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Future Projected Groundwater Level Trend Analysis using GIS Techniques

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Abstract: ***High Population Growth and increase the urban sprawl in earth to less the groundwater resources causes degradation of groundwater Level in India. Water is very important for our life and natural resources. There are various uses of groundwater just as drinking, irrigation, and manufacturing. Today we are facing the shortage of groundwater level. The main goal of study is, because of increase in the population there is increase the number of bore well in earth surface this the reason to declination of groundwater level, so in these study to analysis of spatio-temporal changes in groundwater level fluctuation in Bhopal district in Madhya Pradesh, India. According to censes in Huzur Tehsil, M.P, Bhopal District, in 2001 population is 1429132 and 2011 population is 1834493. Collected the total of 350 observation wells Huzur Tehsil, Bhopal district for point observations. And using the GIS techniques spatial Analysis tools in ArcGIS10.5 to find out different Change of Groundwater Level Fluctuation since period (1996-2015) and using Matlab to generate the GWL (groundwater level) modeling .Generate the Future projected Groundwater level Fluctuation(2016-2050) and Trend Analysis of Groundwater Level (1996-2015) and Future Projected Groundwater level (2016-2050).***

Keywords: High Population; Trend analysis; GIS, Groundwater Fluctuation; Mapping.

I. INTRODUCTION

The Water is the important for all survival of earth. Rainfall is the main source of water which is unevenly distributed spatially and temporally (T.Subramani et al.2016).Rapid growth in population, leads to higher levels of human demand. So that issues on water availability and demand become critical (Vijay Kumar et al. 2006). This makes the management of water resources include assessing, managing and planning a complex task. 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 (Shukla Vimal et al.2019).

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Various states in India use different way to maintain groundwater quantity and to ensure that over drafting does not occur (Khazaz Lamiaa et al.2015). Groundwater is the important for drinking in every area. It is estimated that approximately one third of world's population use groundwater for drinking purpose (Nickson et al., 2005). In number of rural and urban households, public water supplies in various parts of the world depend on groundwater resources like bore well. But due to Growth of population that means urban sprawl much more increases the demand of water. The high Population to increases the number of bore well each and every house holding in urban area, due to Groundwater level fluctuation decline. GIS is a most important tool for analysis and monitoring in feature planning for groundwater level scenario in earth surface.

II. STUDY AREA

The study was located at 23°04'18" and 23°25'46" and East longitude 77°10'07" and 77°37'32 of district Bhopal, Huzur tehsil, Madhya Pradesh, India (Figure.1). That is covering an overall area in 1361.77 km^2. The dominated study area is started monsoon (June to September) and non-monsoon time period started (October to May). The minimum temperature is approximate 30 °C (86 °F), with the high peak of summer in May, when the maximum regularly exceed 40 °C (104 °F). IMD (India Meteorological Department) Normal annual rainfall of district Bhopal is 1240 mm. The annual average rainfall is approximate 1121 mm per year. There are available clay and loam clay soil.

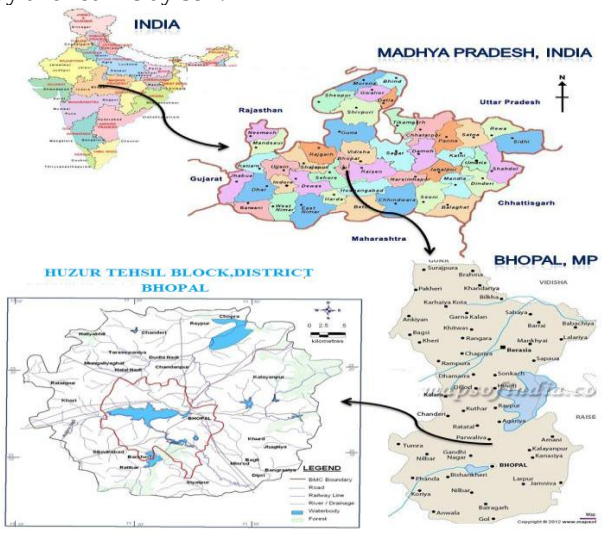


Figure.1 Study area location of district Bhopal, Huzur Tehsil, Madhya Pradesh, India

III. OBJECTIVES OF THE STUDY

The main goal of study trend analysis of a spatial distribution of groundwater levels fluctuation in Bhopal district, Huzur Tehsil, Madhya Pradesh, India. Techniques of Geographical information system (GIS) that is inherent in the spatial analysis. The study includes the analysis of long term trend groundwater fluctuation (1996-2015) pre-monsoon. Based on Groundwater fluctuation (GWF) period 20 years (1996-2015) to find out the study includes the analysis of future projected groundwater fluctuation (2016-2050) and trend of future projected (2016-2050).

IV. DATA COLLECTION AND ANALYSIS

In District Bhopal Huzur Tehsil, Madhya Pradesh (India) is collected 350 bore well Groundwater fluctuation (GWF), and Ground truthing using the hand hold GPS to locate the location of bore well, information in whole area in District Bhopal, Madhya Pradesh. Show in below the well location in Figure3. The following points have to consider while choosing a well as an observation well.

- The well should be agriculture or urban bore well.
- The fluctuation of the observation well is to be considered (mbgl) in whole area.
- The usage of bore well condition in agriculture and urban area.

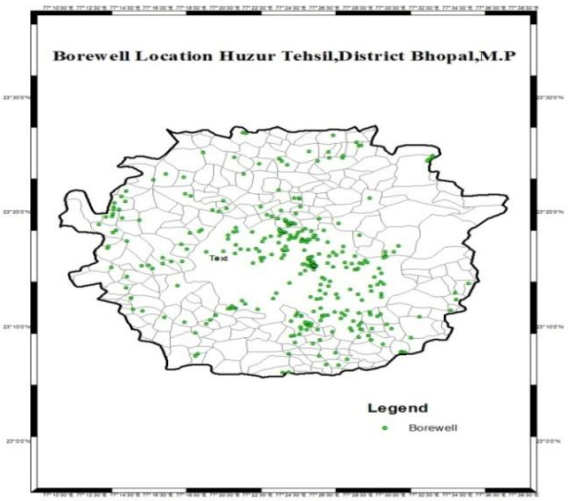


Figure 3: Index map of Location well observation in District Bhopal Huzur, Tehsil.

The Population of District Bhopal, Madhya Pradesh (India) as per census 2001 & 2011 out of total population, 89.5% people lives in urban areas while 10.5% lives in the rural areas. And use the Arithmetical Increase Method to calculate the projected population. Show the total population of Huzur, Tehsil, District Bhopal, M.P in Figure 4 and Show the actual and future projected Population in District Bhopal, Madhya Pradesh (India) Figure 5. Design of water supply and sanitation scheme is based on the projected population of a particular city, estimated for the design period. Any underestimated value will make system inadequate for the purpose intended; similarly overestimated value will make it costly. Changes in the population of the city over the years occur, and the system should be designed taking into account of the population at the end of the design period. Arithmetical Increase Method is used to analysis of projected population. This method is suitable for large and old city with considerable development. If it is used for small, average or comparatively new cities, it will give lower population estimate than actual value. In this method, from the past census reports we calculate the average increase in population per decade. To find out the population of the next decade we have to add this increase to the present population. Suppose that the population is increasing at constant rate. Hence, dP/dt = C i.e., rate of change of population with respect to time is constant.

Therefore, Population after nth decade will be $Pn = P + n.C$ ---- (1)

Where, Pn is the population after 'n' decades and 'P' is population present.

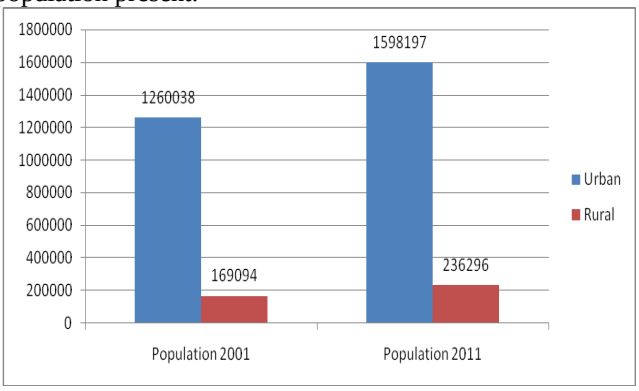


Figure 4: Show the total population of District Bhopal, Madhya Pradesh

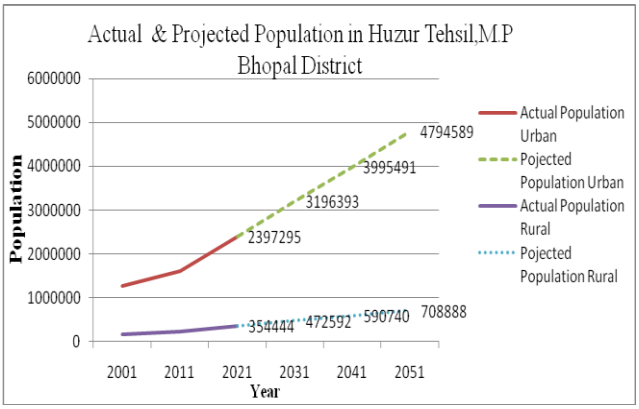


Figure 5: Actual & future projected Population in Rural & Urban in District Bhopal, Madhya Pradesh

V. METHODOLOGY

Using Survey of India topographical maps prepared study area. The well observation data was plotted on to the map by using latitude & longitude location of each bore well. In 350 total observation wells are used for further processing of the data for Groundwater level fluctuation (GWL) analysis. Put in the Geographical information system (GIS) tool to analysis and managed, monitoring the fluctuations of GWL and generate maps were prepared with the help of Geo-spatial interpolation model in Arc GIS10.5 and interpreted using standard methods.

In this study , Kriging method was used for made in spatial data distribution of Groundwater level fluctuation (mbgl) five year interval (1996-2000, 2001-2005, 2006-2010, 2011-2015) and Long term Trends (1996-2015) and find out the feature projected Groundwater level (GWL) and long trends since (2016-2050) .Using the Matlab 2017 to analysis of Ground water Level in Bore well and Generate the Groundwater Surface Modeling in 3 d visualization .The methodology GIS for the spatial analysis of the groundwater levels fluctuation (GWF) is as illustrated in Figure 6, and involved the following steps: spatial data analysis Exploratory (SDAE) using ArcGIS software for the water level to study the Following:

- Spatial Data distribution.
- Local and Global outliers.
- Trend analysis.

Spatial model interpolation for groundwater level data using ArcGIS 10.5 software, while kriging ordinary (KO) is applied by consisting the following steps:

- Semi-variogram modeling.
- Validation model.
- Surfaces generation groundwater level data.

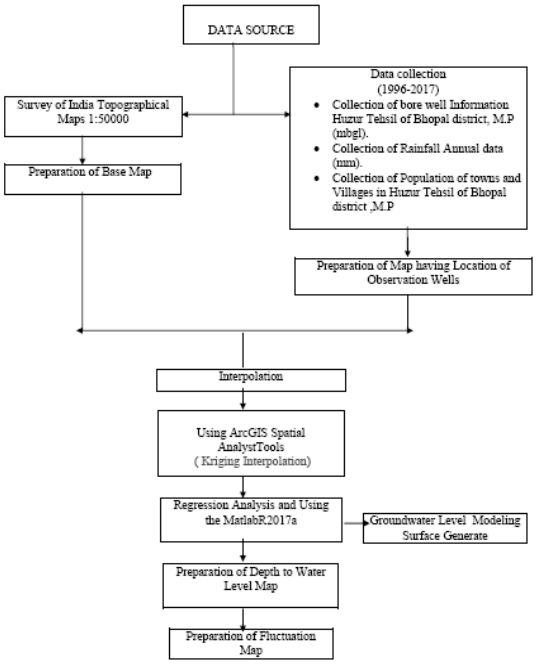


Figure 6: Methodology Chart for Analysis of groundwater fluctuation

VI. RESULTS AND DISCUSSIONS

According to study evaluate the behavior of Groundwater level fluctuations (GWF) by the major influencing factors and statistical properties on groundwater level. The study focuses on the overall status of groundwater level fluctuations (GWL).The growth of Population and increasing the density of district Bhopal, Madhya Pradesh as per Census 2001 and 2011 the water demanded are much more in 2011. And calculate the total projected Population 2051 in 5503477 Projected Population in district Bhopal, Madhya Pradesh. Show the total actual population & future projected population in district Bhopal, Madhya Pradesh in Figure 7.

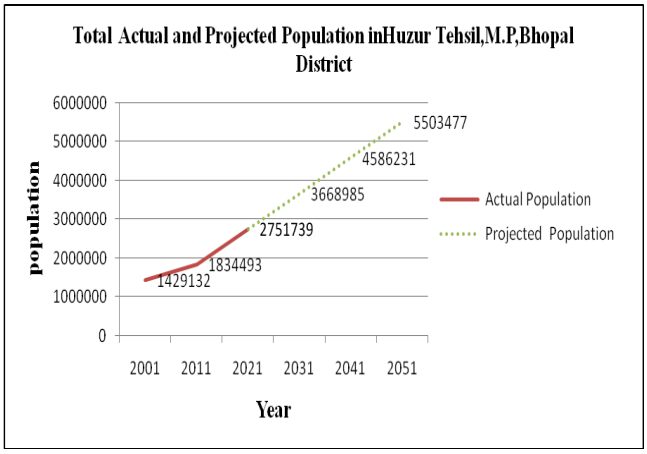


Figure 7: Total actual population & future projected Population District Bhopal, Madhya Pradesh

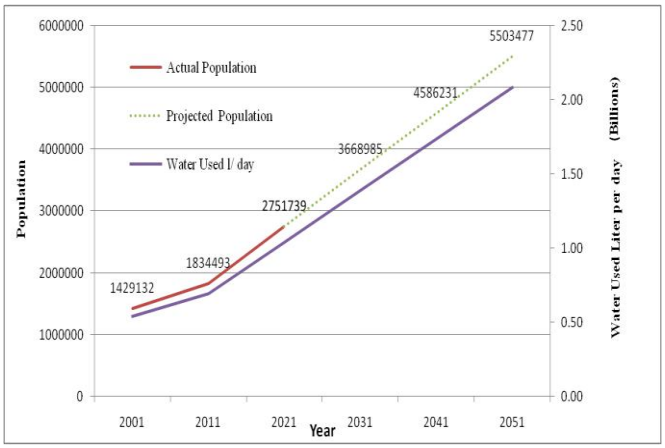
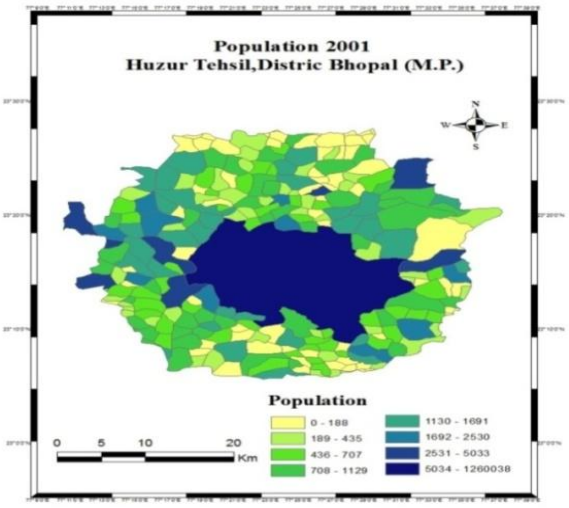
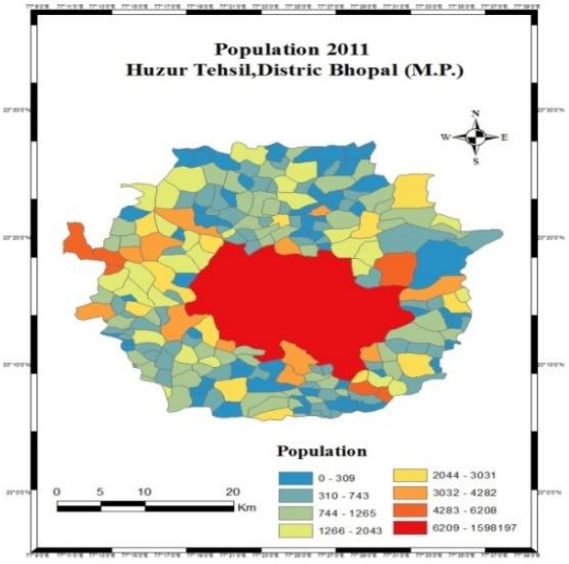


Figure 8: Water utility of Liter per day in actual and projected Population in District Bhopal, Madhya Pradesh

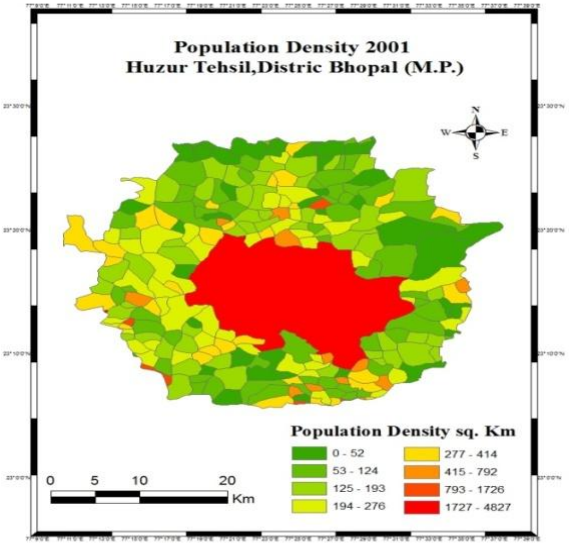
As the rapidly developing city, there is increase in the people migration from nearby town and villages. The source of Groundwater level full-fill refilling depends upon the season of monsoon. In the years (2011-2015) when the monsoon is not good, there is a high crisis of water in the winters and summers period. And each person uses about 80-100 gallons of water per day (USGS), and 1 gallon is approximately Values in 3.78 Liter that means the Population of Huzur, Tehsil, District Bhopal Madhya Pradesh 2001 - 2011 is 1429132 and 1834493. And Water Requirement is 540211896 l/day scenic 2001 and 2011 water required is 693438354 l/day. That means GWL decline yearly by yearly. Show the Water utility of Liter per day in actual and projected Population in study area in Figure 8.Using the GIS techniques to analysis of Population and water used in study area and that effect on Groundwater level in Bhopal district, Madhya Pradesh. The overall total area of district Bhopal, Huzur tehsil is 1,361.77 km^2 with population densities in 2001 is 1,049 and 2011 is 1347 (per sq.km). Geographical information system (GIS) provides the information of population and density in district Bhopal, Huzur tehsil, Madhya Pradesh as shown in figure 9.



(a)



(b)



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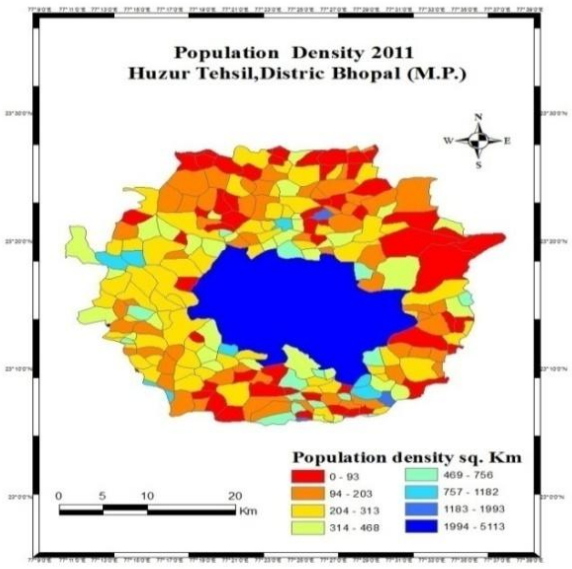


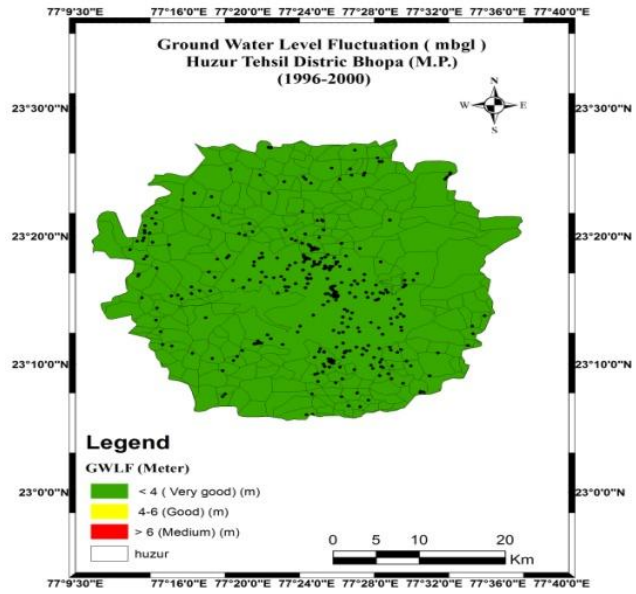
(d)

Figure 9: Population (a, b) and density (c, d) Map of Huzur Tehsil, Bhopal District, Madhya Pradesh (2001&2012)

A. Effect of groundwater level fluctuation

The water level fluctuation of five year annual intervals represented by the change in pre-monsoon and post- monsoon groundwater levels (1996-2015). as shown in table 26 representations the Ground water level fluctuation (1996-2000, 2001-2005, 2006-2010 and 2011-2015) divided into four units ranging, and apply the interpolation ordinary kirging (OK) methods.

As shown in the graph of each five year Groundwater level fluctuation Period 1996-2000, 2001-2005, 2006-2010 and 2011-2015 (Figure 25). During 1996 to 2000, the Groundwater level very good condition, the water level gets to 4-6 mbgl, and after the 2001 to 2005, the Groundwater level good condition, the water level gets to 6-8 mbgl, and 2006-2010, the Groundwater level Medium condition, the water level gets to 6-10 mbgl, and after 2011-2015 the very poor condition, the water level gets to 6-18 mbgl, and that means the overall the compared to three five year annual interval of groundwater level (1996-2000,2001-2005,2006-2010) are satisfactory condition but last five year annual interval of groundwater level (2011-2015) are going to decline In this study, Kriging model was used for spatial distribution of Groundwater level fluctuation (mbgl) interval five year (1996-2015) and long trends (1996-2015) and projected future trends (2016-2050).Using the Matlab 2015 to analysis of Ground water Level in Bore well and Generate the Groundwater Surface Modeling.



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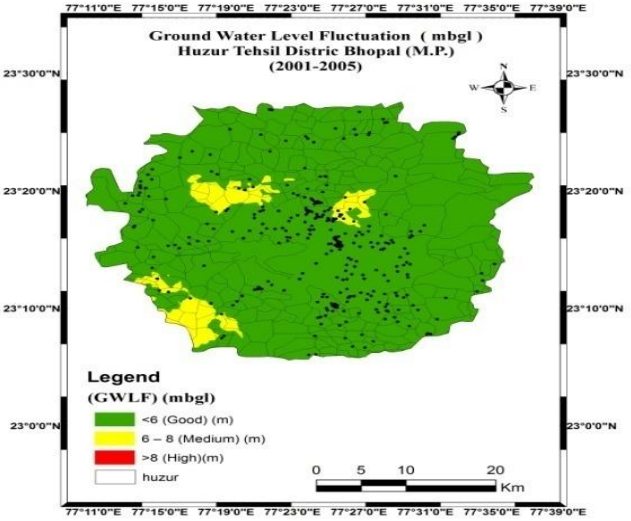
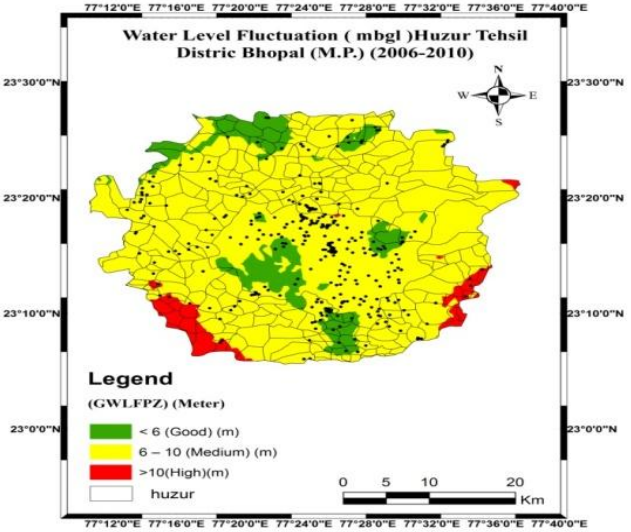
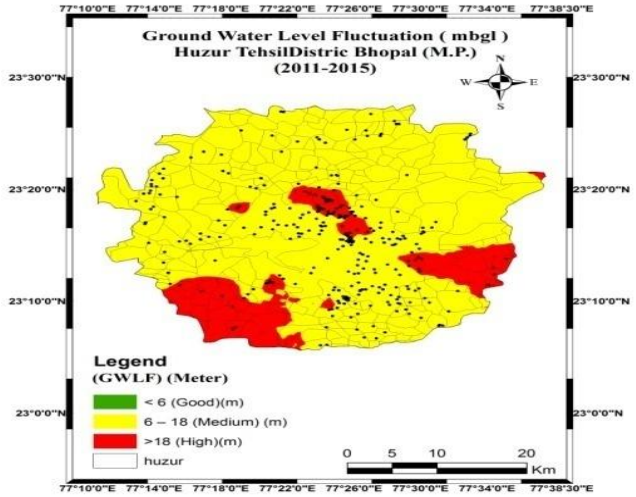
(d)



(e)



(f)



(g)

Figure10: Groundwater Level fluctuation maps (d, e, f, and g) for the five years interval 1996-2000, 2001-2005, 2006-2010 and 2011-2015.

B. Effect of Long trend Groundwater level fluctuation

Analysis of decadal pre-monsoon groundwater level information data (1996- 2015) indicates that, in general, the declining trend in groundwater levels fluctuation 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 5 to 61 m/year (Figure 11).and generates the Long Trend of Groundwater Level modeling in pre-monsoon (1996-2017) as shown in Figure 15. 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 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 12).

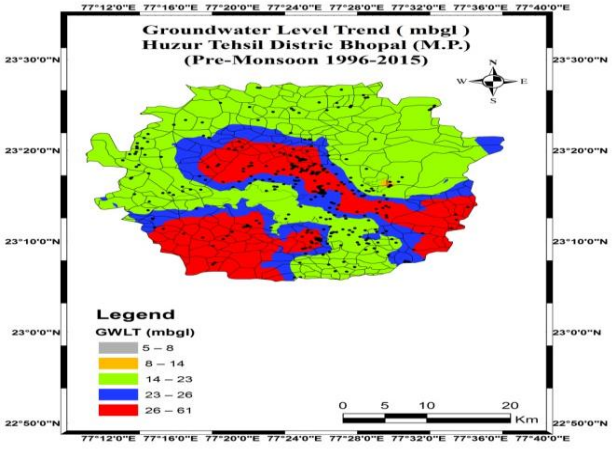


Figure 11: Decadal pre-monsoon water level Long trend map (1996– 2017)

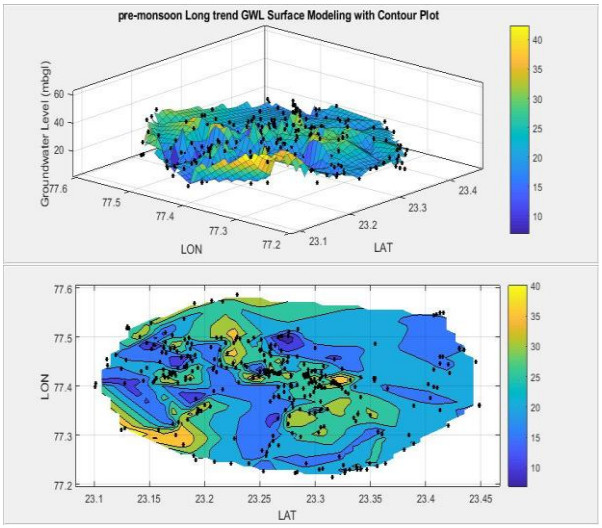


Figure 12: Long trend of Groundwater Level modeling in pre-monsoon (3d Surface) (1996-2017)

C. Effect Future Projected Trend Groundwater Level

Theses section analysis of projected future Groundwater Level in Huzur Tehsil, District Bhopal. As shown in Figure 14 to show the long trends in water level decline, and the groundwater level to decline, so we are using the projected formula. And how the water level in Huzur Tehsil, district Bhopal decline or incline. And applying GIS techniques (Spatial Interpolation) to find out Groundwater Level fluctuation as shown (Figure 13), and study the projected Feature Groundwater Level. And final analysis finds out the trend of increasing Groundwater Level declining (since 1996-2015 to 2016-2050). After the analysis future Projected Forecast Groundwater Level Fluctuation Since (2016-2020,2021-2025,2026-2030,2031-2035,2036-2040,2041-2045,2046-2050).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) (Figure13). And future Projected Forecast Groundwater fluctuation GIS map generates. In this study using the function FORECAST is used functions Statistical. It will predict future value calculate using existing values. As the shown in below the projected future forecasting Groundwater level fluctuation (Table7).

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

Equation=FORECAST (A, known_y's, known_x's) --3

The function FORECAST considered the following arguments:

1. **A** (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 function FORECAST that is calculated a new y-value using the straight-line formula:

y=a+bx,

Where:

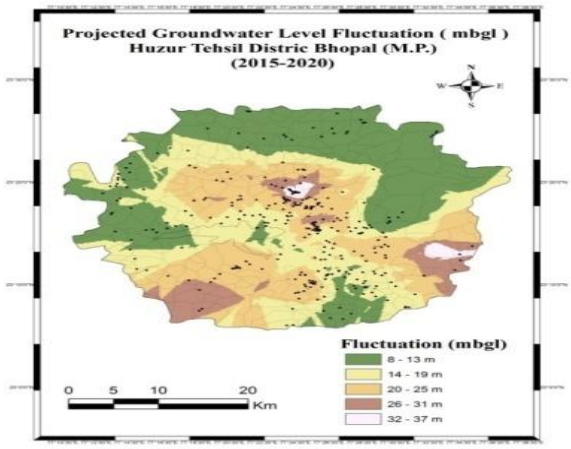
$$a = \bar{y} - b\bar{x}$$

and:

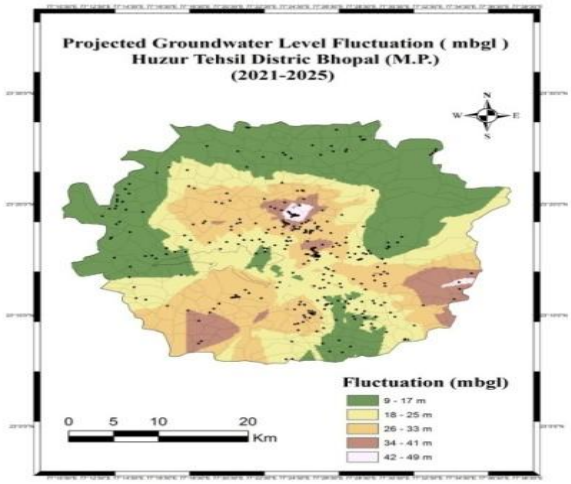
And the values of x and y are the sample means (the averages) of the known x- and the known y-values.

Table 7: Analysis of Projected future Forecasting Groundwater Level Fluctuation values

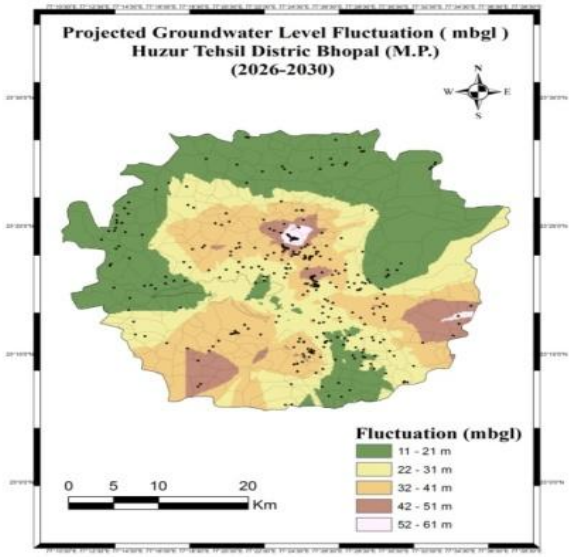
Projected Fluctuation (2018-2022)	Projected Fluctuation (2023-2027)	Projected Fluctuation (2028-2032)	Projected Fluctuation (2033-2037)	Projected Fluctuation (2038-2042)	Projected Fluctuation (2043-2047)	Projected Fluctuation (2048-2051)
7.69	9.41	10.93	12.27	13.76	15.22	17.17
13.48	17.36	20.94	23.92	27.4	30.75	34.21
19.26	25.31	30.93	35.57	41.03	46.27	51.23
25.04	33.25	40.92	47.21	54.66	61.8	68.25
30.82	41.2	50.92	58.85	68.29	77.32	85.27
13.47	17.35	20.93	23.91	27.39	30.74	34.2
19.25	25.3	30.92	35.56	41.02	46.26	51.22
25.03	33.24	40.91	47.2	54.65	61.79	68.24
30.81	41.19	50.91	58.84	68.28	77.31	85.26
36.59	49.13	60.9	70.49	81.9	92.83	102.28


Projected Groundwater Level Fluctuation (mbgl)
Huzur Tehsil Distric Bhopal (M.P.)
(2015-2020)
Fluctuation (mbgl)
8 - 13 m
14 - 19 m
20 - 25 m
26 - 31 m
32 - 37 m
0 5 10 20
Km

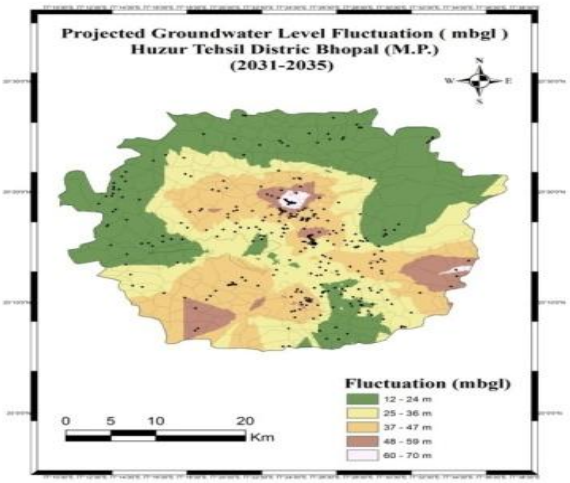
(a)


Projected Groundwater Level Fluctuation (mbgl)
Huzur Tehsil Distric Bhopal (M.P.)
(2021-2025)
Fluctuation (mbgl)
9 - 17 m
18 - 25 m
26 - 33 m
34 - 41 m
42 - 49 m
0 5 10 20
Km

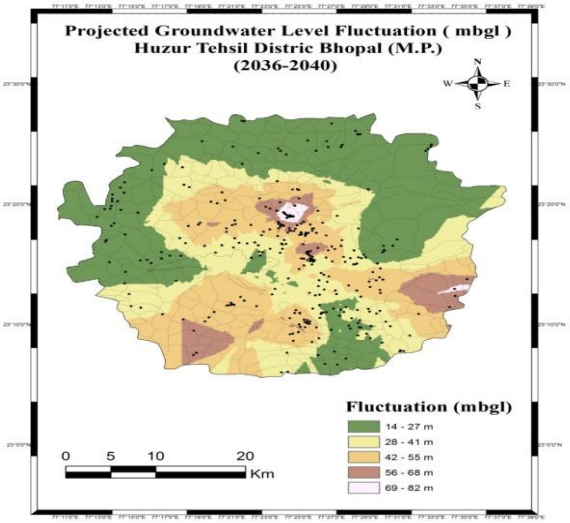
(b)


Projected Groundwater Level Fluctuation (mbgl)
Huzur Tehsil Distric Bhopal (M.P.)
(2026-2030)
Fluctuation (mbgl)
11 - 21 m
22 - 31 m
32 - 41 m
42 - 51 m
52 - 61 m
0 5 10 20
Km

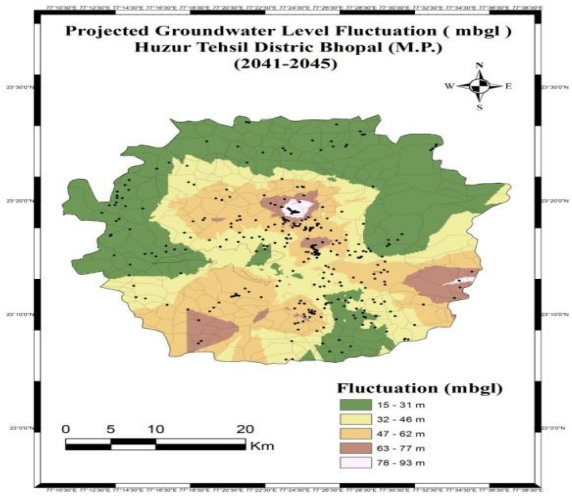
(c)


Projected Groundwater Level Fluctuation (mbgl)
Huzur Tehsil Distric Bhopal (M.P.)
(2031-2035)
Fluctuation (mbgl)
12 - 24 m
25 - 36 m
37 - 47 m
48 - 59 m
60 - 70 m
0 5 10 20
Km

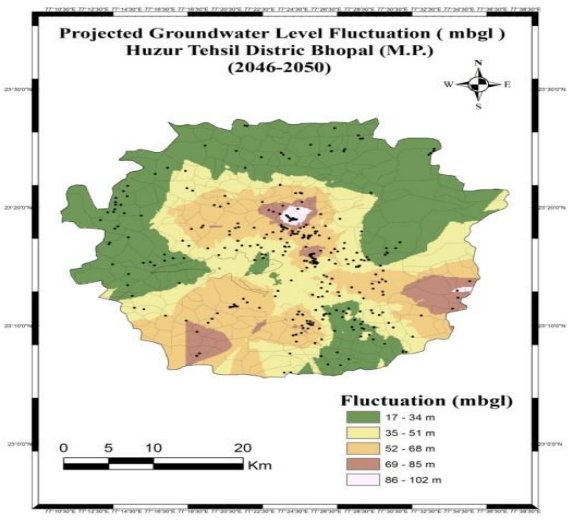
(d)


Projected Groundwater Level Fluctuation (mbgl)
Huzur Tehsil Distric Bhopal (M.P.)
(2036-2040)
Fluctuation (mbgl)
14 - 27 m
28 - 41 m
42 - 55 m
56 - 68 m
69 - 82 m
0 5 10 20
Km

(e)


Projected Groundwater Level Fluctuation (mbgl)
Huzur Tehsil Distric Bhopal (M.P.)
(2041-2045)
Fluctuation (mbgl)
15 - 31 m
32 - 46 m
47 - 62 m
63 - 77 m
78 - 93 m
0 5 10 20
Km

(f)



(g)

Figure 13: Future projected five year interval Groundwater level Fluctuation (a, b, c, d, e, f, and g) maps for the years (2016-2050)

D. Long trend projected water level fluctuation

Analysis of Projected decadal groundwater level pre-monsoon data for the Since (2016- 2050)indicates that, in general, the declining trend in water levels has been in most parts Bhopal District, Huzur, Tehsil, 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 9 to 149 m/year (Figure 14).and generate the Projected future Long Trend of Groundwater Level GIS map in pre-monsoon (2016-2050) as shown Figure using Matlab to projected 3d surface and contour plots(Figure 15). 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.

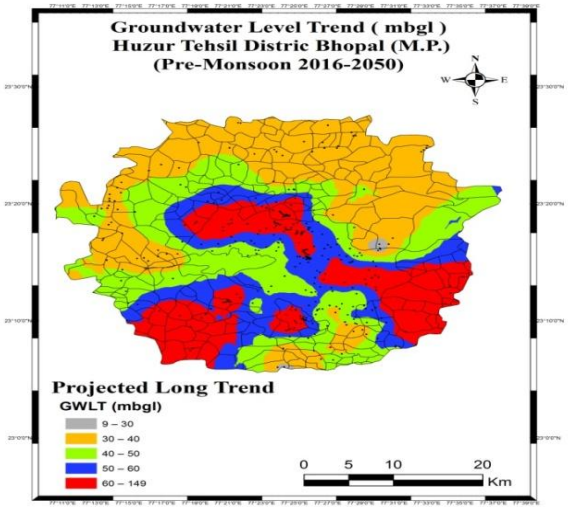


Figure 14: Projected future Long trend decadal pre-monsoon water level trend map (2016– 2050)

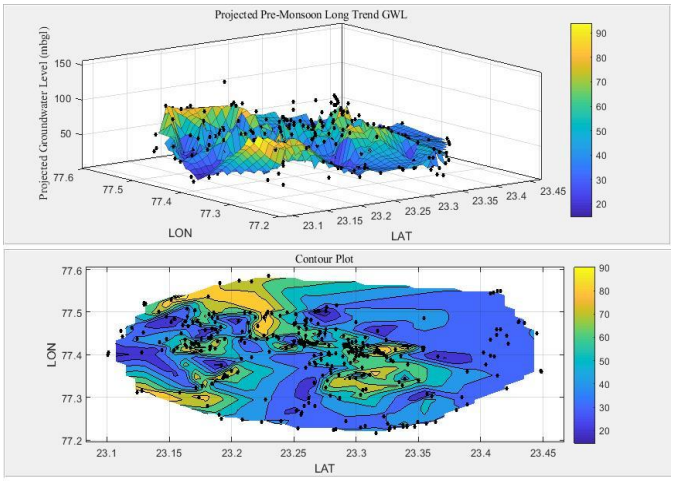


Figure 15: Projected future Long trend of Groundwater Level modeling in pre-monsoon (3d Surface)

VII. CONCLUSION

The overall study reflects an decline trend of groundwater level over the period. In general, the show results that the district Bhopal is facing the problem of groundwater Level decline in the recent past, year 2011. In 2011 to 2015 Groundwater level Fluctuation pre-monsoon time most of the area decline in district Bhopal. That why number of bore well drought condition in pre-monsoon time. The areas showing decline trend on a long -term bases (1996-2015) to feature projected (2016-2050).Since 1996-2015 the Groundwater Level trend was between lies 5-61 (mbgl), and the period 2016-2050 feature projected groundwater level trend between 9 -149 (mbgl). That means increasing the population, in urban sprawl, the effect of the increasing decline of groundwater. The study represented the use of GIS in spatial data distribution monitoring and mapping for groundwater level fluctuation in present and feature in the area. The behavior of groundwater level fluctuations is, however, is in the initial phases for the management and development of groundwater resources as an alternative resource for domestic purposes and drinking for future demand.

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