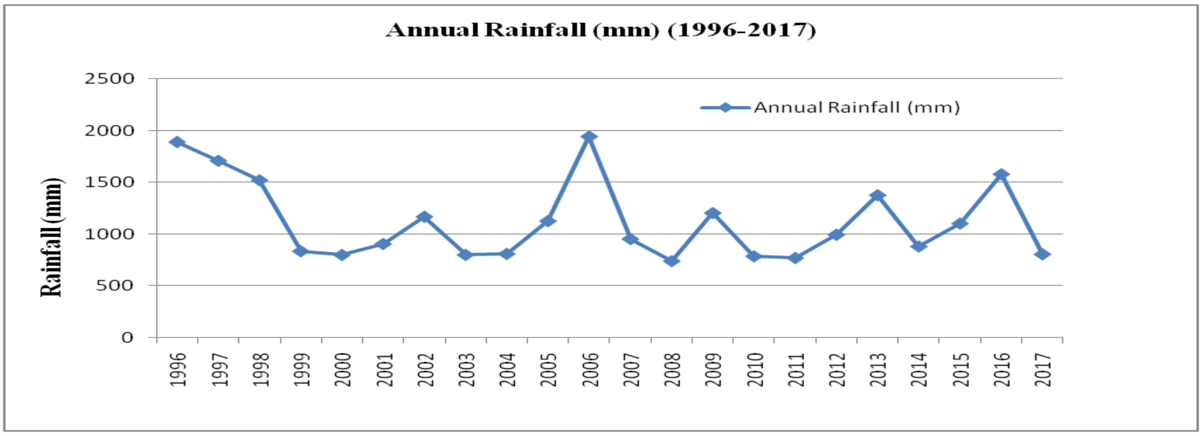


Figure 3: *Rainfall Patter*

2.3. Well Distribution

Above the study area to collect the 130 rural and 220 urban areas bore well point. Show in below location of well point in urban and rural area (Figure 4).

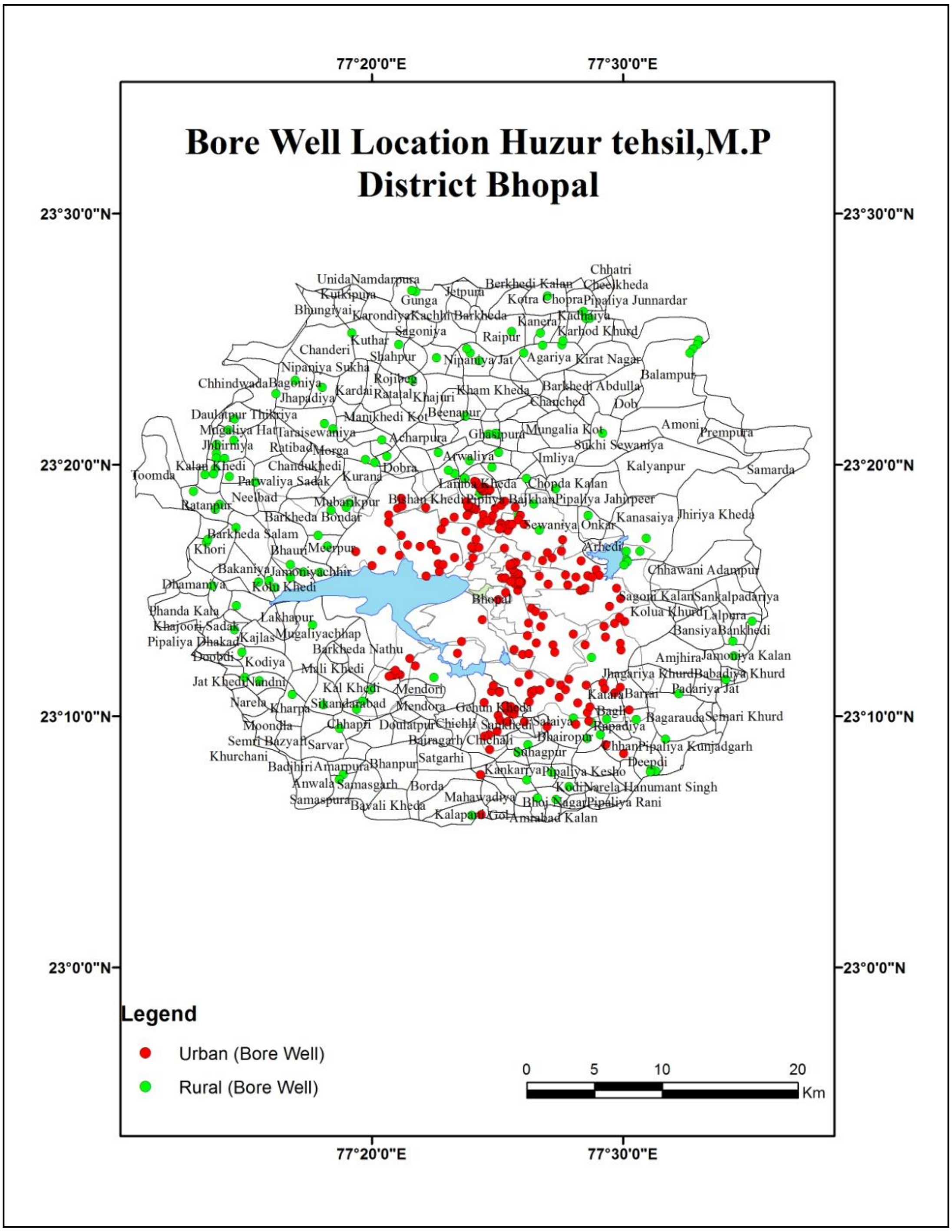


Figure 4: *Location of well distribution in Huzur Tehsil District Bhopal, Madhya Pradesh, India*

3. Data Collection and Methodology

3.1. Data collection

Central Ground Water Board (CGWB) maintains 350 wells Huzur Tehsil, Bhopal district for monitoring groundwater resources. We have collected a total of 350 bore wells data that are collected in Huzur tehsil, Bhopal District. They are identification of well Location Ground truths using the handholds GPS. As shown in below the Well Location map in Huzur tehsil, District Bhopal, Madhya Pradesh (Figure 4). The collected urban and rural Groundwater Level Bore well (mbgl) data (1996-2017) Huzur Tehsil, District Bhopal, Madhya Pradesh as shown in two sample of Table 1, 2 (Source: Central *Ground Water*

Board, Ministry of Water Resources, Government of India, India, taken 2015). And Five year annual average groundwater level between the 1996-2000, 2001-2005, 2006-2010 shows in Table 3, 4, 5. And last seven year period lies 2011-2017 as shown in Table 6 (Source: Central *Ground Water Board, Ministry* of Water Resources, Government of India, India, taken 2015).

***Table 1**: List of Two Urban area Pre –Post Monsoon Groundwater Level (mbgl) in Huzur Tehsil (1996- 2017)*

WL_ID	Lat	Long	Site_ Type	Year_Obs	Pre-monsoon (mbgl)	Post-monsoon (mbgl)
UA101	23.26	77.43	Bore Well	1996	4.35	3
UA101	23.26	77.43	Bore Well	1997	7.42	3.05
UA101	23.26	77.43	Bore Well	1998	8.13	4.22
UA101	23.26	77.43	Bore Well	1999	9.92	5.14
UA101	23.26	77.43	Bore Well	2000	10.95	5.24
UA101	23.26	77.43	Bore Well	2001	12.83	5.35
UA101	23.26	77.43	Bore Well	2002	13.55	5.46
UA101	23.26	77.43	Bore Well	2003	14.78	7.13
UA101	23.26	77.43	Bore Well	2004	15.48	7.56
UA101	23.26	77.43	Bore Well	2005	15.78	7.65
UA101	23.26	77.43	Bore Well	2006	16.09	7.79
UA101	23.26	77.43	Bore Well	2007	16.54	7.86
UA101	23.26	77.43	Bore Well	2008	16.75	7.89
UA101	23.26	77.43	Bore Well	2009	16.89	7.95
UA101	23.26	77.43	Bore Well	2010	16.99	8.12
UA101	23.26	77.43	Bore Well	2011	17.15	8.45
UA101	23.26	77.43	Bore Well	2012	17.55	8.67
UA101	23.26	77.43	Bore Well	2013	17.79	8.96
UA101	23.26	77.43	Bore Well	2014	17.98	9.12
UA101	23.26	77.43	Bore Well	2015	18.11	10.36
UA101	23.26	77.43	Bore Well	2016	18.55	11.58
UA101	23.26	77.43	Bore Well	2017	18.78	12.8
UA102	23.26	77.43	Bore Well	1996	14.72	9.91
UA102	23.26	77.43	Bore Well	1997	15.79	10.45
UA102	23.26	77.43	Bore Well	1998	16.75	11.76
UA102	23.26	77.43	Bore Well	1999	33.16	19.51
UA102	23.26	77.43	Bore Well	2000	33.59	19.73
UA102	23.26	77.43	Bore Well	2001	33.68	20.35
UA102	23.26	77.43	Bore Well	2002	33.85	20.74
UA102	23.26	77.43	Bore Well	2003	33.95	20.98
UA102	23.26	77.43	Bore Well	2004	34.15	21.11
UA102	23.26	77.43	Bore Well	2005	34.98	22.27
UA102	23.26	77.43	Bore Well	2006	40.98	22.35
UA102	23.26	77.43	Bore Well	2007	42.52	28.25
UA102	23.26	77.43	Bore Well	2008	45.84	32.24
UA102	23.26	77.43	Bore Well	2009	47.25	36.52
UA102	23.26	77.43	Bore Well	2010	49.33	39.2
UA102	23.26	77.43	Bore Well	2011	52.15	42.13
UA102	23.26	77.43	Bore Well	2012	54.35	44.02

UA102	23.26	77.43	Bore Well	2013	56.48	46.05
UA102	23.26	77.43	Bore Well	2014	60.25	48.15
UA102	23.26	77.43	Bore Well	2015	65.28	50.25
UA102	23.26	77.43	Bore Well	2016	68.15	52.15
UA102	23.26	77.43	Bore Well	2017	70.55	54.55

Table 2*: List of Two Rural area Pre –Post Monsoon Groundwater Level (mbgl) in Huzur Tehsil (1996- 2017)*

WL_ID	Lat	Long	Site_ Type	Year_Obs	Pre-monsoon (mbgl)	Post-monsoon (mbgl)
R201	23.28	77.51	Bore Well	1996	7.56	4.57
R201	23.28	77.51	Bore Well	1997	7.75	6.15
R201	23.28	77.51	Bore Well	1998	8.05	6.25
R201	23.28	77.51	Bore Well	1999	8.45	7.10
R201	23.28	77.51	Bore Well	2000	8.65	6.98
R201	23.28	77.51	Bore Well	2001	11.32	10.86
R201	23.28	77.51	Bore Well	2002	12.66	11.34
R201	23.28	77.51	Bore Well	2003	14.32	12.11
R201	23.28	77.51	Bore Well	2004	16.10	17.66
R201	23.28	77.51	Bore Well	2005	17.10	17.76
R201	23.28	77.51	Bore Well	2006	17.76	11.45
R201	23.28	77.51	Bore Well	2007	17.80	10.54
R201	23.28	77.51	Bore Well	2008	20.22	17.76
R201	23.28	77.51	Bore Well	2009	24.38	17.76
R201	23.28	77.51	Bore Well	2010	26.30	18.32
R201	23.28	77.51	Bore Well	2011	27.00	17.76
R201	23.28	77.51	Bore Well	2012	27.31	13.91
R201	23.28	77.51	Bore Well	2013	27.42	14.00
R201	23.28	77.51	Bore Well	2014	27.52	14.10
R201	23.28	77.51	Bore Well	2015	27.73	14.60
R201	23.28	77.51	Bore Well	2016	28.65	22.55
R201	23.28	77.51	Bore Well	2017	30.48	23.46
R202	23.28	77.50	Bore Well	1996	8.82	2.50
R202	23.28	77.50	Bore Well	1997	15.30	10.18
R202	23.28	77.50	Bore Well	1998	16.12	12.60
R202	23.28	77.50	Bore Well	1999	19.14	12.23
R202	23.28	77.50	Bore Well	2000	19.24	13.52
R202	23.28	77.50	Bore Well	2001	16.66	13.54
R202	23.28	77.50	Bore Well	2002	16.98	12.82
R202	23.28	77.50	Bore Well	2003	19.65	13.20
R202	23.28	77.50	Bore Well	2004	17.90	13.90
R202	23.28	77.50	Bore Well	2005	18.40	13.92
R202	23.28	77.50	Bore Well	2006	17.23	13.98
R202	23.28	77.50	Bore Well	2007	18.10	14.06
R202	23.28	77.50	Bore Well	2008	18.25	13.15
R202	23.28	77.50	Bore Well	2009	19.70	13.04
R202	23.28	77.50	Bore Well	2010	19.80	12.71

R202	23.28	77.50	Bore Well	2011	19.95	12.45
R202	23.28	77.50	Bore Well	2012	20.00	12.52
R202	23.28	77.50	Bore Well	2013	20.12	12.92
R202	23.28	77.50	Bore Well	2014	20.25	13.12
R202	23.28	77.50	Bore Well	2015	22.86	20.72
R202	23.28	77.50	Bore Well	2016	24.38	22.25
R202	23.28	77.50	Bore Well	2017	24.38	22.25

***Table 3**: Five year annual average groundwater level sample rows from Bore well point of Huzur Tehsil, M.P, Bhopal (1996-2000)*

WL_ID	YEAR	Pre-monsoon (mbgl)	Post-monsoon(mbgl)	LAT	LON	Fluctuation
UA101	1996-2000	8.154	4.13	23.25	77.43	4.024
UA102	1996-2000	22.802	14.272	23.25	77.43	8.53
UA103	1996-2000	8.092	6.21	23.25	77.43	1.882
R201	1996-2000	8.092	6.21	23.27	77.51	1.882
R202	1996-2000	15.724	10.206	23.27	77.50	5.518
R203	1996-2000	8.706	3.954	23.27	77.50	4.752

***Table 4**: Five year annual average groundwater level sample rows from Bore well point of Huzur Tehsil, M.P, Bhopal (2001-2006)*

WL_ID	YEAR	Pre-monsoon (mbgl)	Post-monsoon(mbgl)	LAT	LON	Fluctuation
UA101	2001-2005	14.484	6.63	23.25	77.43	7.854
UA102	2001-2005	34.122	21.09	23.25	77.43	13.032
UA103	2001-2005	14.3	12.31	23.25	77.43	1.99
R201	2001-2005	14.3	12.236	23.27	77.51	2.064
R202	2001-2005	17.918	13.476	23.27	77.50	4.442
R203	2001-2005	10.924	6.606	23.27	77.50	4.318

***Table 5**: Five year annual average groundwater level sample rows from Bore well point of Huzur Tehsil, M.P, Bhopal (2006-2010)*

WL_ID	YEAR	Pre-monsoon (mbgl)	Post-monsoon (mbgl)	LAT	LON	Fluctuation
UA101	2006-2010	16.652	7.922	23.25	77.43	8.73
UA102	2006-2010	45.184	31.712	23.25	77.43	13.472
UA103	2006-2010	21.292	15.166	23.25	77.43	6.126
R201	2006-2010	21.292	15.166	23.27	77.51	6.126
R202	2006-2010	18.616	13.388	23.27	77.50	5.228
R203	2006-2010	12.13	7.842	23.27	77.50	4.288

***Table 6**: Five year annual average groundwater level sample rows from Bore well point of Huzur Tehsil, M.P, Bhopal (2011-2017)*

WL_ID	YEAR	Pre-monsoon (mbgl)	Post-monsoon(mbgl)	LAT	LON	Fluctuation
UA101	2010-2017	17.987	9.991	23.25	77.43	7.995
UA102	2010-2017	61.03	48.185	23.25	77.43	12.844
UA103	2010-2017	31.905	20.507	23.25	77.43	11.398
R201	2010-2017	28.015	17.197	23.27	77.51	10.818
R202	2010-2017	21.705	16.604	23.27	77.50	5.101
R203	2010-2017	13.468	8.322	23.27	77.50	5.145

3.2. Population data

These are collected the Population of Huzur Tehsil, District Bhopal, Madhya Pradesh as per Census 2001 (1429132) & 2011 (1834493) out of a total population, 89.5% people live in urban areas while 10.5% lives in the rural areas. As shown in below the total population of Huzur Tehsil, district Bhopal, M.P in Figure 5. As per Census 2011, the number of total 211 Villages in Huzur Tehsil of Bhopal district, Madhya Pradesh. Show the Table 7 and 8 lists of cities and villages in Huzur Tehsil of Bhopal district, Madhya Pradesh (Source: As per Census 2011).

Table 7: *List of population in Huzur tehsil, District Bhopal (*censusindia.gov.in)

S.NO	Name	Population - 2001	Population - 2011	Density -2001 (per sq.km)	Density -2011 (per sq.km)
1	Bhopal(M Corp)	1260038	1598197	4031	5113

Table 8*: List of Villages population in Huzur Tehsil (*censusindia.gov.in)

S.NO.	Name	Population 2001	Population 2011	Density 2001 (per sq.km)	Density 2001 (per sq.km)
1	Toomda	5033	5413	387	416
2	Ratanpur	1815	6208	320	1096
3	Bangrasia	2530	4946	838	1639
4	Hatai Khedi	188	247	230	302

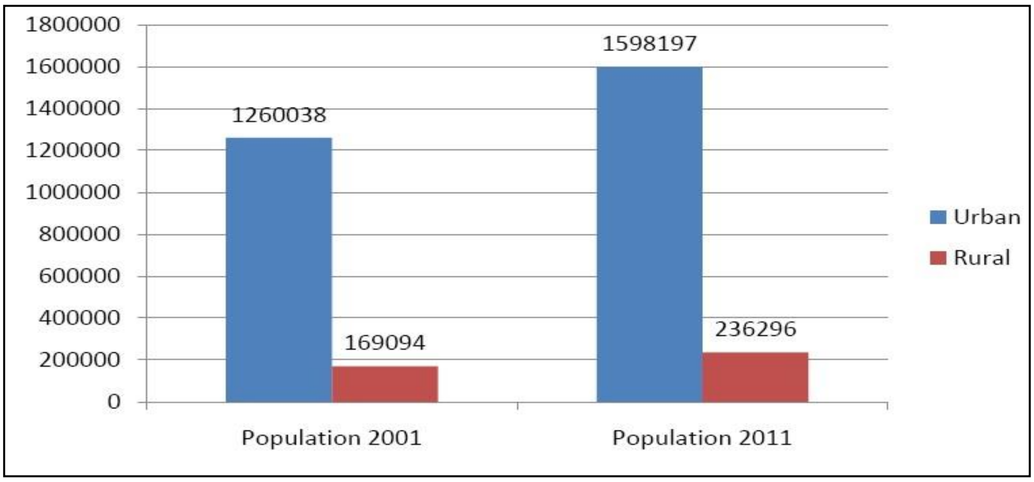


Figure 5*: Show the total population of Huzur, Tehsil, district Bhopal.*

As per Census 2001 and 2011, the water demanded are increasing in 2011, and more water demand day to day, and increase the number of bores well. These causes see the behavioral of groundwater level decline. Apply the Arithmetical Increase Method to find out the projected population. The projected population Huzur tehsil, district Bhopal in 2051.the total projected population is (5503477). As shown in below the total Actual Population & Projected Population in Huzur Tehsil, District Bhopal, Madhya Pradesh (Figure 6). As the city is developing rapidly, there is a huge increase in the migration of people from nearby villages and towns. The source of Groundwater Level refilling depends upon the monsoon in Huzur tehsil. Which is seeing every person uses about 80-100 gallons of water per day (according to USGS). And 1 gallon is approximately Values in 3.78 Liter that means the Population of Huzur, Tehsil, District Bhopal Madhya Pradesh 2001 is 1429132 and 2011 population is 1834493. And every day Water requirement is 540211896 Liter/day (Figure 7). That means Groundwater Level decline yearly by yearly, as show the Water utility of Liter per day in actual and projected Population in the study area (Figure 7). The total area of Huzur is 1,361.77 sq.km with population density in 2001 is

1,049 and 2011 is 1347 (per sq.km). Used the GIS tools to provide information on population and density in Huzur Tehsil, district Bhopal, Madhya Pradesh. And generate the population and density (area per sq. Km) map of Huzur area in (2001 & 2011).

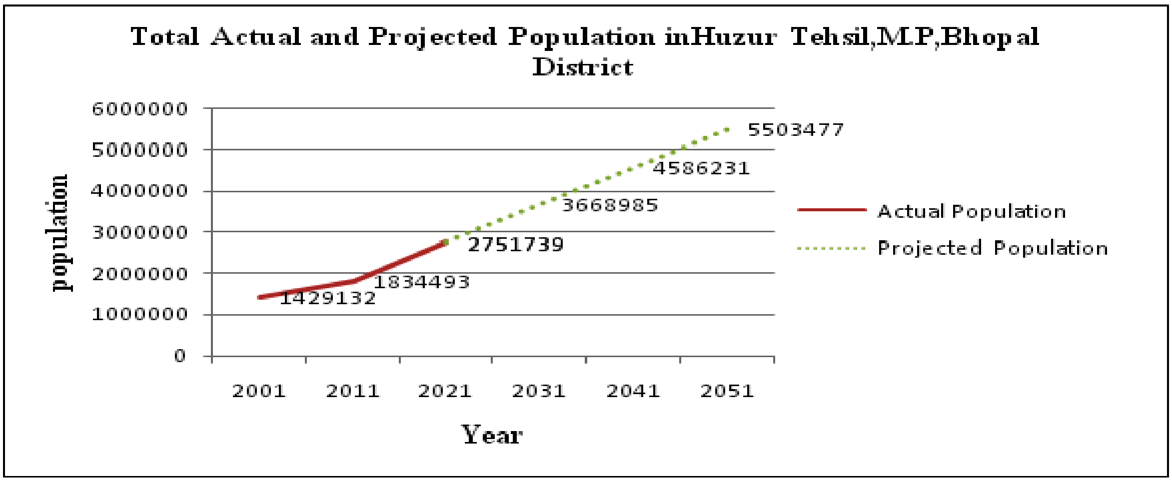


Figure 6: *The total Actual Population & Projected Population in Huzur Tehsil, District Bhopal, Madhya Pradesh*

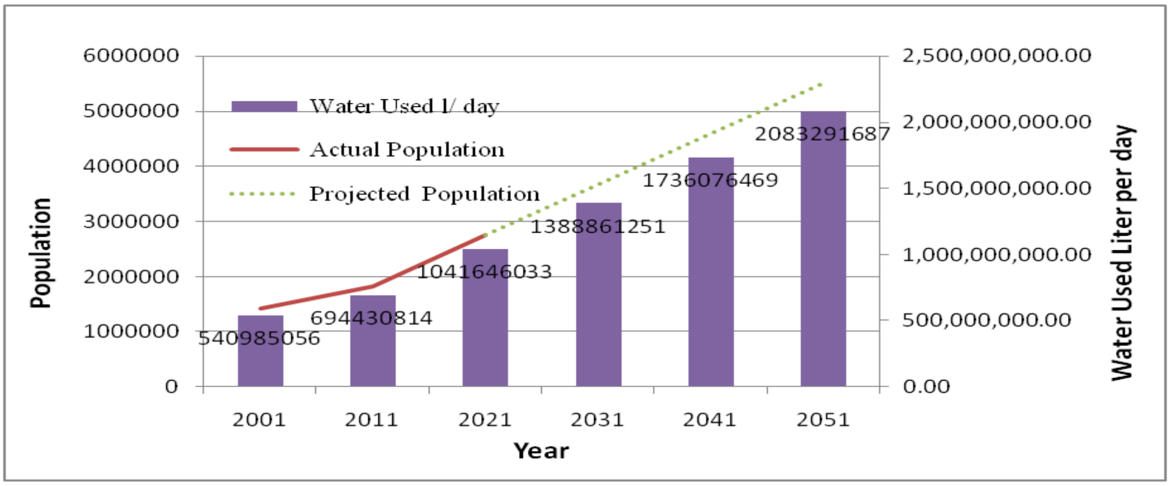


Figure 7: *Water utility of Liter per day in actual and projected Population*

3.4. Methodology

The base map of the study area was prepared using a survey of India topographical maps (Figure 9). The bore well observation data were plotted on to the map by using location (latitude & longitude) of each well. In total 350 observations, wells were selected for further processing of the data for Groundwater Level analysis. Based on above collection these are prepared the GIS map with the help of the Kriging interpolation model technique in Arc GIS Software. In this study, the Kriging technique was used for the spatial distribution of Groundwater level fluctuation (mbgl) for pre and post-monsoon on the five-year average interval (1996-2000, 2001-2005, 2006-2010, 2002-2006, 2006-2010), and one seven year interval (2011-2017). And long term trend fluctuation (1996-2017). Using the Matlab to the analysis of Groundwater Level in bore well, and Generate the Groundwater-Surface Modeling in Pre and Post Monsoon. And find out the Groundwater Level feature Projected (2018- 2022, 2023-2027, 2028-2032, 2033-2037, 2038-2042, 2043-2047, 2048-2051) and long trend in (2018-2051) using GIS technique and prepared the map. Show the flow chart of the methodology in Figure 8.

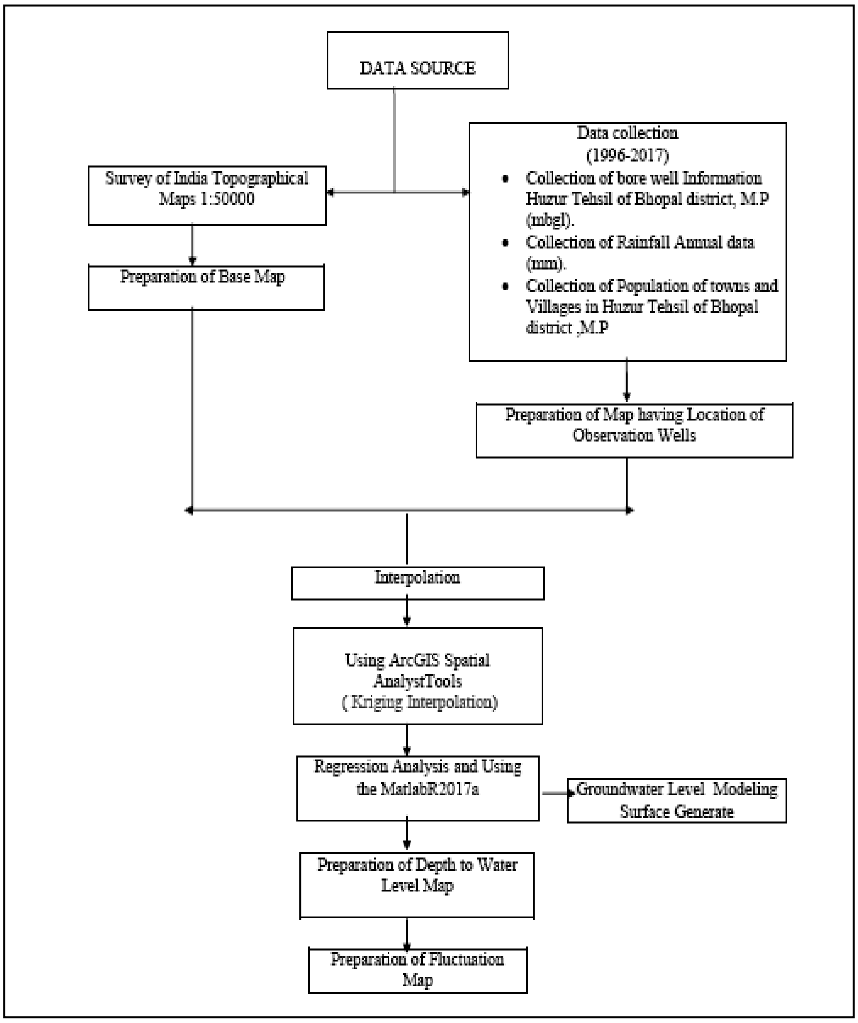


Figure 8: *Flow chart of Methodology*

3.4.1. Kriging Interpolation model

Kriging is named after D.G. Krige, a South African mining engineer and pioneer in the application of statistical techniques to mine evaluation. The Kriging technique is derived from the theory of regionalized variables (Krige, 1966; Matheron, 1963). An advantage of Kriging (above other moving averages like inverse distance) is that it provides a measure of the probable error associated with the estimates. Kriging can be seen as a point interpolation, which requires a point map as input and returns a raster map with estimations and optionally an error map. The estimated or predicted values (Z) is thus a linear combination known input point values (zi) and have a minimum estimation error.

Thus,

$$Z = \sum (wi * zi) \text{--}1$$

Where wi is weight factors. In case the value of an output pixel would only depend on three input points, this would read:

$$Z = w1 * z1 + w2 * z2 + w3 * z3 \text{------------------------------------}2$$

Thus, to calculate one output pixel value Z, first, three weight factors w1, w2, w3 have to be found (one for each input point value z1, z2, z3), then, these weight factors can be multiplied with the corresponding input point values and summed. In Kriging, the weight factors are calculated by finding the semi-variance values for all distances between input points and by finding semi-variance values for all distances between an output pixel and all input points; then a set of simultaneous equations has to be solved. The weight factors are calculated in such a way that the estimation error in each output pixel is minimized. All semi-variance values are calculated by using a user-specified semi-variogram model. The model describes the expected variance in value between pairs of samples with a given relative orientation. One of the best semi-variogram models like Spherical, Exponential, and Gaussian, etc. is selected and values for the sill, range, and nugget are chosen for best fit. Thus, the semi-variogram model and values for sill, range, and nugget have been finalized, and the Kriging operation has been continued.

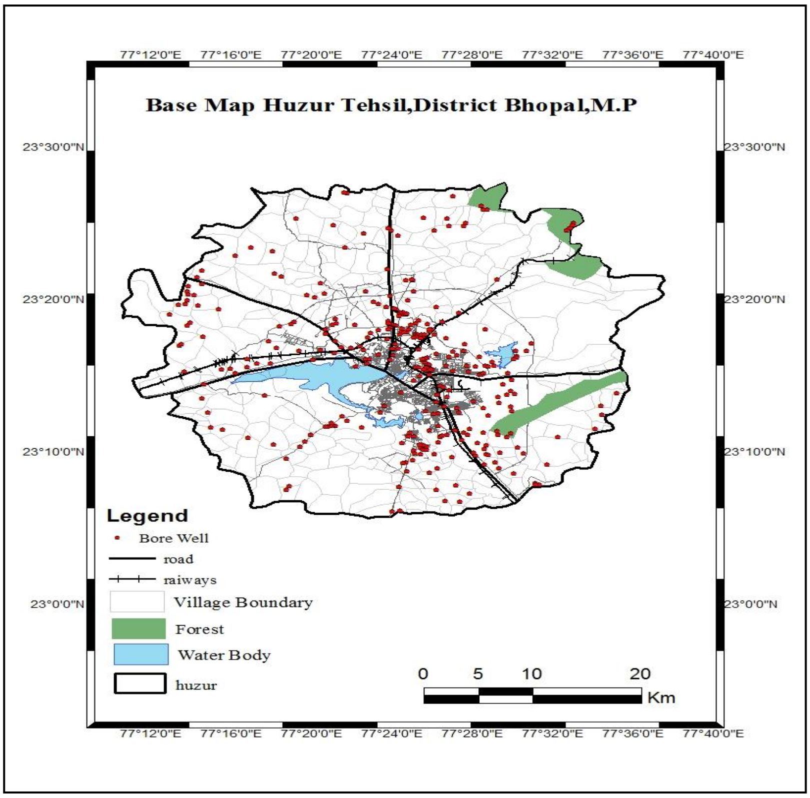


Figure 9: *Classification of base map Huzur tehsil, District Bhopal, Madhya Pradesh*

4. Results and Discussion

It has taken all twenty two year annual rainfall (1996-2017) and each well point groundwater level in pre-post seasons of the year. And analysis of population 2001 and 2011 based on that analysis to project the population in 2051 year. That means the population are increase yearly to yearly, the water demand are increases in Huzur tehsil, district Bhopal, which effected the declination of water level. The Groundwater is not in underground lakes, nor is it water flowing in underground rivers. It is simply water that fills pores or cracks in subsurface rocks. When rain falls or snow melts on the surface of the ground, some water may run off into lower land areas or lakes and streams. What is left may be absorbed by the soil, seep into deeper layers of soil and rock, or evaporate into the atmosphere.

4.1. Groundwater System Behavior

Groundwater System Behavior which is that will help in a better understanding of the Huzur tehsil groundwater system. And water depth in bore well and fluctuation of water level in bore well in the same village and urban area, and long trend of water level.

4.1.1. Depth to water level

The groundwater level is an important parameter to understand the existing groundwater potential of an area. The groundwater potential can be estimated by the depth of the water found. It can be inferred that if the depth to the water level from ground level is shallow, then the Groundwater condition is good. But if the depth is deep then the groundwater level is poor. Water level mainly depends upon rainfall, sub-surface geological nature, weathering condition, depth to bedrock, etc. but few years saw declination of groundwater level which is Urban sprawl or suburban sprawl. To understand the water level of the study area, groundwater level data for both pre-monsoon and post-monsoon, was data collected for 360 bore wells which are monitored by Central Ground Water Board Water Resource Data Centre, Bhopal. The groundwater level of the study for pre-monsoon, the post-monsoon season has been calculated from 1996-2017. Above the (Table 1, 2, 3, 4) data collection in groundwater Level bore well in the study area. To show the average value of depth to water level (mbgl) for different year Pre-monsoon in (1996-2000, 2001-2005, 2006-2010, 2011-2017) (Figure 10). Using the ArcGIS10.5 generates the Groundwater Level depth map Pre-monsoon between 1996-2000, 2001-2005, 2006-2010, and 2011-2017. During pre-monsoon (period 1996-2000, 2001-2005, 2006-2010, 2011-2017), the depth to the water level in the district varied largely from between 6.56 - 13.79, 12.55-20.65, 16.06-26.44, and 22.87-49.19 mbgl (Figure 12). The Average value of depth to water level (mbgl) for different year Post-monsoon is (1996-2000, 2001-2005, 2006-2010, and 2011-2017) (Figure 11). Using the ArcGIS10.5 generates the Groundwater Level Depth Map Post-monsoon 1996-2000, 2001-2005, 2006-2010, and 2011-2017 (as shown in Figure13). During post-monsoon (Period 1996-2000, 2001-2005, 2006-2010, 2011-2017), the depth to water level in the district varied largely from between 4.34 - 9.49, 8.47- 14.15, 11.76- 17.50, 16.11- 24.94 (mbgl) (Figure 13).

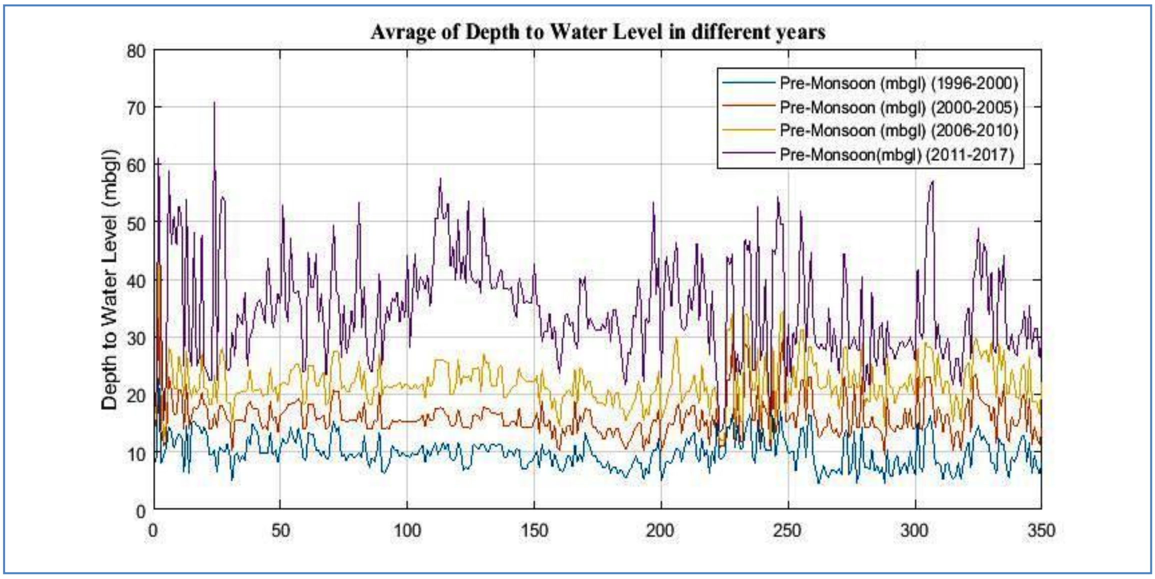


Figure 10: *Pre-monsoon Average depth to the water level in Huzur, M.P, Bhopal District for Years 1996-2000, 2001-2005, 2006-2010 and 2011-2017*

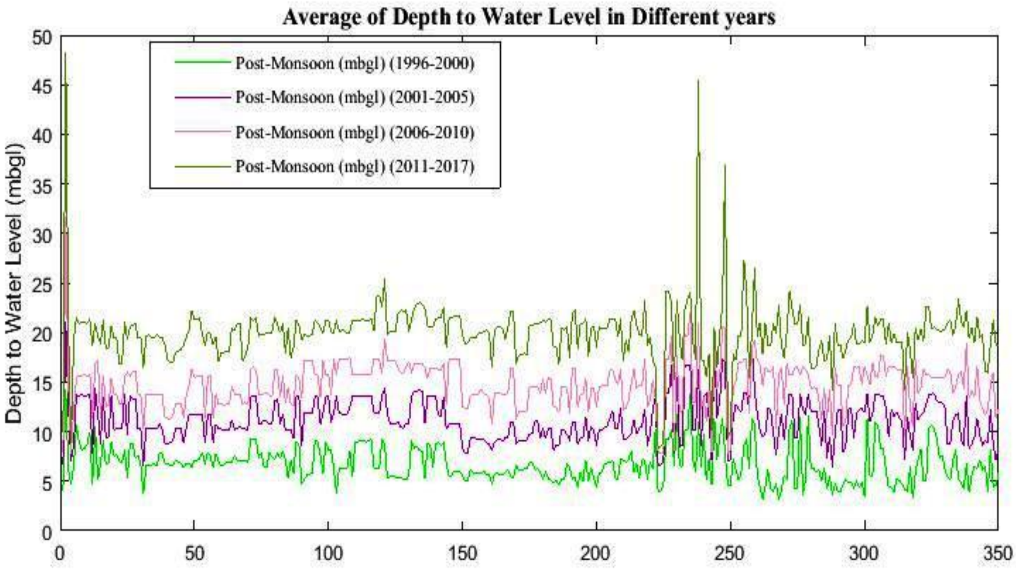
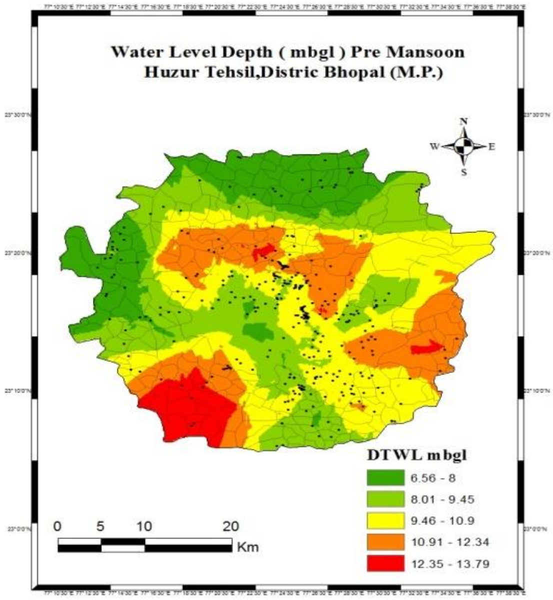
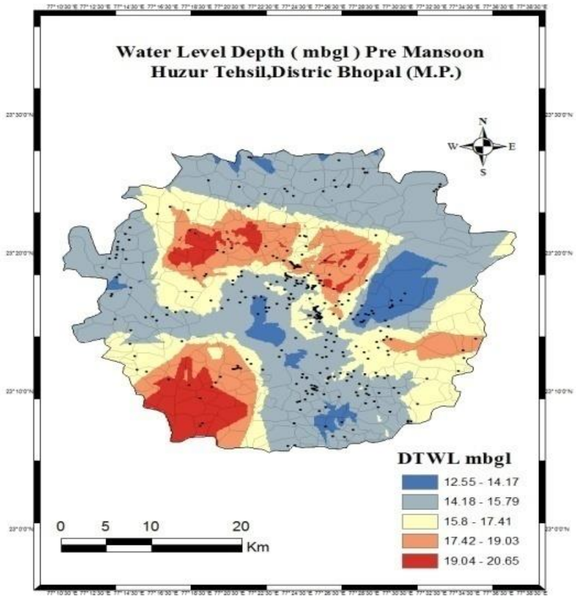


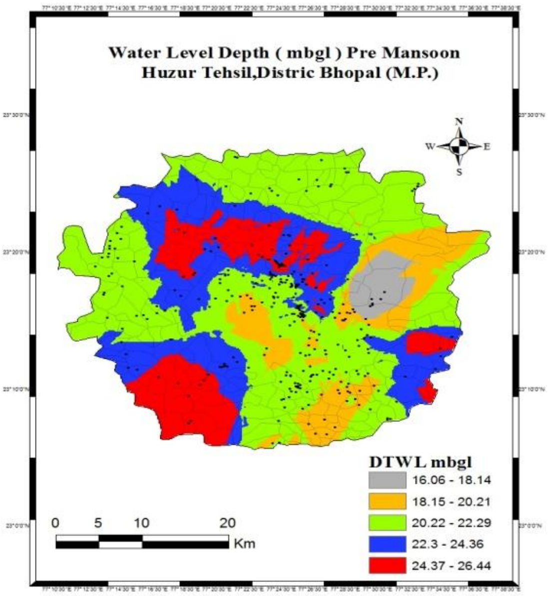
Figure 11: *Post-monsoon Average depth to the water level in Huzur Tehsil, M.P, Bhopal District for Years 1996-2000, 2001-2005, 2006-2010 and 2011-2017*



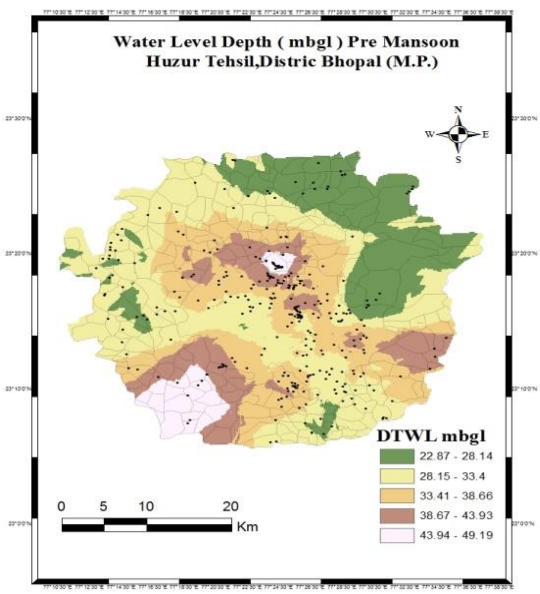
Pre-Monsoon **(1996-2000)-a**



Pre-Monsoon **(2001-2005)-b**

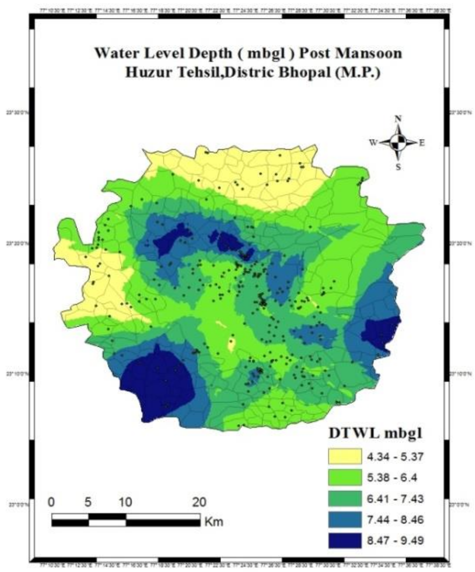


Pre-Monsoon **(2006-2010)-c**

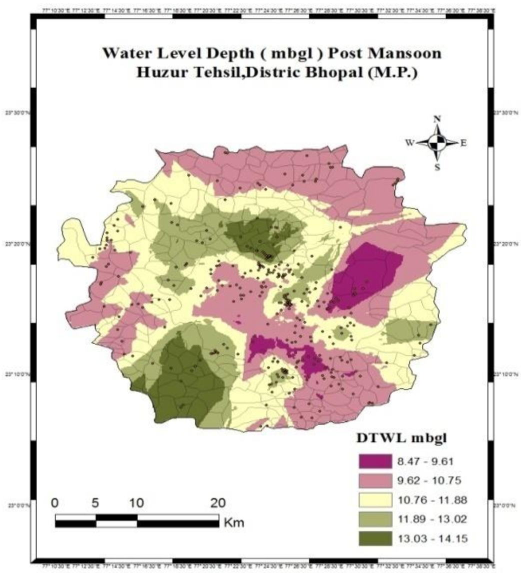


Pre-Monsoon **(2011-2015)-d**

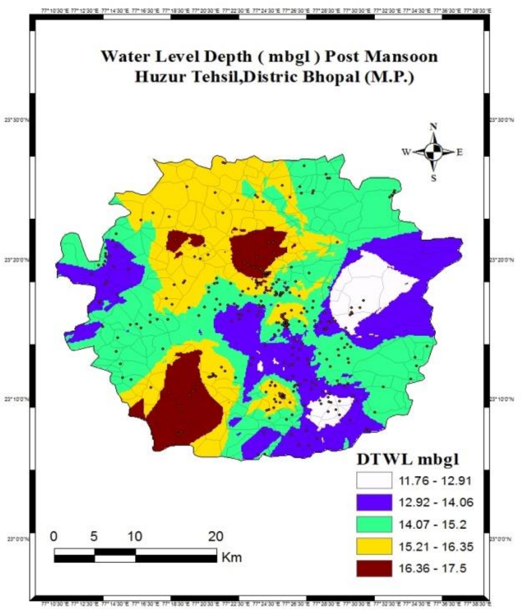
Figure 12: *Pre-Monsoon Depth to water level maps for the years 1996-2000, 2001-2005, 2006-2010 and 2011-2017*



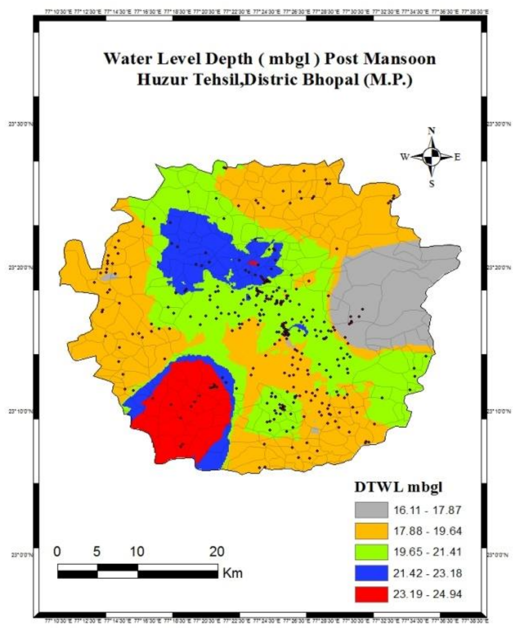
Post-Monsoon **(1996-2000)-a**



Post-Monsoon **(2000-2005)-b**



Post-Monsoon **(2006-2010)-c**



Post-Monsoon **(2011-2017)-d**

Figure 13: *Post-Monsoon Depth to water level maps for the years 1996-2000, 2001-2005, 2006-2010 and 2011-2017*

4.1.2. Water Level Fluctuation

The water level fluctuation of 1996-2000, 2001-2005, 2006-2010, 2011-2017 that the groundwater level between lies 1.63-4.76, 2.73-7.97, 4.26-10.92, 6.58-27.40 (mbgl). The analysis of water level fluctuation of the Pre-monsoon and Post-monsoon period during 1996- 2000, 2001-2005, 2006-2010 indicates the bores well are good condition. But after (2011-2017) indicates that 70% of the bore wells are dried. That means Groundwater Level decline. As shown in the graph of average interval Groundwater level fluctuation Period 1996-2000, 2001-2005, 2006-2010 and 2011-2017 (Figure 14). And after the analysis to find out the since (2011-2017) is groundwater Level fluctuation more decadal. Using the ArcGIS10.5 generates the Groundwater Level depth fluctuation map as shown the water level fluctuation maps in Huzur Tehsil, M.P, Bhopal District for Years 1996-2000, 2001-2005, 2006-2010 and 2011-2017(Figure 15).

4.1.3. Long term water level fluctuation

Analysis of decadal pre-monsoon water level data for the period 1996- 2017 indicates that, in general, the declining trend in water levels has been in most parts of Huzur, Tehsil, District Bhopal, Madhya Pradesh. The Groundwater Level maximum decline was in an urban area while the minimum in decline was rural areas. The declining trend ranges from 13.71 to 37.96 m/year (Figure 16).and generates the Long Trend of Groundwater Level modeling in pre-monsoon (1996-2017) and Water level contour map created from the model results as shown in Figure 17.

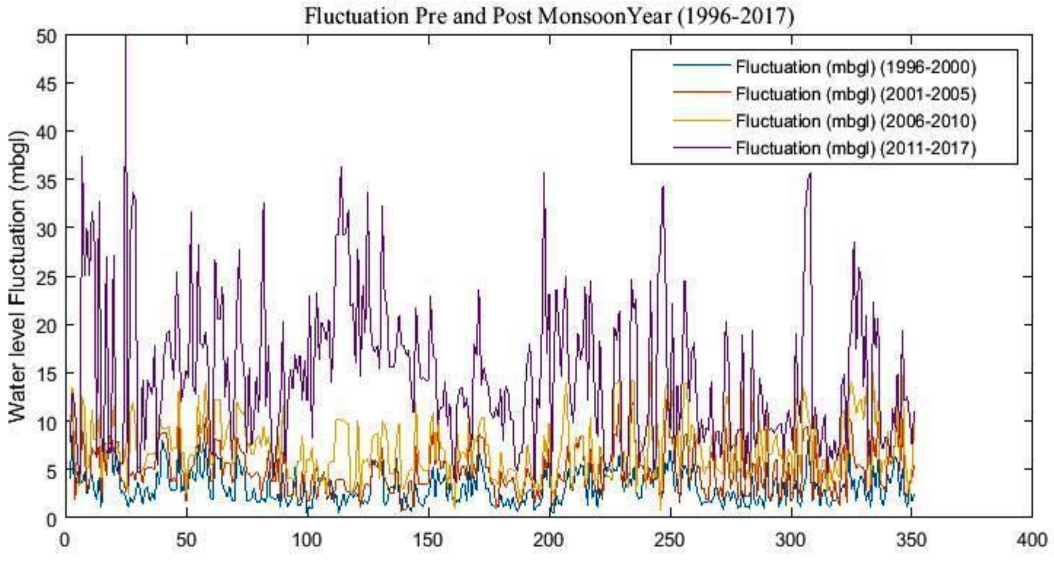
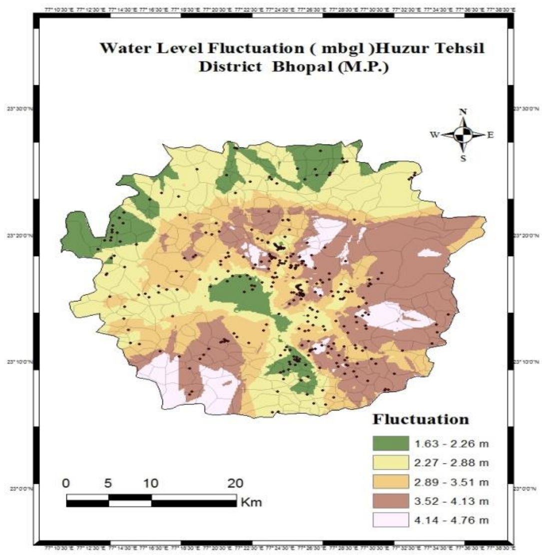
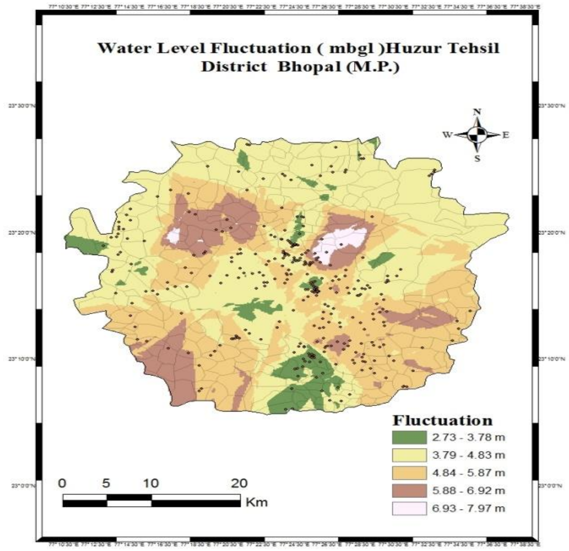


Figure 14: *Fluctuation of Groundwater Level in Huzur Tehsil, M.P, Bhopal District for Years 1996-2000, 2001-2005, 2006-2010 and 2011-2017*



Fluctuation **(1996-2000)-**a



Fluctuation (**2000-2005**)-b

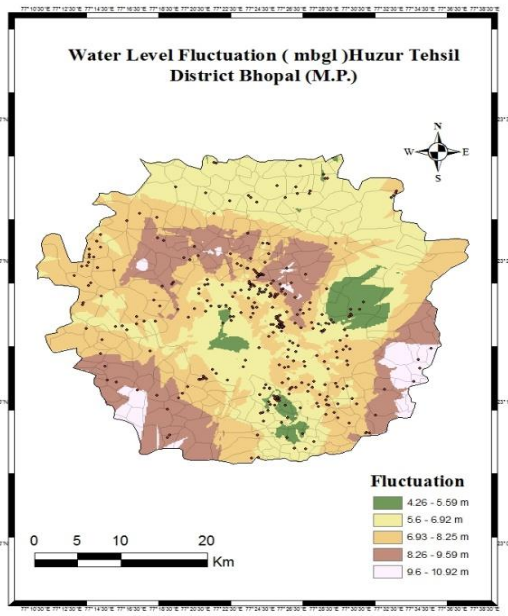
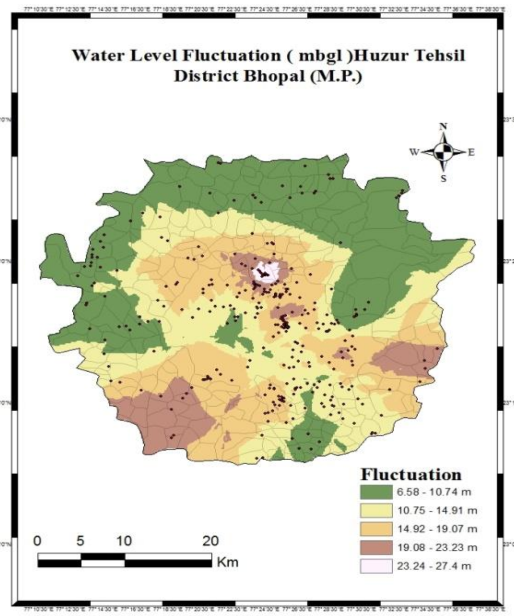
 Fluctuation **(2005-2010)-**c	 Fluctuation **(2011-2017)-**d

Figure 15: *Fluctuation of water level maps for the years 1996-2000, 2001-2005, 2006-2010 and 2011-2017*

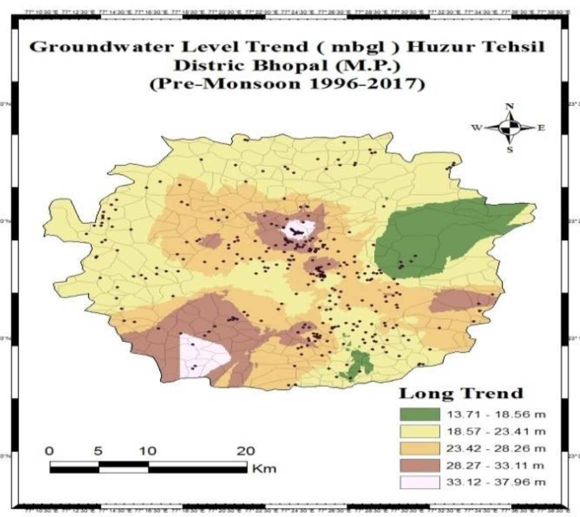


Figure 16: *Decadal pre-monsoon water level Long trend map (1996– 2017)*

Using MATLAB R2017b Curve Fitting Toolbox provides an app and functions for fitting curves and surfaces to data. The toolbox lets you perform exploratory data analysis, preprocess and post-process data, compare candidate models. The library provides optimized solver parameters and starting conditions to improve the quality of your fits. The toolbox also supports nonparametric modeling techniques, such as spines, interpolation, and smoothing. Using the MATLAB to show the Long trend of Groundwater Level modeling in pre-monsoon (3d Surface) (Figure 17).

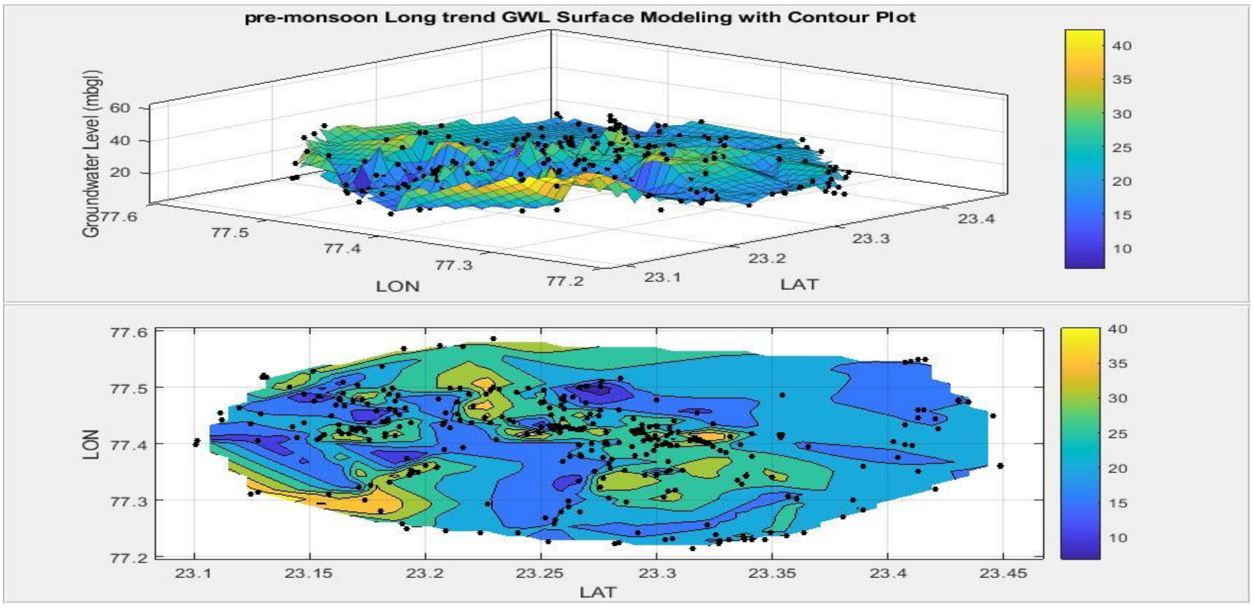


Figure 17: Long Trend of Groundwater Level modeling in pre-monsoon and Water level contour map created from the model results (3d Surface) (1996-2017)

4.1.4. Projected Feature Forecast Trend Groundwater Level

Based on the above analysis groundwater level (1996 - 2017) in Huzur tehsil, District Bhopal, deal with the provided the feature projected Ground water Level in Huzur tehsil, District Bhopal (2018-2051).Theses section analysis of Projected Feature Groundwater Level in Huzur Tehsil, District Bhopal. These are using FORECAST Function is categorized under Statistical functions. It will calculate or predict future value using existing values.

Formula=FORECAST(x, known_y's, known_x's) ---------------------------3

The FORECAST function uses the following arguments:

1. **X** (required argument) – It is a numeric x-value for which we want to forecast a new y-value.
2. **Known_y's** (required argument) – It is the dependent array or range of data.
3. **Known_x's** (required argument) – It is the independent array or range of data that is known to us.

The equation for FORECAST function will calculate a new y-value using the simple straight-line equation:

y=a+bx,

Where:

$$a = \bar{y} - b\bar{x}$$

And:

$$b = \frac{\sum (x-\bar{x})(y-\bar{y})}{\sum (x-\bar{x})^2}$$

And the values of x and y are the sample means (the averages) of the known x- and the known y-values. Based on the above Table 1 & 2 with reacted to find out the feature projected values in ground water level in study area (2018-2051) as shown in Table 9 and 10 two urban and rural pre-post monsoon data list. As shown in below the Projected Feature Forecasting Groundwater Level Fluctuation (Table 11). After the analysis Feature Projected Forecast Groundwater Level Fluctuation since 2018-2022, 2023-2027, 2028-2032, 2033-2037, 2038-2042, 2043-2047, 2048-2051. The Groundwater Level fluctuation was between 7.69 - 36.59, 9.41 - 49.13, 10.93 - 60.9, 12.27 - 70.49, 13.76 - 81.9, 15.22 - 92.83, 17.17 - 102.28 (mbgl) (Figure 18, 19, 20).

Table 9: *List of Two Urban areas Pre –Post Monsoon Feature projected Groundwater Level (mbgl) in Huzur Tehsil (2018- 2051)*

WL_ID	YEAR_OBS	Pre-monsoon (mbgl)	Post-monsoon (mbgl)
UA101	2018	21.17	11.67
UA101	2019	21.29	11.98
UA101	2020	21.53	12.24
UA101	2021	21.70	12.55
UA101	2022	21.92	12.92
UA101	2023	22.13	13.26
UA101	2024	22.43	13.58
UA101	2025	22.74	13.86
UA101	2026	23.12	14.26
UA101	2027	23.53	14.69
UA101	2028	23.96	15.13
UA101	2029	24.39	15.56
UA101	2030	24.85	15.99
UA101	2031	25.31	16.40
UA101	2032	25.77	16.78
UA101	2033	26.20	17.14
UA101	2034	26.62	17.49
UA101	2035	27.04	17.81
UA101	2036	27.45	18.11
UA101	2037	27.82	18.36
UA101	2038	28.16	18.66
UA101	2039	28.47	19.05
UA101	2040	28.75	19.54
UA101	2041	29.19	19.92
UA101	2042	29.63	20.31
UA101	2043	30.07	20.68
UA101	2044	30.50	21.05
UA101	2045	30.93	21.42
UA101	2046	31.35	21.79
UA101	2047	31.75	22.15
UA101	2048	32.15	22.50
UA101	2049	32.54	22.85
UA101	2050	32.93	23.20
UA101	2051	33.32	23.55

UA102	2018	70.52	55.57
UA102	2019	72.69	57.97
UA102	2020	74.64	60.26
UA102	2021	76.31	62.50
UA102	2022	79.24	65.31
UA102	2023	82.18	68.10
UA102	2024	85.08	70.87
UA102	2025	87.89	73.56
UA102	2026	90.55	76.12
UA102	2027	93.02	78.48
UA102	2028	95.29	80.66
UA102	2029	97.84	82.53
UA102	2030	100.32	84.58
UA102	2031	102.86	86.73
UA102	2032	105.32	89.02
UA102	2033	107.71	91.36
UA102	2034	110.10	93.78
UA102	2035	112.43	96.21
UA102	2036	114.69	98.63
UA102	2037	117.01	101.06
UA102	2038	119.58	103.50
UA102	2039	122.25	105.92
UA102	2040	124.97	108.36
UA102	2041	127.52	110.68
UA102	2042	130.05	112.99
UA102	2043	132.53	115.27
UA102	2044	134.92	117.52
UA102	2045	137.32	119.77
UA102	2046	139.73	122.06
UA102	2047	142.17	124.37
UA102	2048	144.63	126.72
UA102	2049	147.11	129.10
UA102	2050	149.59	131.50
UA102	2051	152.06	133.91

Table 10*: List of Two Rural areas Pre –Post Monsoon Feature projected Groundwater Level (mbgl) in Huzur Tehsil (2018- 2051)*

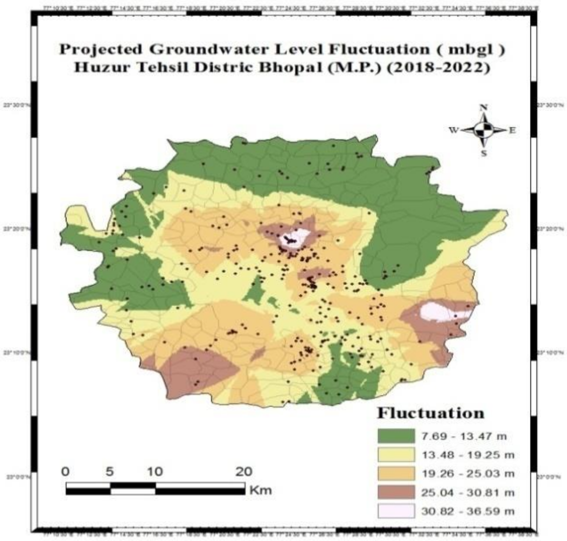
WL_ID	YEAR_OBS	Pre-monsoon (mbgl)	Post-monsoon (mbgl)
R201	2018	33.02	21.17
R201	2019	34.42	21.63
R201	2020	35.77	22.13
R201	2021	37.05	22.53
R201	2022	38.24	22.89
R201	2023	39.30	23.10
R201	2024	40.45	23.54

R201	2025	41.58	23.95
R201	2026	42.73	24.36
R201	2027	43.91	25.26
R201	2028	45.07	26.25
R201	2029	46.16	26.67
R201	2030	47.10	26.88
R201	2031	48.10	27.67
R201	2032	49.35	28.49
R201	2033	50.73	29.38
R201	2034	52.13	30.24
R201	2035	53.51	30.71
R201	2036	54.83	31.06
R201	2037	56.06	31.27
R201	2038	57.18	31.35
R201	2039	58.24	32.05
R201	2040	59.30	32.87
R201	2041	60.46	33.47
R201	2042	61.64	34.09
R201	2043	62.83	34.72
R201	2044	64.04	35.34
R201	2045	65.26	35.96
R201	2046	66.47	36.55
R201	2047	67.68	37.13
R201	2048	68.89	37.68
R201	2049	70.11	38.21
R201	2050	71.33	38.75
R201	2051	72.55	39.33
R202	2018	23.43	18.66
R202	2019	23.24	18.40
R202	2020	23.50	18.68
R202	2021	23.79	19.15
R202	2022	24.35	19.59
R202	2023	24.96	20.15
R202	2024	25.34	20.74
R202	2025	25.73	21.28
R202	2026	26.35	21.85
R202	2027	26.82	22.49
R202	2028	27.32	23.15
R202	2029	27.68	23.82
R202	2030	28.07	24.51
R202	2031	28.42	25.09
R202	2032	28.85	25.63
R202	2033	29.26	26.07
R202	2034	29.64	26.40
R202	2035	29.98	26.61

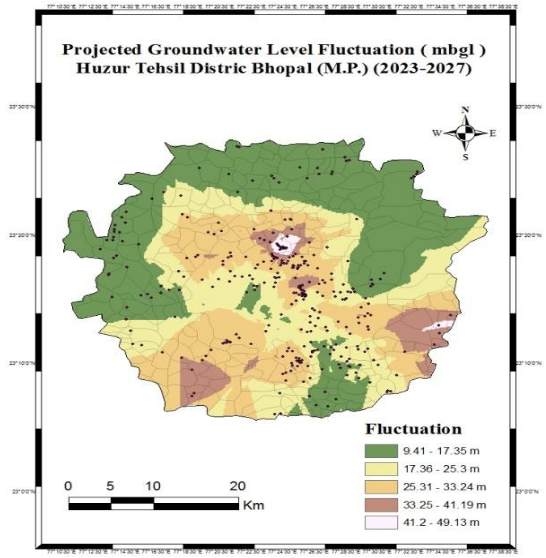
R202	2036	30.26	26.73
R202	2037	30.48	26.71
R202	2038	30.89	27.30
R202	2039	31.42	28.08
R202	2040	31.97	28.94
R202	2041	32.43	29.50
R202	2042	32.84	30.00
R202	2043	33.23	30.48
R202	2044	33.61	30.95
R202	2045	33.98	31.41
R202	2046	34.37	31.85
R202	2047	34.75	32.30
R202	2048	35.13	32.73
R202	2049	35.51	33.16
R202	2050	35.91	33.60
R202	2051	36.31	34.04

Table 11: *Analysis of Projected Feature Forecasting Groundwater Level Fluctuation values*

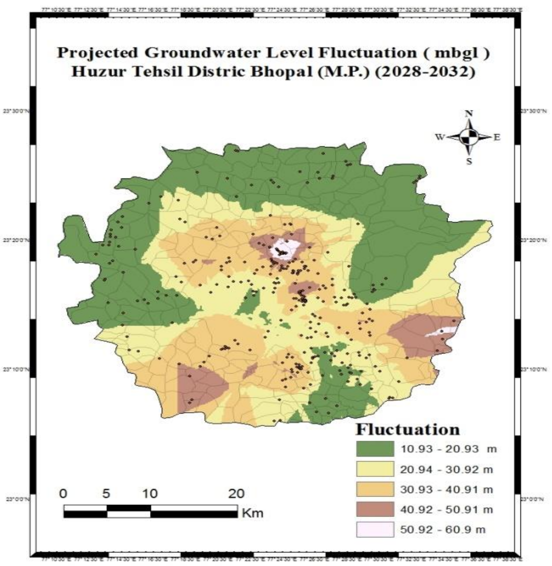
Fluctuation (1996-2000)	Fluctuation (2000-2005)	Fluctuation (2006-2010)	Fluctuation (2011-2017)	Projected Fluctuation (2018-2022)	Projected Fluctuation(2023-2027)	Projected Fluctuation (2028-2032)	Projected Fluctuation (2033-2037)	Projected Fluctuation (2038-2042)	Projected Fluctuation (2043-2047)	Projected Fluctuation (2048-2051)
1.63	2.73	4.26	6.58	7.69	9.41	10.93	12.27	13.76	15.22	17.17
2.27	3.79	5.6	10.75	13.48	17.36	20.94	23.92	27.4	30.75	34.21
2.89	4.84	6.93	14.92	19.26	25.31	30.93	35.57	41.03	46.27	51.23
3.52	5.88	8.26	19.08	25.04	33.25	40.92	47.21	54.66	61.8	68.25
4.14	6.93	9.6	23.24	30.82	41.2	50.92	58.85	68.29	77.32	85.27
2.26	3.78	5.59	10.74	13.47	17.35	20.93	23.91	27.39	30.74	34.2
2.88	4.83	6.92	14.91	19.25	25.3	30.92	35.56	41.02	46.26	51.22
3.51	5.87	8.25	19.07	25.03	33.24	40.91	47.2	54.65	61.79	68.24
4.13	6.92	9.59	23.23	30.81	41.19	50.91	58.84	68.28	77.31	85.26
4.76	7.97	10.92	27.4	36.59	49.13	60.9	70.49	81.9	92.83	102.28



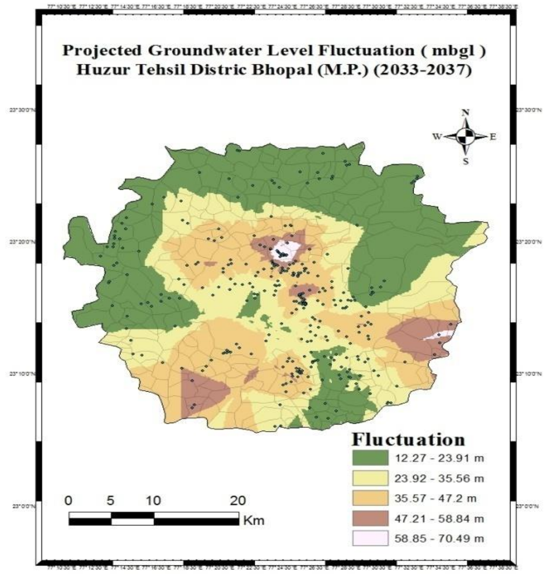
Projected GWL Fluctuation (2018-2022)-a



2-Projected GWL Fluctuation (2023-2027)-b

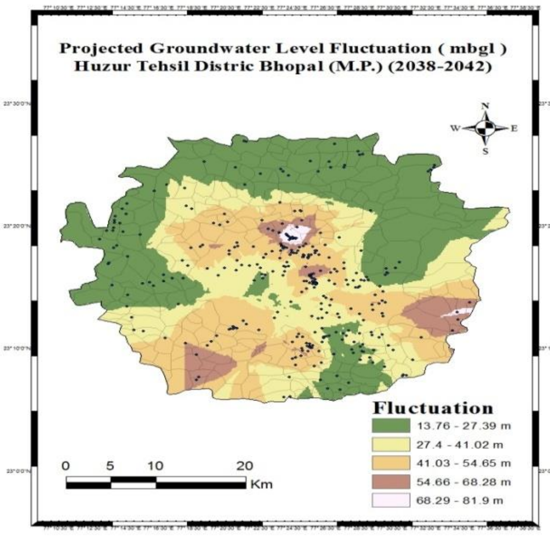


3-Projected GWL Fluctuation (2028-2032)-c

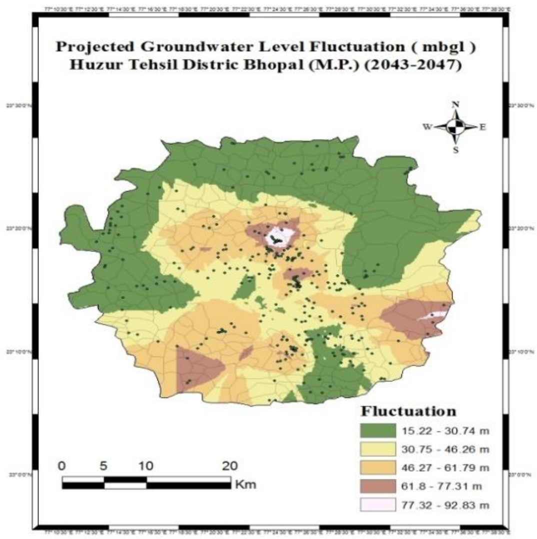


4-Projected GWL Fluctuation (2033-2037)-d

Figure 18: *Feature Projected Forecast Groundwater Fluctuation of water level maps for the years (2018-2022, 2023-2027, 2028-2032 and 2033-2037)*

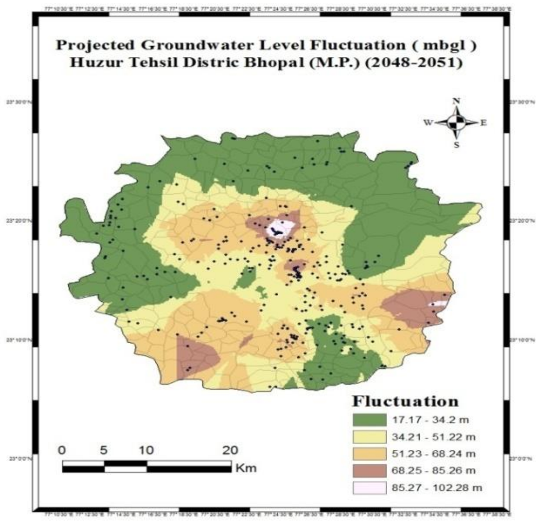


5-Projected GWL Fluctuation (2038-2042)-e



6-Projected GWL Fluctuation (2043--2047)-f

***Figure 19**: Feature Projected Forecast Groundwater Fluctuation of water level maps for the years (2038-2042, 2043-2047)*



7-Projected GWL Fluctuation (2048-2051)-g

***Figure 20:** Feature Projected Forecast Groundwater Fluctuation of water level maps for the years (2048-2051)*

4.1.5. Long term projected water level fluctuation

Analysis of Projected decadal pre-monsoon water level data for the period 2018- 2051 indicates that, in general, the declining trend in water levels has been in most parts of Huzur, Tehsil, District Bhopal, Madhya Pradesh. The Groundwater Level maximum decline was in an urban area while the minimum in decline was a rural area. The declining trend ranges from 27.65 to 91.58 m/year (Figure 21) and generate the Projected Feature Long Trend of Groundwater Level GIS map in pre-monsoon (2018-2051) as shown Figure using Matlab to projected 3d surface and Water level contour map created from the model results (Figure 22).

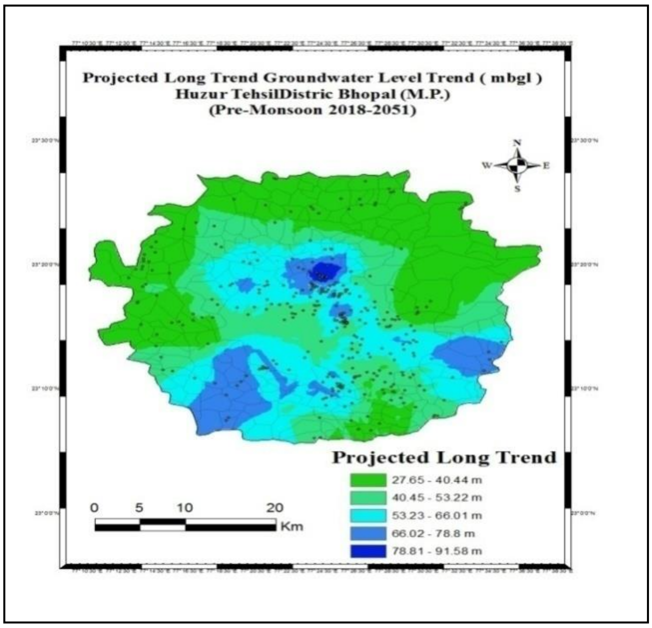


Figure 21: *Projected Feature Long trend decadal pre-monsoon water level trend map (2018– 2051)*

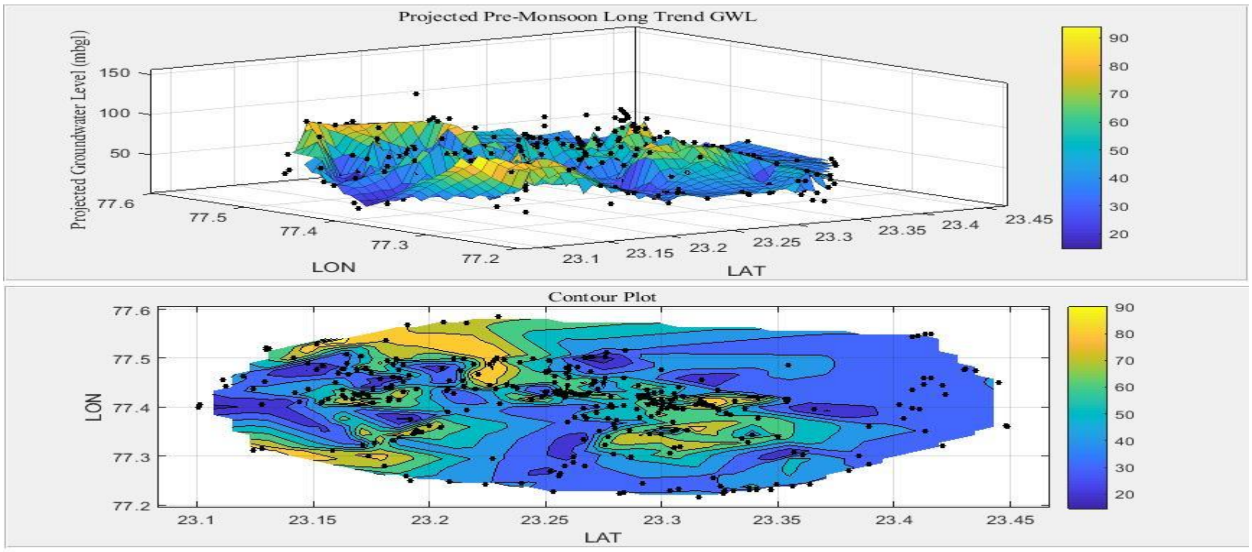


Figure 22: *Projected Long Trend of Groundwater Level modeling in pre-monsoon and Water level contour map created from the model results (3d Surface) (2018-2051)*

After the analysis of groundwater trend in pre-monsoon actual and projected feature shown the decline in the groundwater level. If we can do not stop the population growth and Urban sprawl such that after 20 or 30-year water level much more decline. And water will be not getting on the earth. Which is generated the drought condition in more area India? That means the Groundwater Level trend is increasing order (Figure 23).

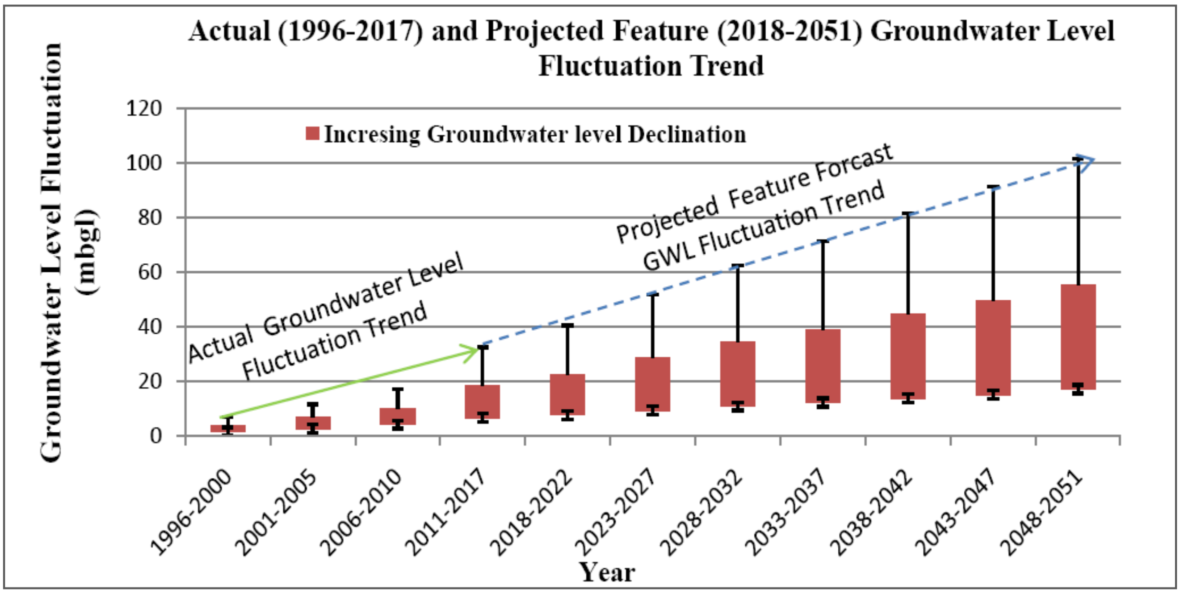


Figure 23: *Increase decline Groundwater Level Fluctuation Trend (1996 -2017 to 2018-2051)*

5. Conclusions

The study reflects an overall inclining trend of depth to groundwater level over the study period. In general, the results show that the district is facing the problem of declining groundwater Level in the recent past, after the year 2011. In 2011 to 2017 Huzur tehsil District Bhopal, Madhya Pradesh Groundwater level at the time of pre-monsoon time most of the area decline. And an increasing number of bore well drought. The areas showing inclining trend on a long -term bases (1996-2017 to 2018-2051) are the areas having decline groundwater level. Since 1996-2017 the Groundwater Level fluctuation was between lies 1.63-27.40 (mbgl). And the period 2018-2051 feature projected groundwater level fluctuation since 2018- 2051 feature projected Groundwater Level fluctuation was between 7.69 -102.28 (mbgl) and after analysis of pre-long trend Groundwater Level Fluctuation period 1996-2017. The declining trend ranges from 13.71 to 37.96 m/year. And the projected feature pre-long trend declining trend ranges from 27.65 to 91.58 m/year (period 2018-2051). That means increasing the population, in urban sprawl, the effect of the increasing decline of groundwater. The study demonstrates the subtle use of GIS in spatial distribution mapping and monitoring for groundwater Level in the area. The overall status of groundwater level fluctuations has received very little attention in our study area. The behavior of groundwater level fluctuations is, however, is in the initial phases for the development and management of groundwater resources as an alternative resource for drinking and domestic purposes for future demand. Groundwater level decline shows an increasing trend from 1996 to 2017 and 2018 to 2051.

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