Research Article

Study of Recharge Pattern for Different Rainfall Conditions in Walayar Sub Basin

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Abstract

Quantification of the rate of ground water recharge is a basic prerequisite for efficient ground water resource management. Spatial and temporal changes in precipitation will significantly influence natural recharge. The rainfall and recharge relationship was studied for the period 1999 to 2020 for three rain gauge station. The analysis was done for different rainfall conditions viz. Excess, Normal and deficit period for the three rain gauge stations. It is found the rainfall percentage contribution to recharge during deficit is more than normal and excess year. The recharge rate during continuous rainy years, slightly reduced in the first year gradually increased from second year in both SW and NE monsoon. The contribution of rainfall percentage to recharge is increased after implementation of watershed development programs.

Keywords: Rainfall, Recharge, Walayar sub basin

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Introduction

The impacts of climate change and climate variability on human life have led the scientific community to monitor the behavior of weather and climate variables [1, 2]. Rainfall as one of the most important of these variables has a direct and indirect impact on the natural environment and human life [3]. Spatial and temporal changes in precipitation will significantly influence natural recharge [4]. Moreover, since a good deal of natural recharge occurs in areas with vegetative cover, such as forests, changing ET rates resulting from rising temperatures may reduce infiltration rates from natural precipitation thus reducing recharge[5, 6]. Recharge responds strongly to the temporal pattern of precipitation as well as to soil cover and soil properties [7].

Ground water constitutes a major issue in regions where there is a large demand, such as in deficit irrigation commands, where irrigation water supply is confined only for few months and farmers have to inevitably depend on ground water, which is a key factor to agricultural development in these areas [8]. Quantification of the rate of ground water recharge is a basic prerequisite for efficient ground water resource management [9]. To meet our water demand, we entirely depend upon rivers, lakes & ground water [10]. Keeping in this view, the study on the impact of climate change in groundwater recharge was conducted in Kinatahukadavu block Walayar sub basin,Tamil Nadu.

Study Area

The study area Kinathukadavu block is located in Coimbatore district. It exists in Koraiyur watershed which covers the part of Coimbatore, Pollachi, Palladam, and palghat. and in Pollachi sub watershed. The study area is lying in walyar sub basin. It is in the over exploited groundwater extraction category (>100%) and located in Granite (Anamalai) terrain. The depth to bottom of aquifer is lying 60-70 m below ground level. The study area is 740 ha.The predominant rock types found in this river basin is crystalline rocks of Archean age. The winter water level varies from 4.00 to 18.00 m and the summer water level ranges from 18.00 to 18.25m below ground level. The location of the study area are given in **Figure 1**. The soils of the study area are shallow, well drained sandy loam, sandy clay loam soils and moderately deep well drained medium to fine clay loam soils.The study area is covered with buried pedipla, buried pediment shallow and buried pediment deep.

Methods and Materials

Rainfall analysis

In dealing the stochastic nature of rainfall, it is important to determine the probability of rainfall for estimating the aquifer response to rainfall which affects the recharge in an area. The daily rainfall data for 22 years (1999-2020) for three rain gauge stations namely Negamam, Podanur and Sultanpet in the study area was collected from Public Works Department, Coimbatore and used for analysis.The contributed area of each rain gauge station was worked out by

Thession polygon method. The contributed area for three rain gauge stations Negamam, Sultanpet, and Podanur were 153.86 sq. km, 48.63 sq. km and 87.32 sq. km respectively as shown in **Figure 2**.

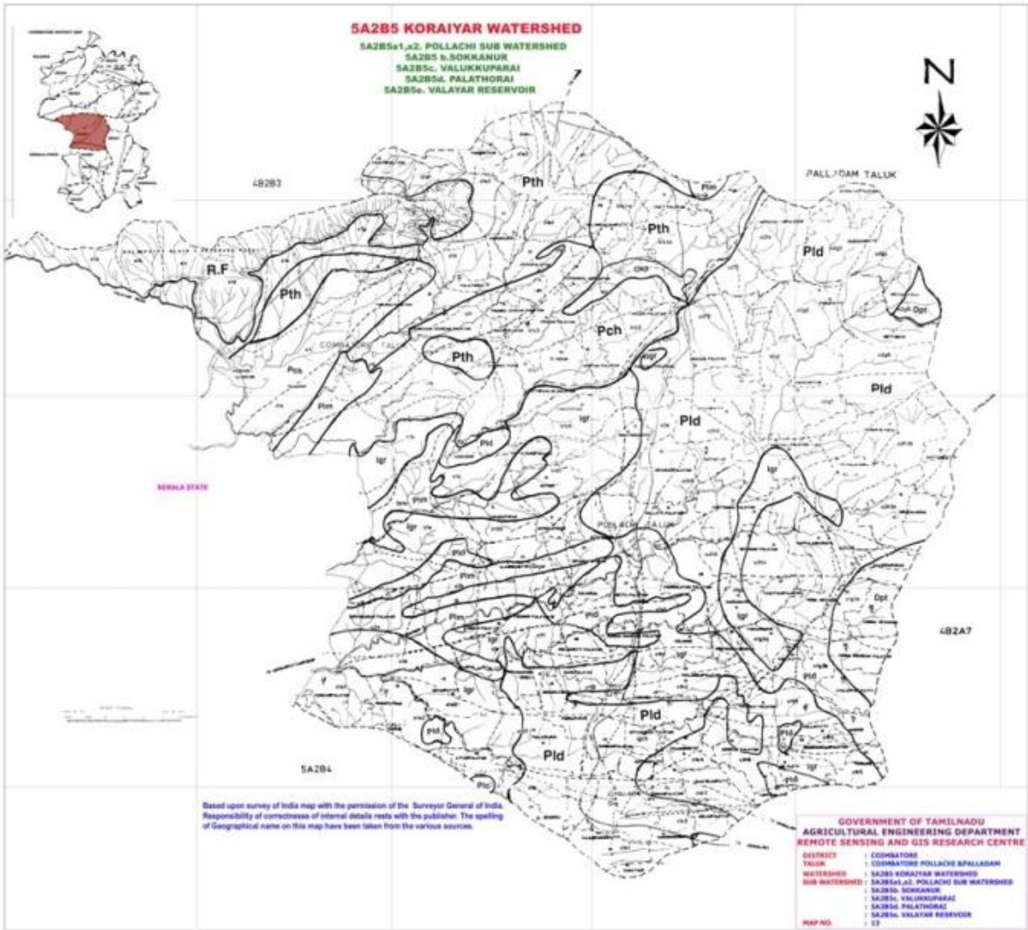

Figure 1 Location of Study area

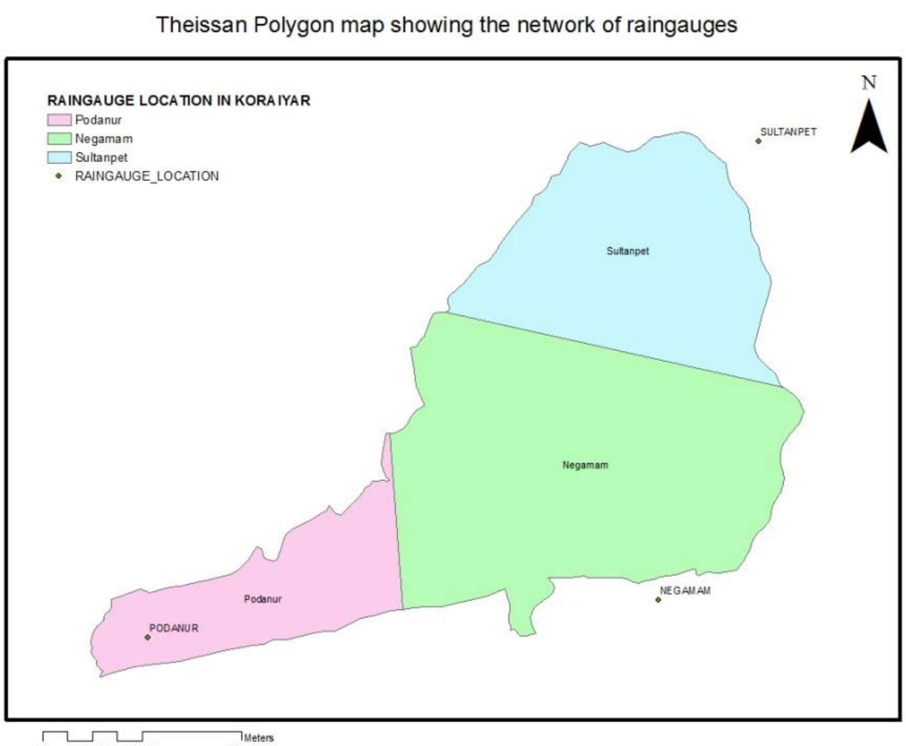

Figure 2 Theissan polygon map showing the network of rain gauges

Recharge estimation

The seasonal recharge in the study area are computed using water table fluctuation method (Healy and Cook, 2002) for both South west and North East monsoon periods. A value of 2.5 percent was assumed for the specific yield of the aquifer in the area (a hard rock area) based on the guidelines of GEC of GOI (2007). The seasonal recharges were arrived separately with the seasonal weighted rainfall for different rain gauge stations of the study area for the period 1991 to 2012.

Results and Discussion

The rainfall and recharge relationship was studied for the period 1999 to 2020 for three rain gauge station. The analysis was done for different rainfall conditions viz. Excess, Normal and deficit period for the three rain gauge stations.

Table 1 Seasonal Recharge of Negamam Rain gauge station

year	Seasonal Rainfall in mm	Category		Average fluctuations in 'm'	Area		sp yield	Recharge volume in Mm^3		Recharge in percent	
	SW	**NE**		**SW**	**NE**	**Sq.km**		**SW**	**NE**	**SW**	**NE**
1999	529	40.7	Normal	2.86	0.17	153.86	2.5	1101.58	66.84	2.08	1.64
2000	494.7	362	Excess	4.32	4.82	153.86	2.5	1661.50	1853.93	3.36	5.12
2001	513	40.7	Normal	1.74	0.43	153.86	2.5	668.67	167.00	1.30	4.10
2002	286	273	Deficit	1.09	5.62	153.86	2.5	418.81	2160.30	1.46	7.91
2003	256.7	138	Deficit	1.20	2.10	153.86	2.5	461.58	807.77	1.80	5.85
2004	365.5	333	Excess	2.53	3.17	153.86	2.5	971.47	1220.38	2.66	3.66
2005	210	711.6	Excess	0.82	5.96	153.86	2.5	316.58	2293.51	1.51	3.22
2006	365	524	Excess	1.05	3.70	153.86	2.5	403.86	1423.63	1.11	2.72
2007	167	495	Normal	0.80	1.86	153.86	2.5	306.00	715.49	1.83	1.45
2008	388	211	Normal	1.83	0.81	153.86	2.5	705.27	312.70	1.82	1.48
2009	193	181	Deficit	0.35	1.14	153.86	2.5	135.44	436.60	0.70	2.41
2010	148	326	Deficit	0.62	4.24	153.86	2.5	237.34	1630.92	1.60	5.00
2011	116	129	Deficit	0.80	1.10	153.86	2.5	307.72	423.12	2.65	3.28
2012	399	180	Deficit	1.58	4.07	153.86	2.5	609.38	1565.63	1.53	8.70
2013	357	140.3	Normal	2.02	0.79	153.86	2.5	775.13	302.51	2.17	2.16
2014	181	366	Normal	0.52	1.60	153.86	2.5	201.57	614.77	1.11	1.68
2015	352.9	436	Normal	1.24	1.94	153.86	2.5	478.57	747.56	1.36	1.71
2016	266	391.2	Normal	0.87	2.38	153.86	2.5	332.91	917.30	1.25	2.34
2017	268	296	Normal	1.36	5.69	153.86	2.5	523.26	2189.42	1.95	7.40
2018	244	334	Normal	1.29	3.07	153.86	2.5	496.50	1180.73	2.03	3.54
2019	186	444	Normal	0.61	2.71	153.86	2.5	232.79	1041.11	1.25	2.34
2020	112	252	Deficit	1.2	2.1	153.86	2.5	461.58	807.77	4.12	3.21

Study on seasonal recharge for different rainfall conditions

In India, watershed development works has been carried out from 1999 onwards. In order to study the impact of rain water harvesting structures in the watershed, the rainfall and recharge relationship was studied before and after implementation of watershed development activities. The Rainfall, water table depth of the successive month of the season was plotted and recharge was worked out for both monsoon period for Excess rainfall years (2000,2005), Normal years (1999,2013) and deficit rainfall years (2002,2012) as shown in **Figure 3** for Negamam region.

The analysis was done for Podanur regions for Excess years 2002 and 2012, Normal years 2000 and 2008, Deficit years 2001 and 2010.In general, the rainfall percentage contribution to recharge during deficit is more than normal and Excess year and the following trends of recharge rate are observed after 1999 (**Figure 4**). The recharge rate is increased during excess rainfall years due to watershed implementation programme. The rate is decreased during Deficit and normal year.

Similar studies were conducted for Sultanpet regions for different rainfall conditions (**Figure 5**) and found that the recharge rate is increased during excess rainfall years and decreased during normal rainfall years when compared to before and after 1999.

Table 2 Seasonal Recharge of Podanur Rain gauge station

year	Seasonal Rainfall in mm		Category	Average fluctuations in 'm'		Area	sp yield	Recharge volume in Mm^3		Recharge in percent	
	SW	NE		SW	NE	Sq.km		SW	NE	SW	NE
1999	184.4	101.4	Deficit	1.98	0.67	48.63	2.5	760.99	256.91	4.13	2.53
2000	165.5	360	Normal	1.81	3.74	48.63	2.5	694.87	1438.81	4.20	4.00
2001	69.6	337.6	Deficit	1.80	1.50	48.63	2.5	692.37	578.37	9.95	1.71
2002	203.6	316.4	Excess	1.06	2.47	48.63	2.5	408.07	949.53	2.00	3.00
2003	64.6	195.1	Deficit	0.61	3.57	48.63	2.5	233.37	1372.05	3.61	7.03
2004	184	267	Normal	2.52	1.33	48.63	2.5	967.69	511.25	5.26	1.91
2005	130	521.5	Excess	2.18	3.82	48.63	2.5	837.35	1468.38	6.44	2.82
2006	65	386	Normal	0.53	2.00	48.63	2.5	205.35	769.09	3.16	1.99
2007	54	428	Normal	1.07	1.07	48.63	2.5	410.66	412.57	7.60	0.96
2008	283.8	95	Normal	1.60	0.55	48.63	2.5	617.14	212.58	2.17	2.24
2009	99	313	Normal	0.51	1.44	48.63	2.5	196.79	555.44	1.99	1.77
2010	34	211.9	Deficit	0.36	1.29	48.63	2.5	137.41	494.84	4.04	2.34
2011	64.5	276.5	Normal	1.08	2.27	48.63	2.5	416.54	873.99	6.46	3.16
2012	232.5	365	Excess	2.69	5.46	48.63	2.5	1033.47	2099.75	4.45	5.75
2013	168.9	452.6	Excess	3.21	1.79	48.63	2.5	1235.05	687.76	7.31	1.52
2014	118.8	363.9	Excess	0.59	2.56	48.63	2.5	225.50	983.39	1.90	2.70
2015	194.3	444.8	Normal	1.92	1.79	48.63	2.5	739.67	688.17	3.81	1.55
2016	92.5	279.9	Normal	0.72	1.28	48.63	2.5	277.15	491.51	3.00	1.76
2017	107	274.4	Deficit	1.55	2.05	48.63	2.5	596.86	788.53	5.58	2.87
2018	115	415	Normal	0.58	3.47	48.63	2.5	223.10	1334.98	1.94	3.22
2019	129	499	Excess	1.20	2.10	48.63	2.5	461.58	807.77	3.58	1.62
2020	12	151	Deficit	0.09	1.40	48.63	2.5	34.62	538.51	2.88	3.57

Table 3 Seasonal Recharge of Sultanpet Rain gauge station

year	Seasonal Rainfall in mm		Category	Average fluctuations in 'm'		Area	sp yield	Recharge volume in Mm^3		Recharge in percent	
	SW	NE		SW	NE	Sq.km		SW	NE	SW	NE
1999	184.4	101.4	Deficit	1.98	0.67	87.33	2.5	760.99	256.91	4.13	2.53
2000	165.5	360	Normal	1.81	3.74	87.33	2.5	694.87	1438.81	4.20	4.00
2001	69.6	337.6	Normal	1.80	1.50	87.33	2.5	692.37	578.37	4.95	1.71
2002	203.6	316.4	Excess	1.06	2.47	87.33	2.5	408.07	949.53	2.00	3.00
2003	64.6	195.1	Deficit	0.61	3.57	87.33	2.5	233.37	1372.05	3.61	7.03
2004	184	267	Normal	2.52	1.33	87.33	2.5	967.69	511.25	5.26	1.91
2005	130	521.5	Excess	2.18	3.82	87.33	2.5	837.35	1468.38	6.44	2.82
2006	65	386	Normal	0.53	2.00	87.33	2.5	205.35	769.09	3.16	1.99
2007	54	428	Normal	1.07	1.07	87.33	2.5	410.66	412.57	7.60	0.96
2008	283.8	95	Normal	1.60	0.55	87.33	2.5	617.14	212.58	2.17	2.24
2009	99	313	Normal	0.51	1.44	87.33	2.5	196.79	555.44	1.99	1.77
2010	34	211.9	Deficit	0.36	1.29	87.33	2.5	137.41	494.84	4.04	2.34
2011	64.5	276.5	Normal	1.08	2.27	87.33	2.5	416.54	873.99	6.46	3.16
2012	232.5	365	Excess	2.69	5.46	87.33	2.5	1033.47	2099.75	4.45	5.75
2013	168.9	452.6	Excess	3.21	1.79	87.33	2.5	1235.05	687.76	7.31	1.52
2014	118.8	363.9	Normal	0.59	2.56	87.33	2.5	225.50	983.39	1.90	2.70
2015	194.3	444.8	Normal	1.92	1.79	87.33	2.5	739.67	688.17	3.81	1.55
2016	92.5	279.9	Deficit	0.72	1.28	87.33	2.5	277.15	491.51	3.00	1.76
2017	107	274.4	Normal	1.55	2.05	87.33	2.5	596.86	788.53	5.58	2.87
2018	115	415	Normal	0.58	3.47	87.33	2.5	223.10	1334.98	1.94	3.22
2019	129	499	Excess	1.90	3.14	87.33	2.5	730.84	1207.80	5.67	2.42
2020	38	220	Deficit	0.34	1.40	87.33	2.5	130.78	538.51	3.44	2.45

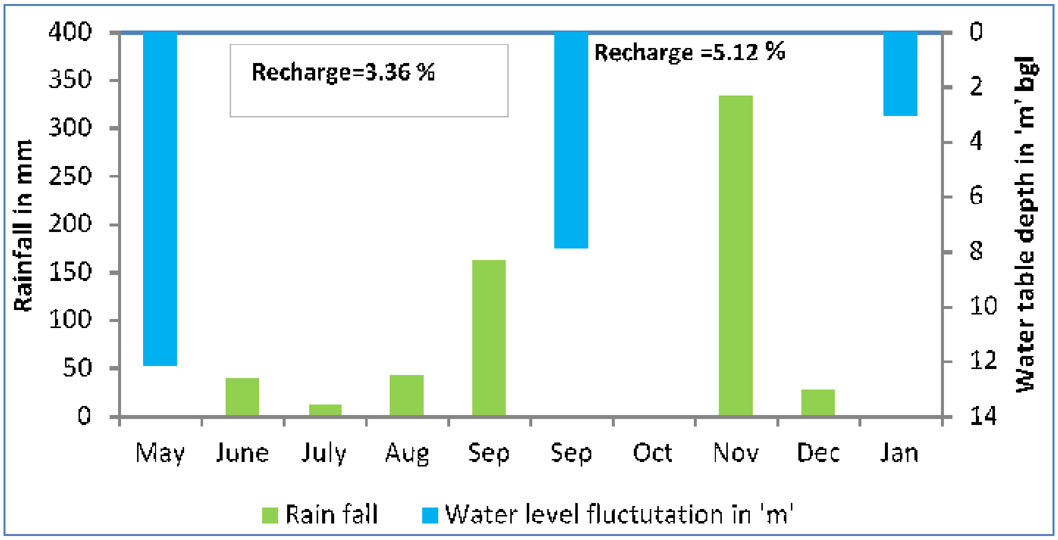

Figure 3a Rainfall and Water table depth of Excess year 2000-Negamam region

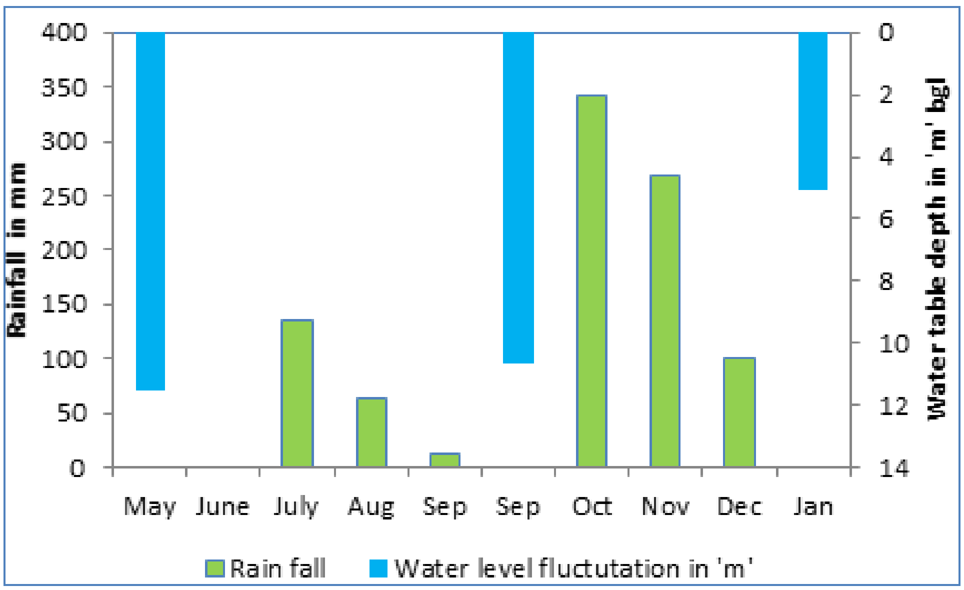

Figure 3b Rainfall and Water table depth of Excess year 2005-Negamam region

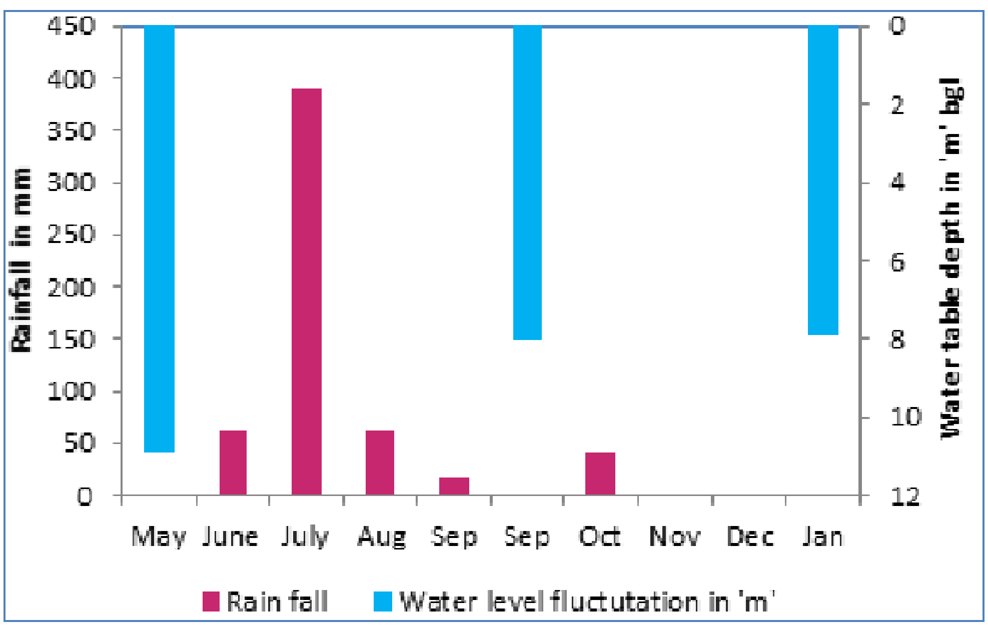

Figure 3c Rainfall and Water table depth of Normal year 1999-Negamam region

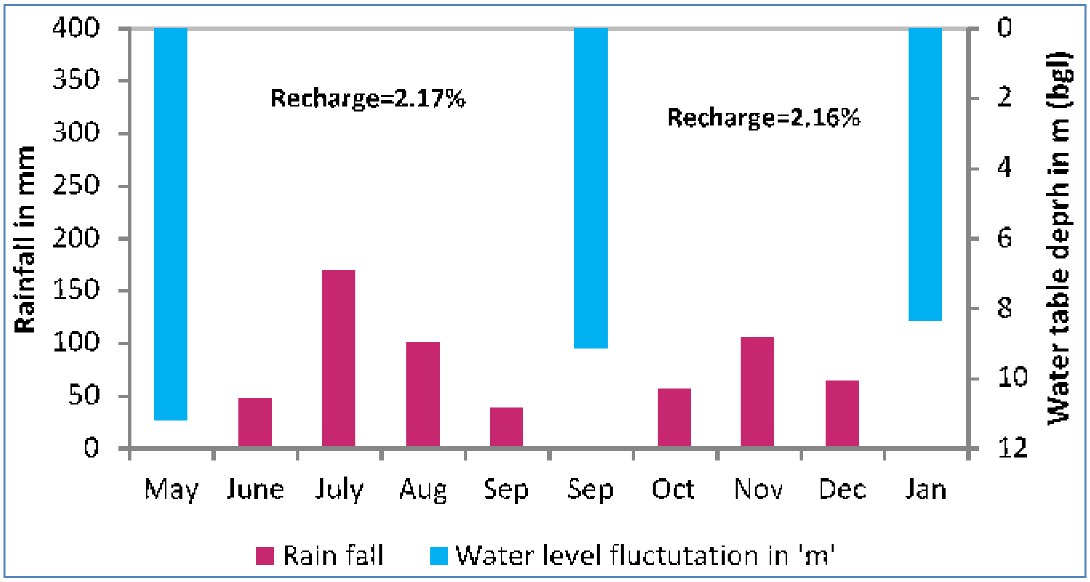

Figure 3d Rainfall and Water table depth of Normal year 2013-Negamam region

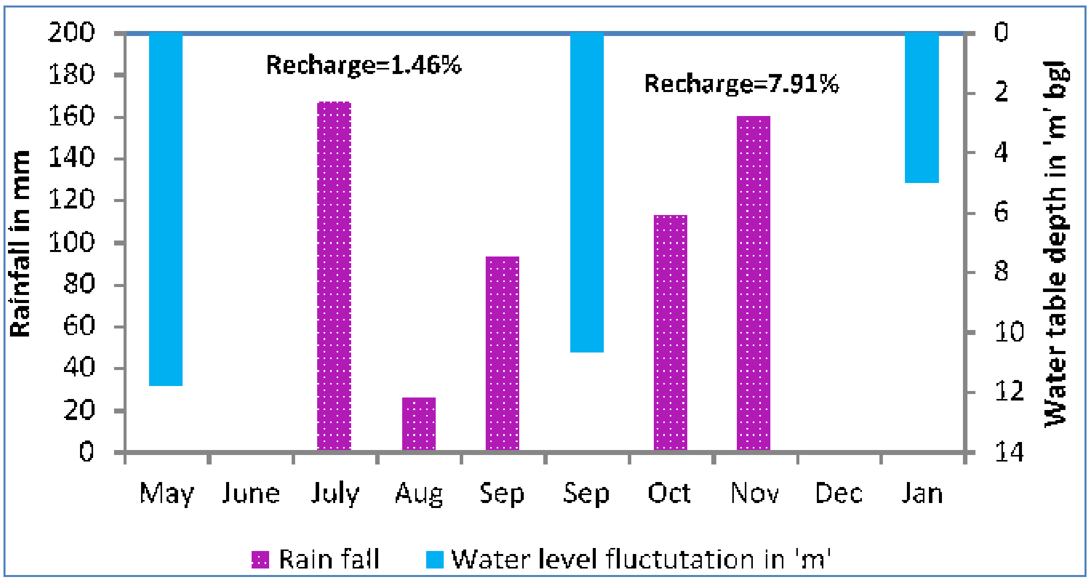

Figure 3e Rainfall and Water table depth of Deficit year 2002-Negamam region

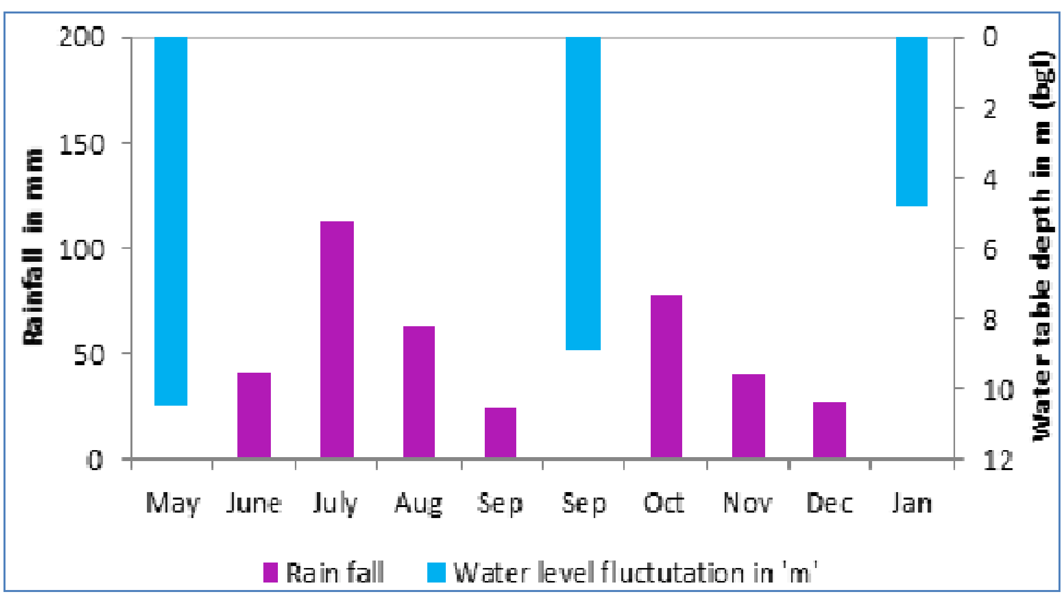

Figure 3f Rainfall and Water table depth of Deficit year 2012-Negamam region

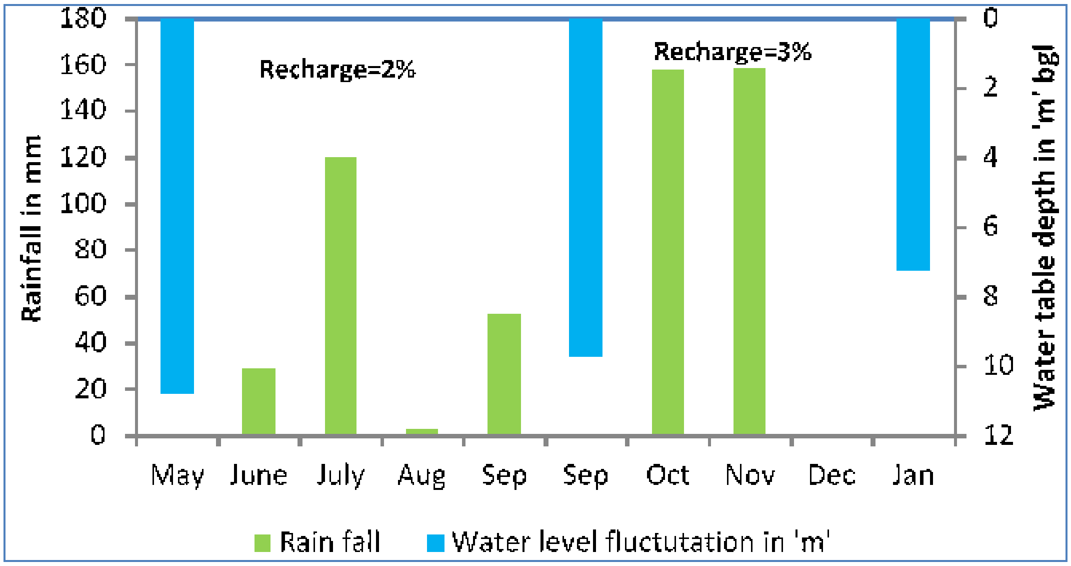

Figure 4a Rainfall and Water table depth of Excess year2002 –Podanur region

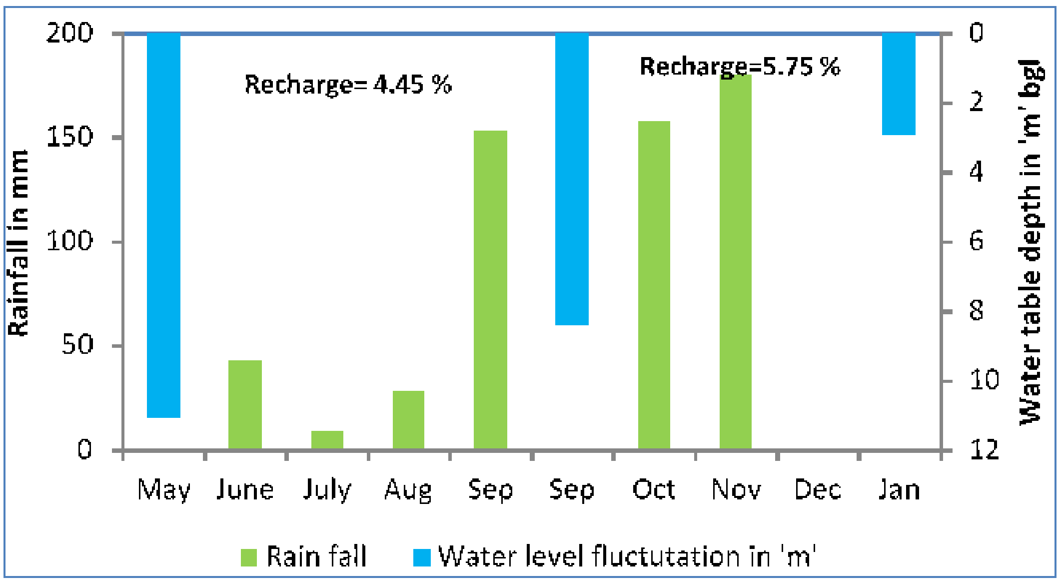

Figure 4b Rainfall and Water table depth of Excess year 2012 –Podanur region

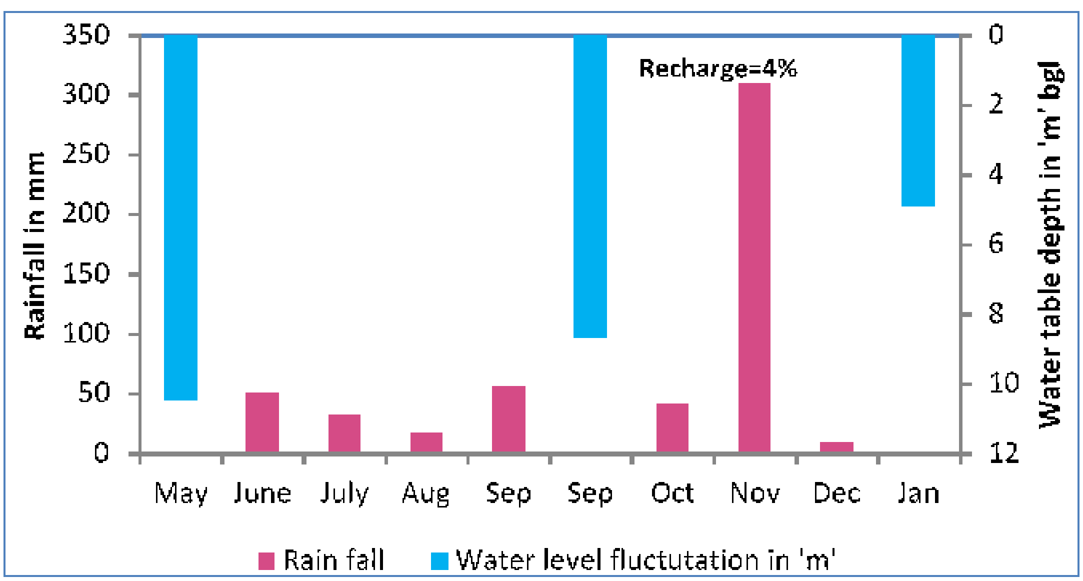

Figure 4c Rainfall and Water table depth of Normal year 2000 –Podanur region

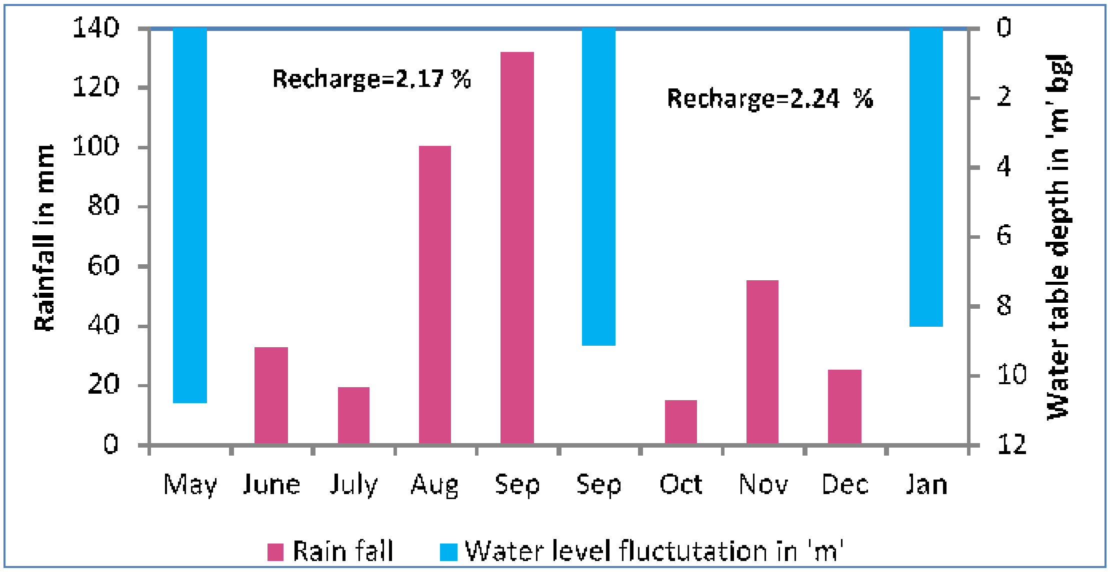

Figure 4d Rainfall and Water table depth of Normal year 2008 –Podanur region

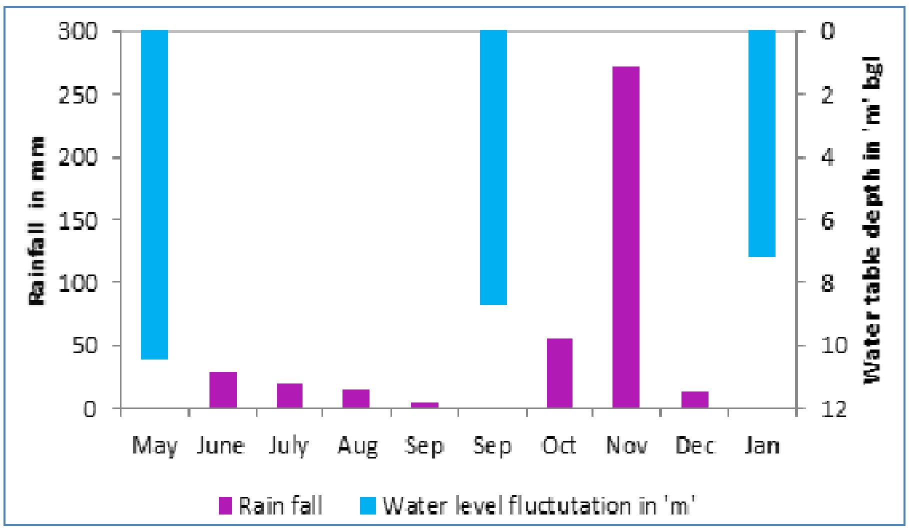

Figure 4e Rainfall and Water table depth of Deficit year 2001–Podanur region

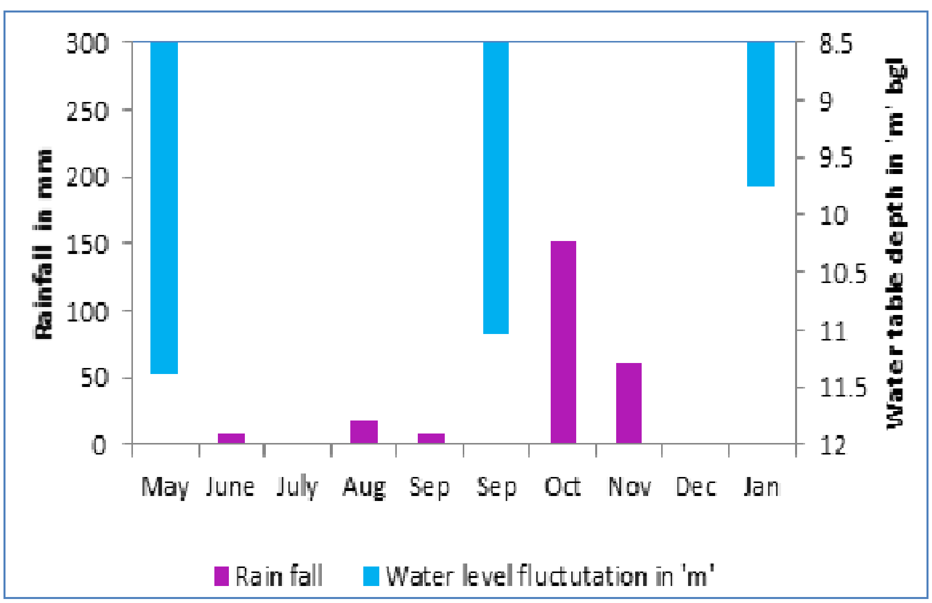

Figure 4f Rainfall and Water table depth of Deficit year 2010–Podanur region

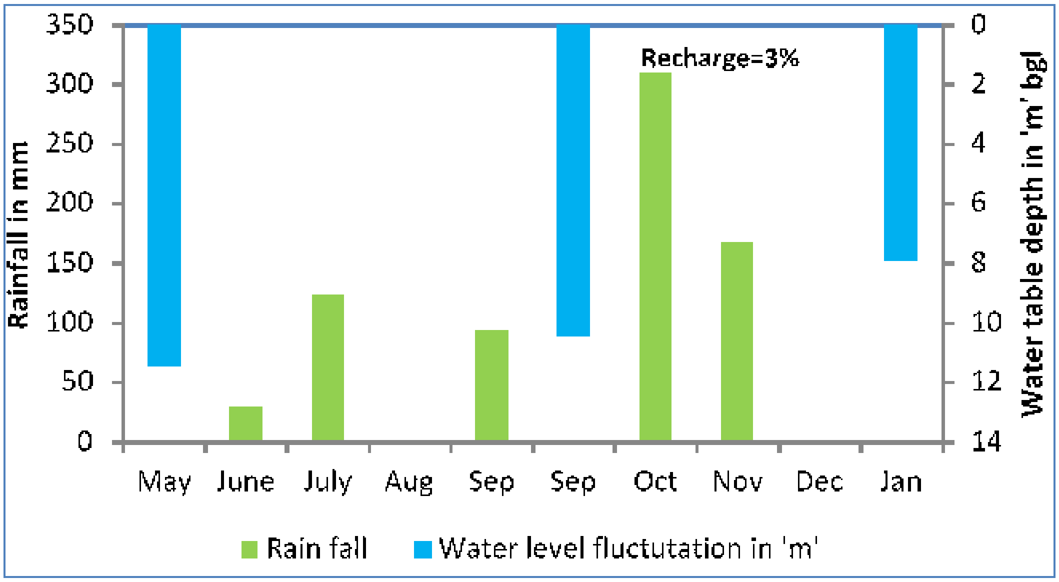

Figure 5a Rainfall and Water table depth of Excess year 2002–Sultanpet region

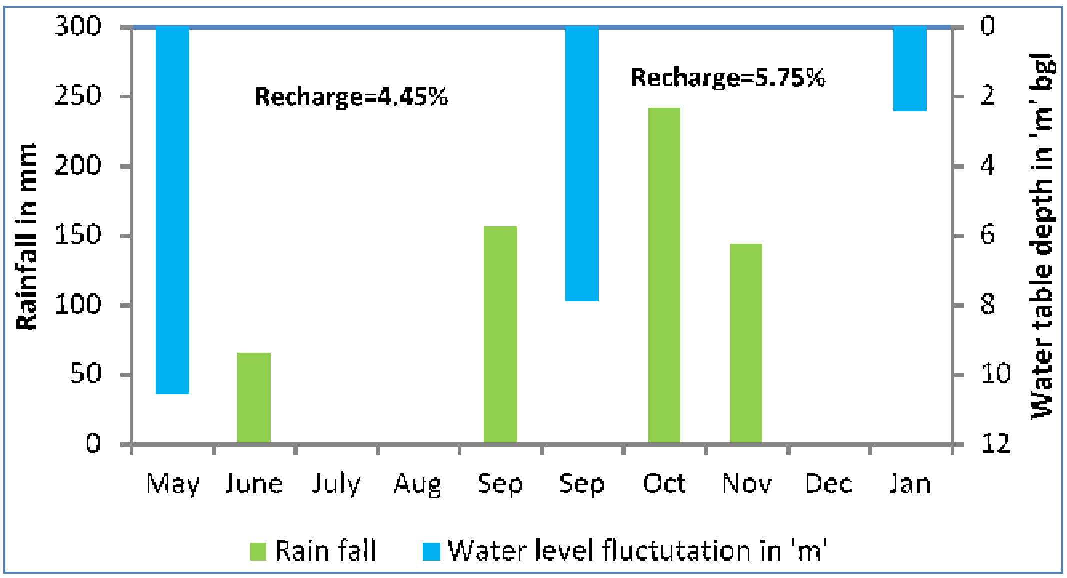

Figure 5b Rainfall and Water table depth of Excess year 2012–Sultanpet region

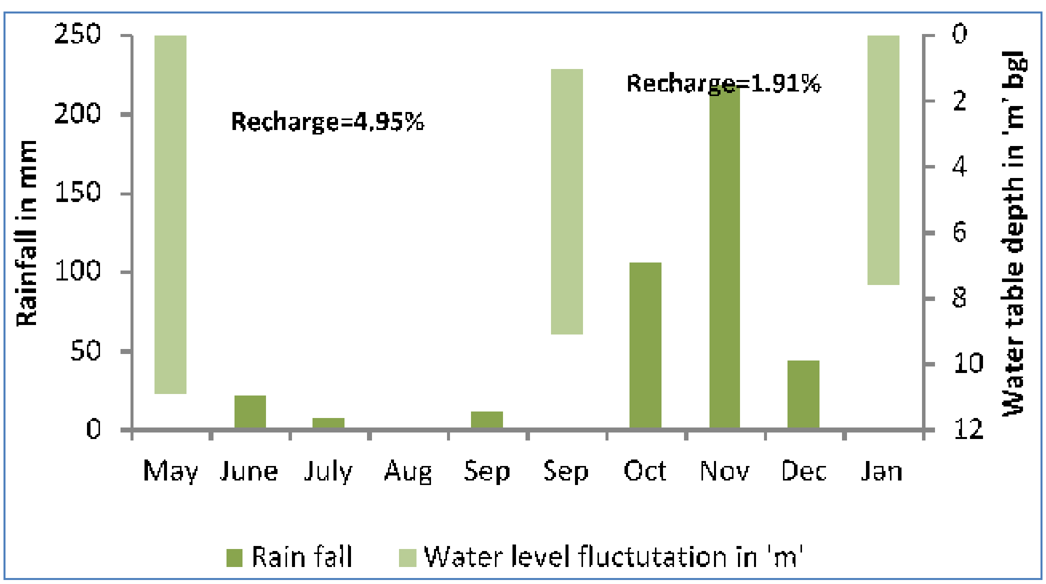

Figure 5c Rainfall and Water table depth of Normal year 2001–Sultanpet region

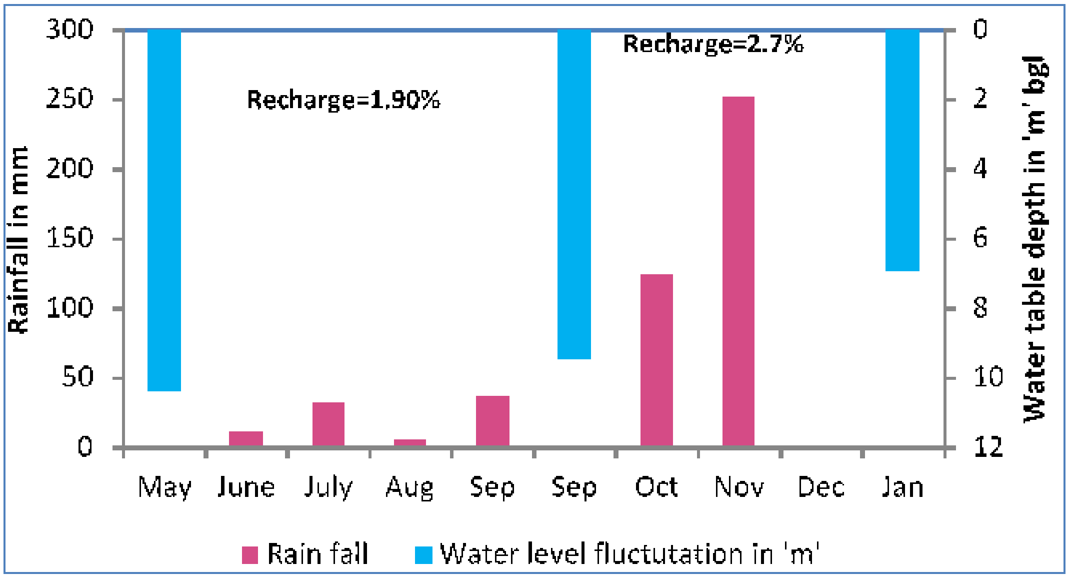

Figure 5d Rainfall and Water table depth of Normal year 2014–Sultanpet region

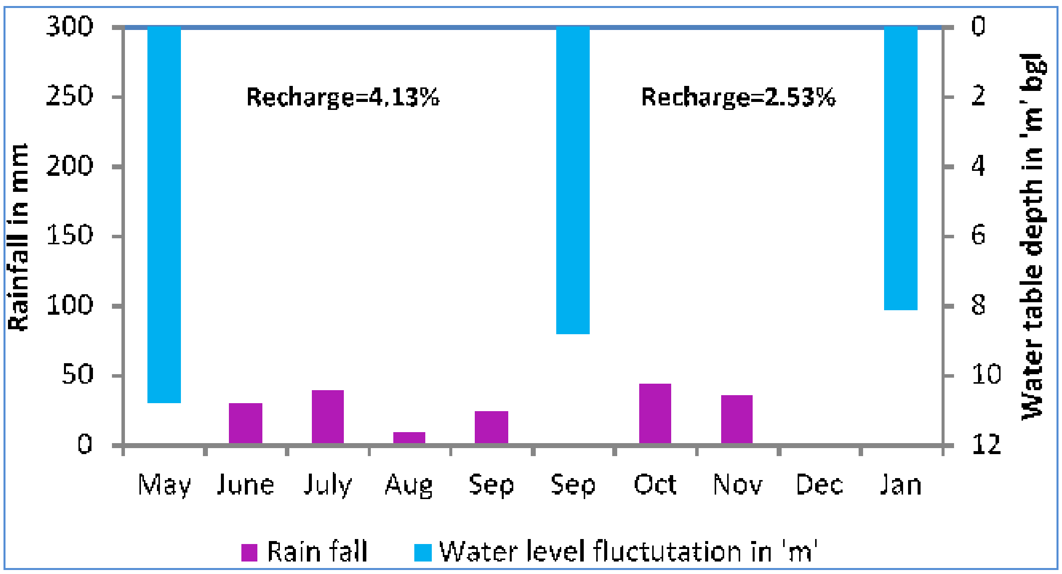

Figure 5e Rainfall and Water table depth of Deficit year 1999–Sultanpet region

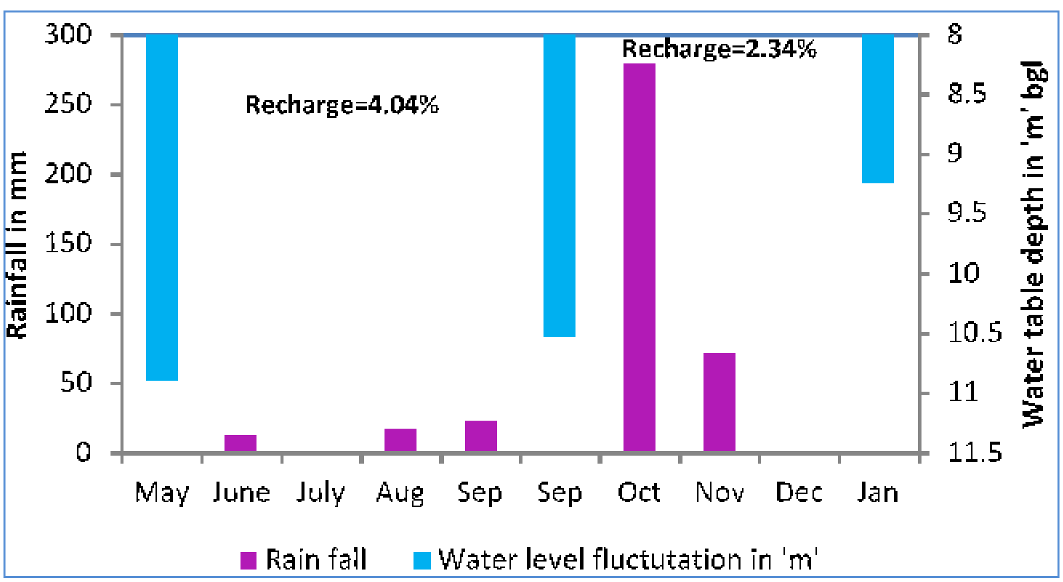

Figure 5f Rainfall and Water table depth of Deficit year 2010–Sultanpet region

Analysis of recharge pattern during continuous normal rainfall years

The recharge pattern of the study area was analyzed for continuous normal rainfall years for Negamam region from 1999 to 2020.The normal rainfall occurred continuously from 2013-2017 and it was found that the recharge rate slightly reduced in 2014 and gradually increased from 2013 to 2017 in both SW and NE monsoon. (**Figures 6** and **7**)

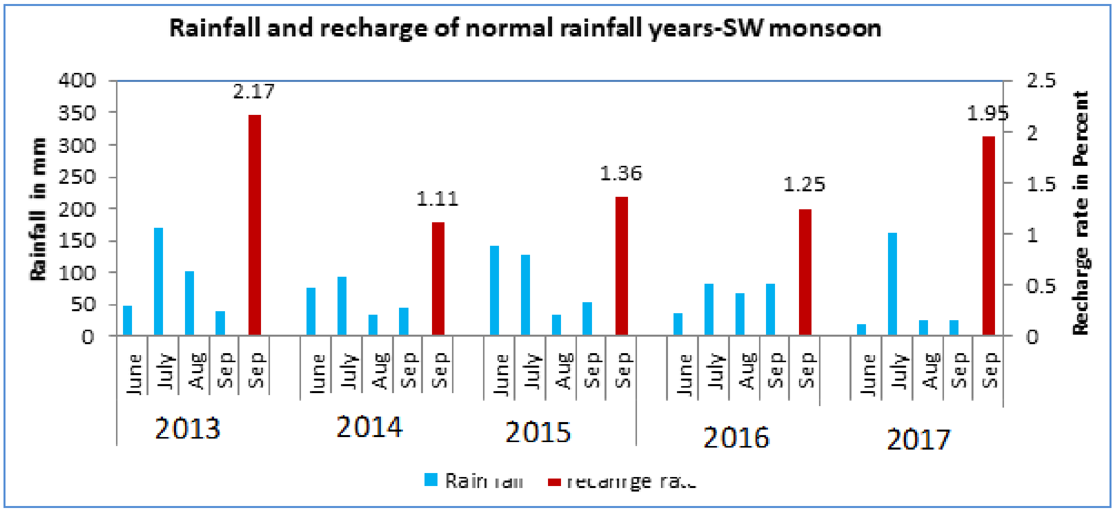

Figure 6 Rainfall and recharge of continuous normal rainfall years-SW monsoon-Negamam region

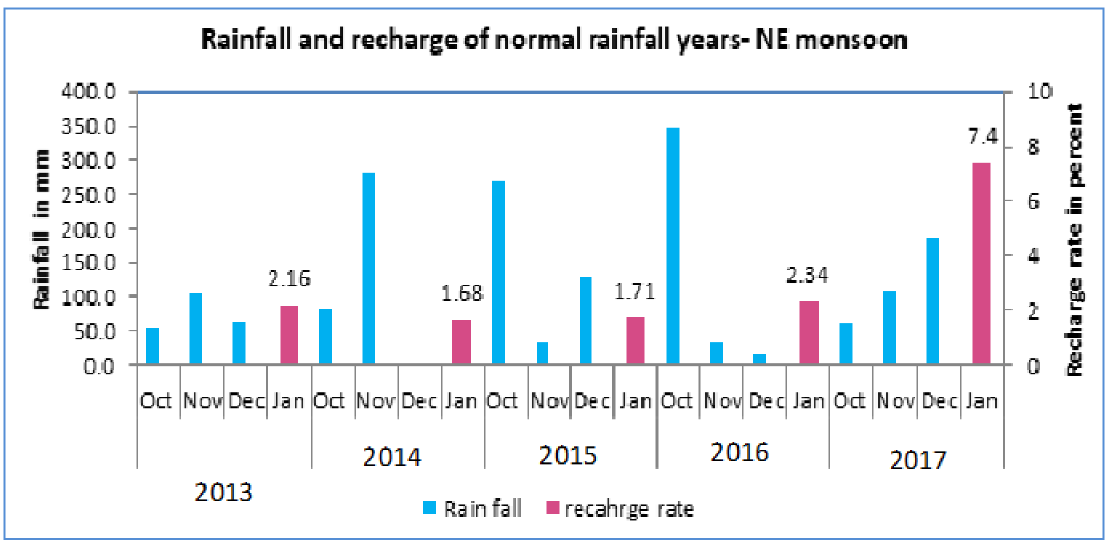

Figure 7 Rainfall and recharge of continuous normal rainfall years-NE monsoon-Negamam region

Conclusion

The recharge studies was carried out for the three rain gauge stations viz. Negaamam, Podanur and Sultanpet located in Kinathukadavu block of Walayar sub basin for normal, deficit and excess rainfall conditions. It is found the rainfall percentage contribution to recharge during deficit is more than normal and excess year. The recharge rate during contionous rainy years, slightly reduced in the first year gradually increased from second year in both SW and NE monsoon. The contribution of rainfall percentage to recharge is increased after implementation of watershed development programs

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Publication History	
Received	21.06.2022
Revised	30.08.2022
Accepted	02.09.2022
Online	30.09.2022