Kavipriya S, 2022, 10:1
ISSN (Online): 2348-4098
ISSN (Print): 2395-4752

International Journal of Science, Engineering and Technology

An Open Access Journal

Groundwater Resources Assessment in Lower Ponnaiyar Sub-Watershed, Tamilnadu, India

Kavipriya S, Sanjeevi A, Riyaz S, Gowrishankar G
Department of Civil Engineering
Kongunadu College of Engineering and Technology (Autonomous), Thottiam, Trichy, Tamilnadu-621215

Abstract- The increase in agricultural production, urbanization and rapid growth of population has led to fresh water shortage in several parts of the Cuddalore and Villupuram districts. Therefore making of quantitative estimation of the available groundwater resources is imperative in these districts. In this study, the Lower Ponnaiyar Sub-watershed is considered as a study area for evaluation of groundwater resources using Groundwater Estimation Committee - 1997 (GEC-1997). The various factors are involved in groundwater resource estimation such as recharge from rainfall, recharge from other sources and groundwater draft in both monsoon seasons. The groundwater utilization is estimated based on the Water Table Fluctuation (WTF) in the monsoon season and by rainfall infiltration factor method (RIF) in the non-monsoon season. The Results showed that the categorization of blocks in the study area such as Safe (Mugaiyur, T.V. Nallur, Annagramam and Bahour), Critical (Kandamangalam) and Over Exploited (Kanai, Kolianur and Cuddalore). This study was suggested; for implementation of appropriate management practices which would be improve the groundwater resources of the study area.

Keywords- Groundwater, Groundwater Resources, Rainfall, Groundwater draft

I. INTRODUCTION

Groundwater plays a key role in meeting the water needs of various user sectors in India. Groundwater provides an additional water supply when there is inadequate precipitation against droughts. Even though Groundwater separated from the land's surface by thousands of feet but still subject to pollution and excessive withdrawals, owing to which, it should be sheltered and altered.

Study area

The Lower Ponnaiyar watershed is considered as study area which is lies between 79º 15′ 13″ to 79º 48′ 28″ E longitudes and 11º 50′ 18″ to 11º 55′ 18″ N latitudes (figure 1). The total area is about 598.162 km2 and it covers five taluks with a general elevation of 81.25 m above MSL. Water flows in the river during Southwest and the Northeast monsoons in Tamilnadu.

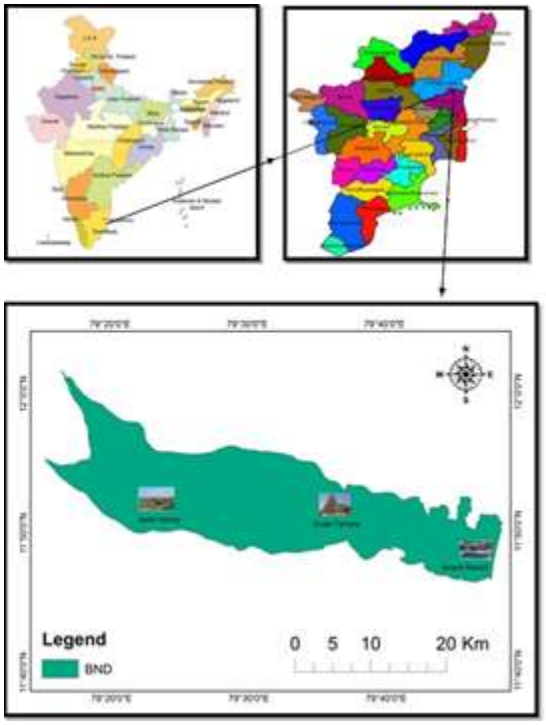

Figure 1 Location map of the study area

II. METHODOLOGY

Required data:

- Area of the study area (Sq.km)
- Suitable area for groundwater recharge (Sq.km)
- Normal rainfall (mm)
- Normal monsoon rainfall (mm)
- Normal non-monsoon rainfall (mm)
- Average Annual rainfall (mm)
- Groundwater draft utilizing the well census data
- Rainfall infiltration factor
- Groundwater level data (both Monsoon and Non-monsoon seasons)
- Paddy cultivated area during monsoon period through surface water
- Non-monsoon paddy cultivated area and Non - Paddy area

Groundwater Recharge from Rainfall (Rr)

The rainfall-infiltration and water-level fluctuation methods are used for estimation of recharge from rainfall. Rainfall data of Lower Ponnaiyar sub-watershed is collected from the four raingauge stations surrounding the study area namely Cuddalore, Panruti, Thirukoilur anicut and Villupuram for a period of 30 years (1983 to 2013). The annual average rainfall obtained from four raingauge stations is 1126 mm by Thiessen polygon method. The normal monsoon rainfall of influencing stations is 1026.34 mm. The normal non-monsoon rainfall is 110.57 mm. The monthly water level data also were taken for groundwater assessment which is collected from 7 observation wells in the study area. The Thiessen polygon map of observation wells is prepared using ArcGIS 10.1 for well numbers CGWB01, CGWB02, OW11404, U33026, HP31562, HP31577 and HP31572. The trend lines are drawn based on monthly water level fluctuations over a 15 years period (2000-2015). Based on the geology, total area is divided into 8 units for more analysis. From that, the respective computation of distributed rainfall recharge for each unit for both seasons are calculated and summed for the quantitative assessment

Water Level Fluctuation Method

This method is used for recharge assessment in the monsoon season. For non-command areas, the recharge in the non-monsoon season is a small component and estimated empirically, as described subsequently. The specific yield is estimated based on the GEC norms for the particular hydrological area and this value used in groundwater balance equation.

Table 1 Recharge Specification of the Study Area

S. No	Unit	h (m)	Specific yield	Area in Sq.km
1	Mugaiyur	3.38	0.20	50.39
2	Kanai	2.44	0.18	20.82
3	T.V. Nallur	1.65	0.17	126.65
4	Koliarur	1.99	0.16	110.18
5	Kandamangalam	1.81	0.16	95.91
6	Annagramam	2.06	0.15	64.15
7	Cuddalore	3.54	0.14	58.37
8	Bahour	3.18	0.12	71.65

Rainfall Infiltration Factor (RIF) Method

The non-monsoon rainfall is more than 10% of normal annual rainfall of the study area, the rainfall infiltration factor suggested by GEC-1997 is considered for computation of non-monsoon (January to May) recharge along with the monsoon recharge as a whole without separately considering command and non-command areas. For this study, the mean rainfall over 30 years (1983-2013) is taken as normal rainfall. The rock type of the study area is delineated and the corresponding percentage of rainfall recharge factor is applied to compute the normal non-monsoon rainfall recharge for the watershed. As per the GEC norms, the weighted rainfall infiltration factor for the study area is varied from 0.12 to 0.15.

Table 2 Distributed Rainfall Recharge using Rainfall Infiltration Method

S. No	Unit	Area in Sq.km	Rainfall Infiltration Factor	Monsoon (MCM)	Non-Monsoon (MCM)
1	Mugaiyur	50.39	0.13	5.98	0.62
2	Kanai	20.82	0.13	2.52	0.24
3	T.V. Nallur	126.65	0.12	14.22	1.40
4	Koliarur	110.18	0.14	14.52	1.38
5	Kandamangalam	95.91	0.15	15.70	1.76
6	Annagramam	64.15	0.14	9.54	1.04
7	Cuddalore	58.37	0.12	8.42	1.03
8	Bahour	71.65	0.13	10.83	1.29

Recharge from Field Irrigation (Rirr)

In the irrigation field, part of the applied water lost in consumptive use and balance is infiltrated

through the soil to recharge the groundwater. The percentage of return flow is estimated based on the type of crop (paddy, non-paddy) as per GEC recommendations.

Table 3 Distributed Groundwater Recharge from Field Irrigation

S. No	Block	Paddy		Non-paddy	
		Monsoon (MCM)	Non-Monsoon (MCM)	Monsoon (MCM)	Non-Monsoon (MCM)
1	Mugaiyur	5.14	1.28	0.94	3.79
2	Kanai	2.41	0.60	0.44	1.78
3	T.V. Nallur	15.29	3.82	2.81	11.26
4	Koliarur	13.98	3.49	2.57	10.30
5	Kandamangalam	11.54	2.88	1.64	6.56
6	Annagramam	7.72	1.93	1.09	4.38
7	Cuddalore	6.53	1.63	0.92	3.71
8	Bahour	7.38	1.84	1.04	4.19

Table 4 Distributed Surface water Recharge from Field Irrigation

S. No	Block	Paddy		Non-paddy	
		Monsoon (MCM)	Non-Monsoon (MCM)	Monsoon (MCM)	Non-Monsoon (MCM)
1	Mugaiyur	2.94	0.73	0.58	2.34
2	Kanai	0.89	0.22	0.17	0.71
3	T.V. Nallur	4.79	1.19	0.95	3.81
4	Koliarur	3.41	0.85	0.67	2.71
5	Kandamangalam	0	0	0	0
6	Annagramam	0	0	0	0
7	Cuddalore	0.56	0.14	0.09	0.37
8	Bahour	1.41	0.35	0.23	0.93

Recharge from Water bodies (Rwb)

In this study the recharge from storage tanks and ponds is taken as 1.4 mm /day for the period in which tank has water and the maximum water spread area is considered as 60% instead of the average area of water spread.

The availability of water is approximately taken as 150 days from August to December and dry season is considered as 90 days (January-march) from the frequent field survey. The distributed recharge from the water bodies in both seasons of the study area is depicted in Table 5.

Table 5 Distributed Recharge from water bodies

S. No	Block	Area in Sq.km	Seepage Factor	Monsoon (MCM)	Non-monsoon (MCM)
1	Mugaiyur	50.39	0.0014	1.22	0.73
2	Kanai	20.82	0.0014	0.54	0.32
3	T.V. Nallur	126.65	0.0014	5.33	3.20
4	Koliarur	110.18	0.0014	4.47	2.68
5	Kandamangalam	95.91	0.0014	1.92	1.15
6	Annagramam	64.15	0.0014	2.01	1.20
7	Cuddalore	58.37	0.0014	0.95	0.57
8	Bahour	71.65	0.0014	1.17	0.70

Groundwater Draft

Groundwater draft is the extraction of water from the groundwater for all uses. As per the GEC norms the computation, the domestic draft is based on the population data. So, the population data for 2011 is collected from the census Department, Collectorate Office of Cuddalore and Villupuram Districts. The draft due to irrigation also identified depends on the number of wells in the study area which are used for irrigation purposes. The Gross draft is derived from the population data and irrigation, which is used for calculation of the recharge.

Domestic Draft

According to 2011 census, the total population in the study area is 5,90,551. The population growth rate is estimated as 8 %. The Present population is 6,40,551 as per growth rate. The per capita demand is considered as 135 lpcd. The draft is calculated using the following relationship

For Monsoon season= Population x Demand per person x 210

For Non - monsoon season= Population x Demand per person x 155

Table 6 Domestic Draft

S. No	Block	Population	No. of days		Monsoon (MCM)	Non-Monsoon (MCM)
			Monsoon	Non-Monsoon		
1	Mugaiyur	50406	210	155	1.42	1.05
2	Kanai	21329	210	155	0.60	0.44
3	T.V. Nallur	245117	210	155	6.94	5.12
4	Koliarur	101790	210	155	2.88	2.12
5	Kandamangalam	73736	210	155	2.09	1.54
6	Annagramam	64977	210	155	1.84	1.35
7	Cuddalore	83196	210	155	2.35	1.74
8	Bahour	10927	210	155	0.30	0.22

Irrigation Draft

Irrigation draft is estimated for the monsoon and non-monsoon period separately and it is based on the type of well and unit draft. In the study area, approximately, 14,400 wells are used for irrigation

purposes. The groundwater withdrawal for irrigation purposes is given as 0.4 ha.m to 1 ha.m for wells. A sample survey conducted by the Electricity Board of the Government of Tamilnadu has concluded that 60% of the annual draft for irrigation takes place during the monsoon and it has been 40% during the non-monsoon (CGWB 2006). Irrigation draft is calculated using following relationships

For Monsoon season=Number of wells x unit draft x 0.6

For Non - Monsoon season = Number of wells x unit draft x 0.4

Table 7 Irrigation Draft

S. No	Block	Wells	Unit draft	Monsoon (MCM)	Non-Monsoon (MCM)
1	Mugaiyur	2100	0.010	12.60	8.40
2	Kanai	530	0.010	3.18	2.12
3	T.V. Nallur	3500	0.010	21.00	14.00
4	Kolianur	2300	0.018	13.80	9.20
5	Kandamangalam	2500	0.010	15.00	10.00
6	Annagramam	1750	0.010	10.50	7.00
7	Cuddalore	1800	0.018	10.80	7.20
8	Bahour	1200	0.015	7.20	4.80

The total recharge is computed separately for both seasons from the rainfall recharge, other sources of recharge and total groundwater draft.

Results and Discussion

This study would be useful for the overall development of Lower Ponnaiyar watershed on a sustainable basis. The following procedure is adopted for categorization of groundwater development.

Computation of Groundwater Balance

An annual utilizable groundwater resource is 85% of total annual groundwater resources.

The total annual groundwater recharge for the Basin = 490.09 MCM

Annual utilizable groundwater resources = 416.57 MCM

Groundwater Balance (490.09 MCM - 416.57 = 73.52 MCM

Estimation of Stage of Groundwater Development

S. No	Stage of Groundwater Development	Categorization
1	< 70%	Safe
2	70–90%	Semi-Critical
3	90-100%	Critical
4	> 100%	Over Exploited

The groundwater assessment unit is categorized into different categories such as Safe, Semi-Critical, Critical and Over Exploited. Criteria for categorization is presented in Table 8

Table 8 Criteria for categorization

The Category of Lower Ponnaiyar sub-watershed is evaluated by following the methodology suggested by GEC.

Stage of Groundwater Development

The stage of groundwater development is calculated using the equation which is expressed as:

Groundwater development=Net groundwater availability / Total draft

Table 9 The categorization of stage of groundwater development of the study area

Block	Monsoon (MCM)	Non Monsoon (MCM)	Total (MCM)	Net Groundwater availability (MCM)	Domestic draft (MCM)	Irrigation draft (MCM)	Total draft (MCM)	Stage of Development (%)	Status
Mugaiyur	44.38	9.52	53.90	45.82	2.51	21.00	23.51	51.31	Safe
Kanai	20.23	3.89	24.13	20.51	1.06	20.05	21.11	102.95	Over - exploited
T.V. Nallur	60.45	24.70	85.16	72.38	12.20	35.00	47.20	65.21	Safe
Kolianur	82.66	21.44	104.10	88.48	5.07	83.92	88.98	100.57	Over-exploited
Kandamangalam	55.42	12.37	67.79	57.62	3.67	50.85	54.52	94.62	Critical
Annagramam	30.05	8.57	38.62	32.83	3.23	17.50	20.73	63.16	Safe
Cuddalore	57.70	7.47	65.18	55.40	4.14	54.00	58.14	104.95	Over-exploited
Bahour	41.87	9.34	51.21	43.53	0.54	30.00	30.54	70.17	Safe

III. CONCLUSIONS

As per the GEC-Norms, the stage of groundwater development for Mugaiyur, T.V. Nallur, Annagramam and Bahour blocks are worked out to 51.31%, 65.21 %, 63.16 % and 70.17 % respectively and these were falling in the Safe category. But the block Kandamangalam worked out to 94.62 % and falling in the Critical category. Kanai, Kolianur and Cuddalore are worked out to 102.95 %, 100.57 % and 104.95 % respectively and these blocks are falling in under Over-exploited. It is recommended that there should not be any planning and further groundwater development as unless otherwise proper conservation of groundwater resources.

REFERENCES

1. CGWB (1997) , Groundwater estimation methodology, Central Ground Water Board, Ministry of Water Resources, Govt. of India
2. CGWB Technical Report (2008), District groundwater brochure, Chennai district, Tamil Nadu, pp. 1–19.
3. CWGB (2009), Government of India Ministry of Water Resources, South Eastern Coastal Region, Chennai
4. Dineshkumar, M and Singh, O.P (2016), How Serious Are Groundwater Over-Exploitation Problems In India? A Fresh Investigation Into An Old Issue , Research gate article, pp.298-317
5. Jayanta Debbarman, Pankaj Kumar Roy and Asis Mazumdar (2013),Assessment of Dynamic Groundwater Potential of Agartala Municipality Area, International Journal of Emerging Trends in Engineering and Development, Vol. 1, pp.220-231
6. Kumar, C. P. (2016) , Article on Assessment of Groundwater Potential, pp. 1 -15 ..
7. Pradeepkumar, G.N. and Srinivas, P (2009), Estimation of Groundwater Resources in a Basin — A Case Study, IGC 2009, Guntur, India.
8. Public Works Department (2002), Ground Water Resources of Tamil Nadu, Government of Tamil Nadu.
9. PWD Report (1994), Groundwater resources of Tamilnadu present status of development. A publication with the assistance of government of Tamilnadu, public works department (PWD), groundwater, Chennai-5