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Geospatial Modeling of Rain Fall Distribution and Ground Water Fluctuation Using GIS: A Case Study for Hard Rock Terrain of Upper Ponniyar Watershed, Tamil Nadu, India

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Abstract - **Ground water is an important natural source of drinking water for many people around the world. Further it is considered to be an essential element to maintain a proper balance between ground water fluctuation and rainfall distribution. Due to irrigation, urbanization and industrialization, the ground water level has declined to a larger extend. Hence in the present work an attempt has been made to analyse the groundwater fluctuation by taking the upper Ponniyar watershed as a study area using geographical information system (GIS). Also a correlative study has been made between the rainfall distribution and ground water fluctuation during the period from 1992 to 2012.**

Keywords: **Groundwater fluctuation, Rainfall, Spatial interpolation, GIS**

I. Introduction

Ground water is the most important water resource on earth (Villeneuve J.P *et al.*1990)[1]. It caters to 80% of the total drinking water requirement and 50% of the agricultural requirement in rural India (Meenakshi and Maheshwari R.C 2006,Murhekar.G.H 2012)[2,3]. The groundwater is a dynamic and rechargeable natural resources but in hard rock terrains its availability is of limited extent and is essentially confined to the fractured and weathered horizons, which points towards efficient management of ground water in these areas (Saraf A.K.and Choudhury P.R 1998)[4].The behavior of ground water in Indian sub continent is highly complicated due to the varied geological formations.

In recent years the ground water level is declining to a larger extent due to rapid increasing industrialization, urbanisation, and agricultural activities. This necessitates the need to maintain a proper balance between ground water fluctuation and rainfall distribution and improper balance between the above parameters affects this sustainability of ground water resources. Hence in the present work an effort has been to study the ground water fluctuation in hard rock terrain of upper Ponniyar watershed flows in Krishnagiri and Hosur taluk,Tamil Nadu using Geographical information system.

II. Study Area

The study area, Upperponiyar watershed, Krishnagiri, Hosur taluk,Tamilnadu has been selected for the study which lies between 12°30' to 13°N latitudes and 77°45'E to 78°E longitudes. It covers a geographical area of 832.85 sq.km and to a total length of 69.42km. Here the river originates in the chikkaballapur district of karnataka at an elevation of about 900m above mean sea level and then flows south and then east for 400 km through Karnataka and Tamilnadu and finally emptying into bay of bengal at cuddalore. The upper part of the Ponnaiyar basin is covered by the Archaean rocks such as Gneiss, Hornblende biotite gneiss, Pyroxene granulites, Quartzite, Ferruginous Quartzite and Amphibolites.

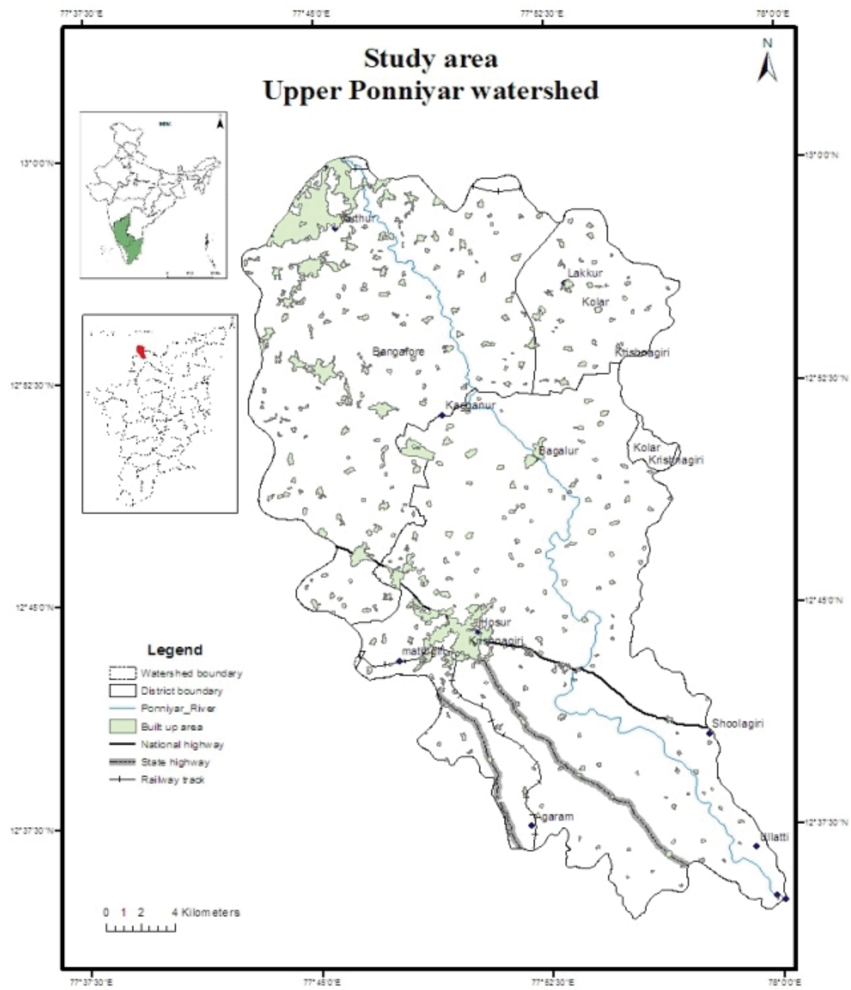

Fig. 1 Study area

III. Materials and Methods

Initially to study the rainfall distribution and ground water fluctuation, rainfall data and ground water level data were collected from Indian meterological department(IMD) Pune and Tamilnadu groundwater board respectively, the rainfall data and ground water level data were collected for nine stations in the proposed study area for a period of 30 years (1983-2012) and 20 years(1992-2012) respectively, with the help of these above data, Inverse distance weighted average (IDWA) is deployed to interpolate and analyze the rainfall and ground water fluctuation.(Source: Indian meterological department, Pune)

IV. Inverse Distance Weighted Averaging - A Statistical Background

IDWA is a deterministic estimation method whereby values at unsampled points are determined by a liner combination of values at known sampled points (Yeshodha.L et al. 2010)[5]. Weighting of nearby points is strictly a function of distance. This approach combines idea of proximity such as thiessen polygons with gradual changes of the trend surface. The assumption is that values closer to the unsampled location are more representative of the values to be estimated than values from samples further away. Weights changes according to the linear distance of the samples from the unsampled point in other words, nearby observations have a heavier weight. The spatial arrangement of the samples does not affect the weight. IDWA approaches the nearest neighbor interpolation method,in which the interpolated values simply takes on the value of the closest sample point. IDWA interpolators are of the form

$$y(x)=\Sigma\lambda_i y(x_i)$$

λ_i = the weights for the individual locations

Table I Annual Rainfall Distribution in Study Area

Year	Devanhalli	Hoskote	Horohalli	Tippagondanahali	Denkanikottah	Hosur	Krishnagiri	Shoolagiri	Mellumali	Total annual rainfall in (mm)
1983	181.6	173.7	201	193.6	184.6	142.9	255.3	212.8	**	1548.48
1984	218.5	169.7	162.7	156.4	190.3	153.4	161.7	192.5	**	1404.9
1985	65.5	116.7	524.7	131.1	145.2	105.4	246.9	169.4	**	1504.62
1986	169.8	296	**	**	151.6	93.5	160.6	176.7	**	1048.14
1987	175.9	262.6	215.9	215.9	98.4	74.3	121.3	117.3	**	1281.6
1988	235.4	263.5	**	275.8	158.9	136.7	353.9	9.5	**	1433.7
1989	132.5	177.6	122.1	**	225.3	147.1	310.9	**	**	1115.55
1990	165.5	147.6	91.62	111.2	136.7	86.5	206.9	147.3	**	1093.14
1991	315.4	320.1	487.3	229.2	355.0	109.1	351.5	259.3	**	2426.76
1992	191.6	178.8	184.4	127	264.7	117.8	136.8	132.3	**	1333.26
1993	218.2	289.3	234.5	112.1	226.4	97.4	179.8	286.5	**	1644.12
1994	199.0	135.75	125.6	110.6	241.1	117.4	214.6	198.8	**	1342.71
1995	199.6	249.2	139.1	**	229.6	134.8	269.5	306.6	**	1448.37
1996	63.6	227.8	270.8	162.5	261.1	112.2	268.5	251.1	**	1617.48
1997	185.1	194.1	139.2	144.8	317.6	163.5	323.1	257.2	**	1724.4
1998	147.2	226.4	192.4	109.1	310.1	208.4	157.8	20.3	**	1371.6
1999	**	**	**	195.1	429.6	293.9	149.2	352.0	**	1419.75
2000	269.6	204.9	282	215.65	403.3	271.1	282.1	300.3	**	2228.76
2001	233.4	249.1	153.55	193.8	149.4	309.2	814.7	249.7	223.0	1942.4
2002	96.4	98.9	136.1	124.9	62.4	229.1	379.5	171.1	166.7	1669.77
2003	**	**	**	**	42.8	149.4	459.9	191.4	611.6	1455.03
2004	189.9	290.3	243.2	**	16	297	317.4	144.5	187.1	1685.34
2005	261.6	285.3	65.2	**	**	347.9	343.3	327.4	337.9	1968.3
2006	127.9	77.8	119.1	133.4	**	119.9	120.8	119.7	169.6	987.92
2007	266.2	214.3	148.5	187.9	**	423.3	265.5	171.3	213.1	1899.27
2008	228.9	280.2	121.7	193.9	**	284.8	353.2	107.3	270.1	1840.05
2009	101.9	138.9	**	168.1	**	190.1	301.0	95.5	229.6	1225.96
2010	**	**	**	**	**	138.7	325.4	141.4	286.3	891.63
2011	**	**	**	**	**	189.3	217.5	210.8	185.5	803.07

$y(x_i)$= the variables evaluated in the observation location

The sum of the weights is equal to 1. Weights are assigned proportional to the inverse of the Distance between the sampled and prediction point. So the larger the distance between sampled point and prediction point, the smaller the weight given to the value at the sampled point.

V. Results and Discussion

As discussed in earlier section, IDWA, a spatial interpolation technique is used to analyze the ground water fluctuation and rainfall distribution. With the help of ground water level data, groundwater fluctuation maps were generated for every four years and accordingly maps were shown in figs 2 to 6.Subsequently the rainfall distribution data were analyzed and shown in table-1 for a period of 30 years. From Table-I it is observed that for most of the years the annual rainfall is more than 1500mm.

From the analysis it is observed that the two variables ie, ground water fluctuation and rainfall distribution have low reliability and high variability because of terrain condition and availability of hard rock. From table-1 though a good quantum of rainfall is observed it does not have significant impact on the ground water recharge in that particular terrain in the regions and this is because of the availability of impermeable hard terrains in this regions such as kelamangalam,shoolagiri and hosur.

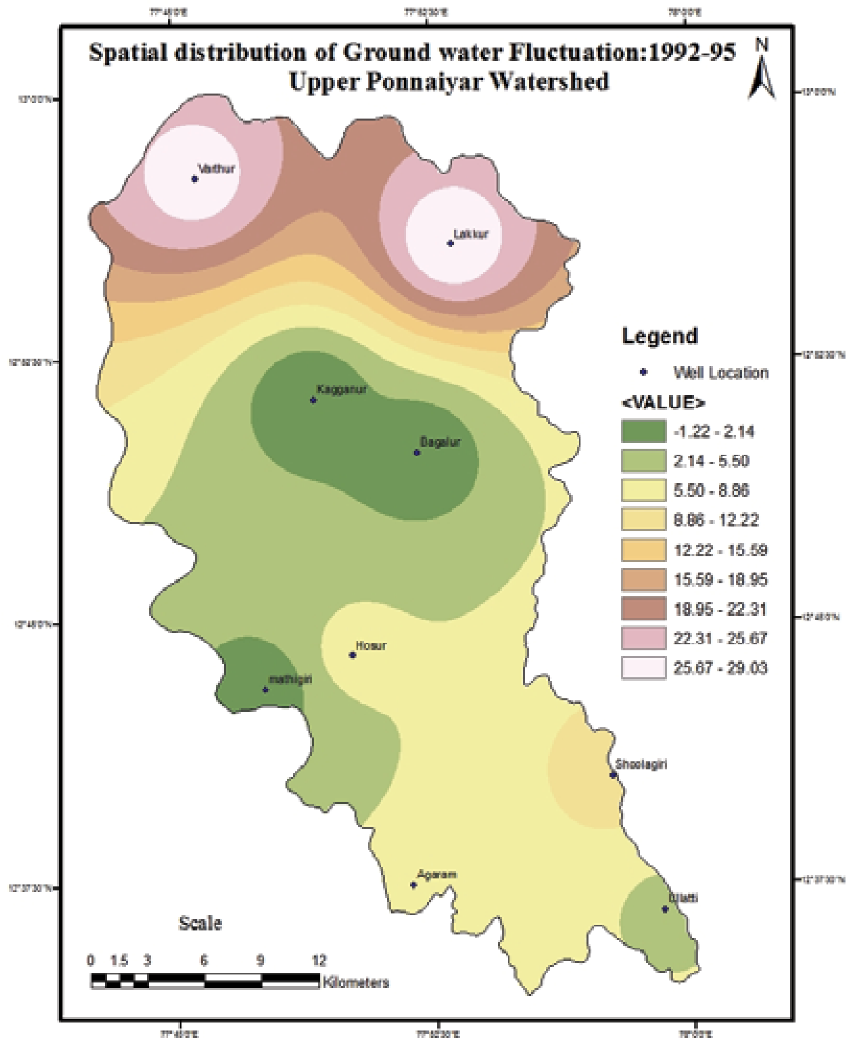

Fig 2.Ground water fluctuation map for 1992-1995

From fig 2, it is observed that the ground water level for the period (1992-1995) in the areas like Kelamangalam & Hosur is as low as 2.14m-5.5m above mean sea level. Similarly the ground water level in Shoolagiri and Anekal / Hoskote, Maluru, Kemgeriare observed to be 12.22m-15.59m and 22.31m-25.67m respectively. From fig 2 it is also observed that the ground water level is very low in the areas near the Vicinity of Hosur, though the rainfall intensity is significant in those regions, this is because due to the availability of Granitoid Gneiss,Basic dykes, Ambhibolite, Basic/Alkaline dykes.

From figure 3, 4, 5 and 6, a similar behavior is being observed as in the period 1992 to 1995. This is mainly due to

- The availability of hard terrains as discussed earlier.
- Considerable amount of pumping of ground water due to rapid industrialization, urbanization and agricultural activities.
- high surface run off due to the presence of rocky soil.

However in the areas like Hoskote, Kemgeri and Maluru the ground water level is found to be better due to the availability more number of ponds and lakes.

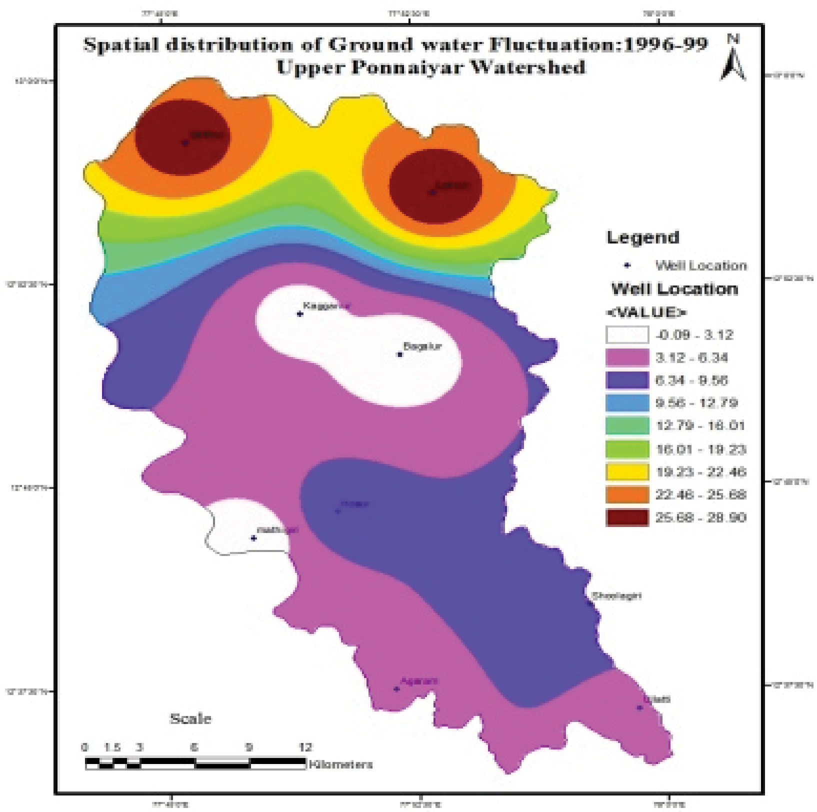

Fig. 3 Ground water fluctuation map for 1996-1999

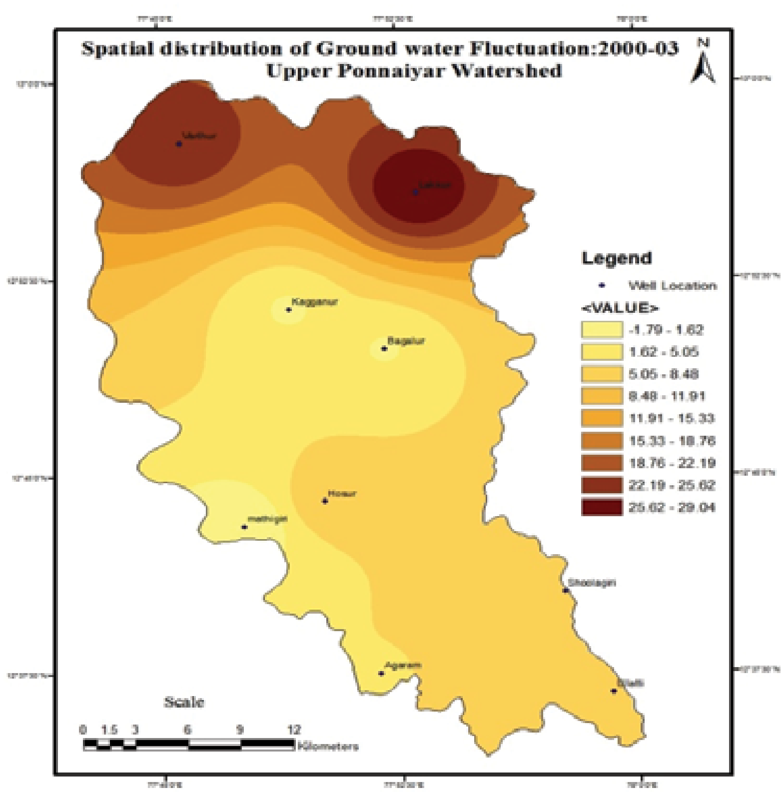

Fig. 4 Ground water fluctuation map for 2000-2003

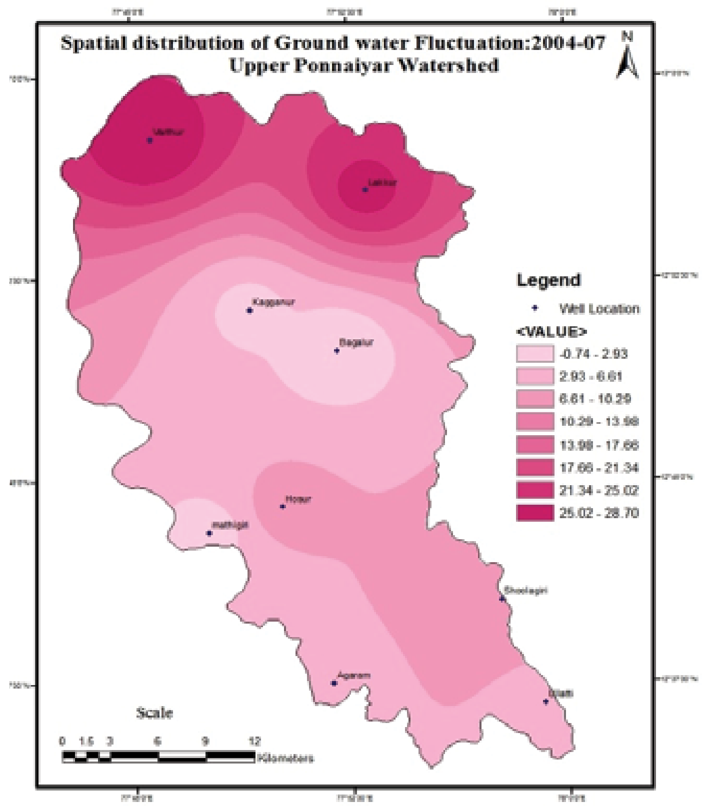

Fig. 5 Ground water fluctuation map for 2004-2007

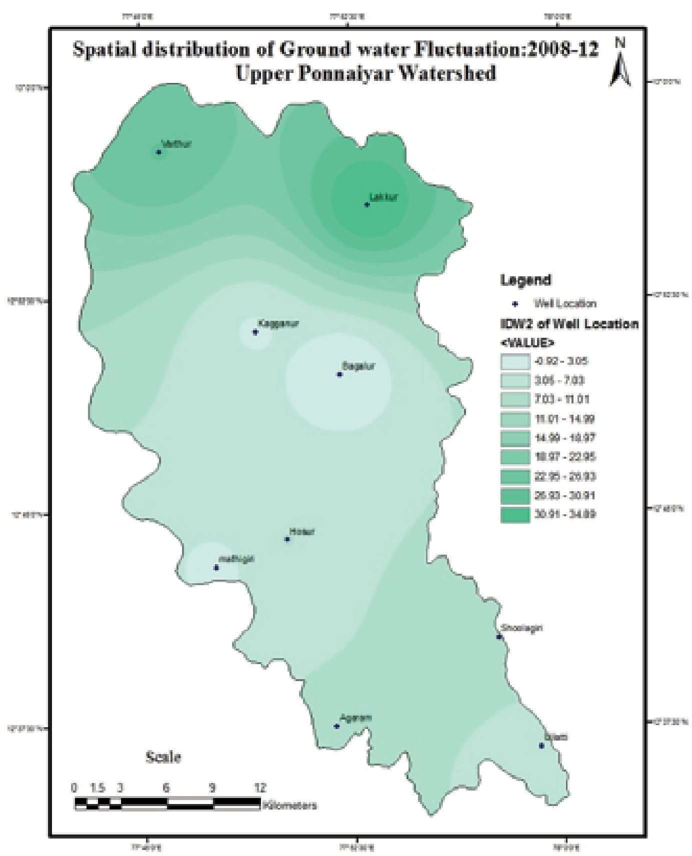

Fig. 6 Ground water fluctuation map for 2008-2012

VI. Conclusion

In the present work an effort has been made to study the ground water fluctuation and the rainfall distribution pattern in the upper Ponniyar watershed in Krishnagiri, Hosur taluk, Tamilnadu, which is declared as a severe drought zone by Tamilnadu Government. Numerical investigations reveals that the ground water level is not that much appreciable though there is a significant rainfall intensity. This is mainly due to demographic increase in populations, urbanization and industrialization.

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