ARTIFICIAL RECHARGING OF GROUNDWATER BY RAINWATER HARVESTING

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Abstract-

Water is considered as never-ending free source which are obtained naturally. Its necessities and demanding supply increases due to growth in population rate. Shortage of water during hot summer and dry weather is major issue in country as we all are familiar with that the amount of precipitation is small and also there is small magnitude of rainfall which falls. Groundwater is major resource of water, that is why the quantity and quality of water is becoming short Sustainable utilization of fresh water could maintain equilibrium state of its demand and supply. Rainwater harvesting (RHS) is traditional and beneficial which can fulfill the basic requirement of residential and commercial buildings. Its practice can surely reduce the pressure and improve the living standards among the creatures. This paper ensures the sustainability and adequate consumption of the Rainwater harvesting (RWH) through assessing several water quality parameters of rainwater.

Keywords:

Percolation wells, Aquifer, Ground water recharge, artificial recharge.

1. INTRODUCTION

The water term refers the sustainable life, Almost water covers 70% of earth's surface, the earth is a watery place, about 71% of earth's surface is enclosed with water, the oceans holds about 97.5% of all earth's water which is saline in nature which is not fit for drinking purpose, water also exists in the atmosphere as water vapors, icecaps, glaciers, aquifers, and many more. it is clear that fresh water through renewable is in limited resource, reports revealed that 768 million people worldwide lack access to potable and fresh water, which may go often water scarcity whereas 1.8 billion people are predicted can observed water scarcity by 2025. All this shortcoming may come are due to insufficient management and planning of water resource. Water provides survival to all ecosystems which is reliant on the water has both physiochemical properties which make it essential to life.

Water are available in different forms in nature, its formation can be seen in atmospheric water which includes moisture contained in clouds which precipitate in the form of rain and snow, snow and rain are the primary source of drinking water.

To conserve and maintain balance in water bodies for preservation and for future use, we must take some initiatives to save water. India has a long tradition of water harvesting due to lack of economic, political, physical factors which have cause water deterioration. (Agarwal and Narian [1].

In this paper I am providing light on rainwater harvesting, According to kim et al. [2] rainwater harvesting is the method available to recovering the natural hydrological cycle and enabling urban development. By performing the rainwater harvesting it can decrease Pressure on the distribution and on supply system and can perform needs of community by serving fresh water. In this Due to limited supply of water it is having urgency to acquire self-sufficiency for satisfaction of water needs. Urban water supply has been created a great stress for being the source of water for multiplying population. Groundwater is getting contaminated and devastated. Soil erosion has been the result of uncontrolled runoff. The update of contaminated water has been the result of the various health issues. Rainwater is the cheap source of water and is having high degree of purity. Rainwater has great application for fascinating plants because it's devoid of chlorination. It is good source of ground water and municipal water. It is the cheapest source as it reduces the water supply cost. It can bestow the excellent backup resource there is requirement of inexpensive technologies which responsible for reduce the chances of flood like disasters and soil erosions. Rainwater harvesting system is mostly used method (discussing in paper) we are doing practice on where the there is adequate rainfall and minimum source of water by examining several factors and parameters.

Water harvesting in India has boomed during the past two decades in two different ways from traditionally techniques large system like hydro system, water distribution system, and urban water supply may help to minimize pressure on it. The limited Indian study on rainwater harvesting (RWH) unnaturally harvesting has focused on engineering recital of individual structure. (Muralidhram and Athawale, [3].

in the areas facing erratic water supplies because of its softness it is used for cleaning purpose resulting in decreases use of detergents. In brief there are in numerable benefits of rainwater harvesting system which cannot be elucidated at all.

2. RELATED WORK

2.1 Rainwater Harvesting Across The World

Kahinda *et al.*[4] described as the rainwater is basically collection and after collection it must be stored then can be used for small scale industrial purpose.

Oweis [5] as the amount of rainwater which is collected by runoff is valuable use for small areas.

Imroatul C. Juliana et. al. [6] Studied about the sustainability of environment to maintain ecological balance and prove conservation of water by saving the natural resources. Due to urbanization the demands of water requirements didn't meets the supply of water. Shifting from rural areas to urban areas the distribution surpass the heavy pressure on water distribution centers and also pressure on resources as well, the water can be conserved and preserved when it is used optimally utilized even one of the potential water resource that is often overlooked is the rain it is noted that the potential rainfall is often waste although it can be used for clean water, rainwater harvesting is the concept in which whole ecological system become sustainable.

Conway and Schipper [7] According to him unsuitability of rainfall over areas/regions has led extremely negative effect in the agricultural fields. By the uneven rains in the regions maximum portion of crops are not well grown and also affected by diseases indirectly speaking it will effect on the economics of the country.

Tasisa Temesge Tolossa [9] Studied about the Rainwater harvesting technology practices and implication of climate change characteristics. It is said that the adopting the rainwater harvesting can improve agricultural production and can fights against drought. The RWH can be easily practiced as runoff irrigation that is runoff farming, flood spreading (spate irrigation), in-situ water harvesting and roof top harvesting. It proved cost beneficial techniques over the irrigation systems and irrigation projects a less amount of economy is funded to setup the rain water harvesting project. Therefore, an assessment could assist in identifying constraints for future strategies that address water scarcity and consequently food security issues at household and national levels.

Aditya Morey et., al. [8] Studied about the rainwater harvesting in his work it is said the rainwater harvesting the technique or process of collection of rainwater from land area to the rain falling after that the collected water is filtered and stored and can be utilized in several purposes. Rainwater harvesting can help in bringing supply of water in same levels. It is also collection of water from the surfaces that is like rain. By adopting the water resource techniques there can be reduces pressure on water distribution system as well it save s the electricity consumption also.

Mati *et al.* [10] defined Rainwater Harvesting is defined if the process of collecting rainwater from surface know as catchment and it is stored in manmade structure or in soil profile.

The demand of rainwater water harvest is increasingly day by day, the practices is coming from ancient times, Drought, pollution and increase in population lead increase its requirement. (Nolde; Meera and Ahameed [11].

Runoff may be harvested from roofs and ground surfaces as well as from irregular or temporary watercourses and thus water harvesting can be sub divided into two extensive categories: Water harvesting techniques which harvest runoff from roofs or ground surfaces termed RWH and all systems which collect discharges from water courses termed as flood water harvesting Critchley*et al.* [12].

Figure-1: Average Annual Rainfall in India

3. METHODOLOGY

3.1 Methods of Rainwater Harvesting

Rainwater can be stored for direct use on above ground or underground sumps/overhead tanks and used directly for flushing, gardening and other activities. Rainwater can be collected through percolations wells, soak pits, bore wells, trenches etc.

3.2 Description of Study Area:-

District Vellore in Tamil Nadu which is located at **12.2°N 79.13°E** 220metre above sea level shown in figure 2. The climate in the district is semi arid climate. Vellore is 135 km far from Tamilnadu, Vellore is situated in the Eastern Ghats region and along paler river basin. The topography of the area is almost plain with slopes from west to east.

Vellore falls in tropical savanna climate (Koppen climate classification). The Vellore district is mostly known for high temperature zone even it is considered as hottest district in Tamil Nadu. It is surrounded by Rocky Mountains which effect the heat radiation to the area. The temperature of Vellore ranges from 13 °C (55 °F) to 39.4 °C (102.9 °F). Likely the months mid of year are considered hottest month in the whole year which are April to June are considered hottest month while as the coldest months in which the temperature falls in the months of December to January.

In every year Vellore receives rainfall of the amount of 1,034.1mm (40.71in). The southwestern monsoon which starts from June to September brings 517.1mm amount of rainfall in which the month of September is considered most rainiest month. While in the northern monsoon which lasts from October to December brings rainfall amount of rarely low as compared to Southern monsoon which is estimated as 388.4 mm of rainfall. The humidity in the area varies from 40%-63% during summer time and in winter time the percentage is likely to be more because of dewdrops present in the atmosphere during winter season which varies from 67%-86%.

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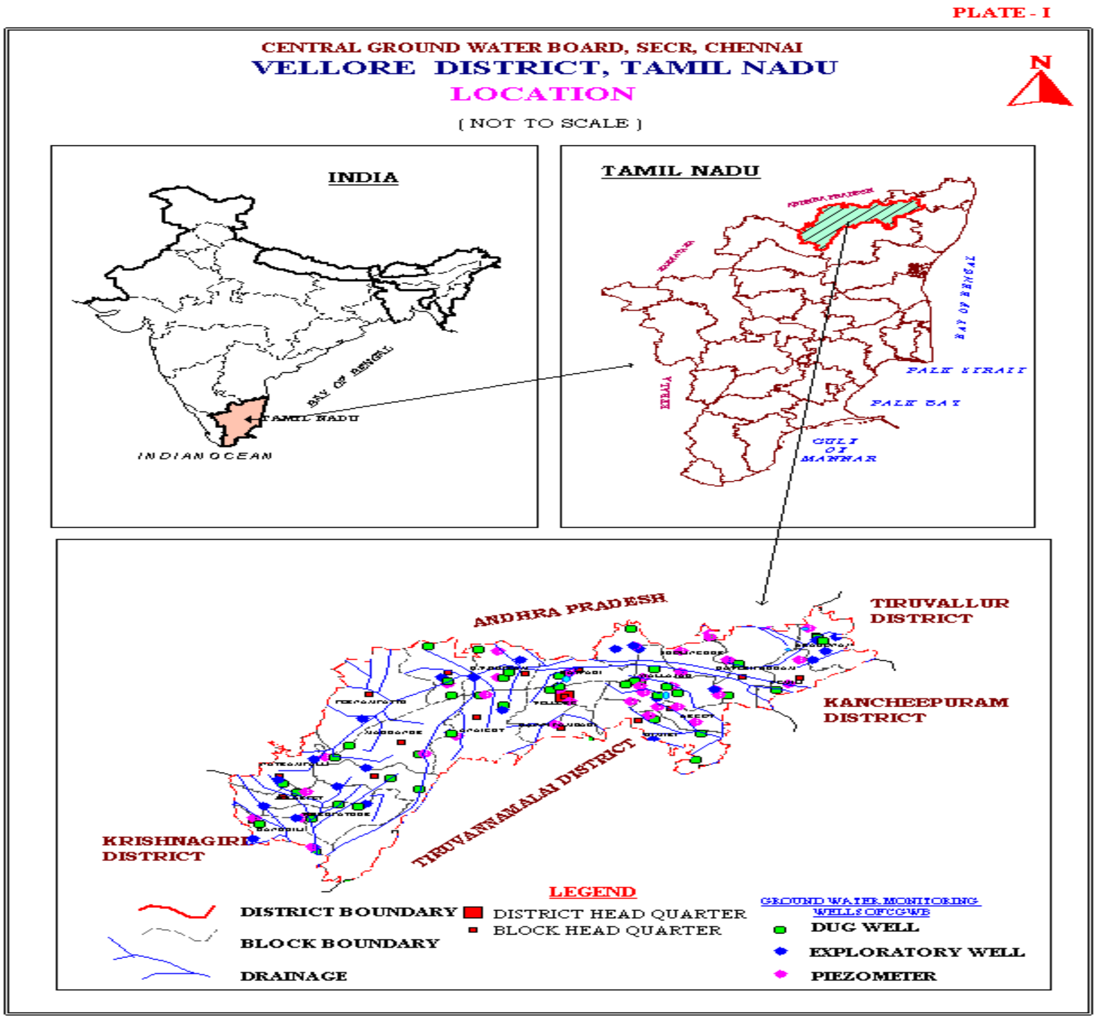


Figure-2: Study Area Vellore

3.3 Geomorphology

From remote sensed areas various lineaments have been recognized. The prominent trend in eastern and southern part of district is NW-SW. In central part, both NE-SW and NW-SE system are regarded of Equal application.

The hydro geographical map of the region also gives the depletion of other major areas. There are two major physiographic division of Vellore district i.e. hilly terrain in the eastern and south western part. The landscape of hilly regions is surrounded by elevations of Eastern Ghats Mayar hills are possessed by Jawada. Elagari and Kalrayan hills, the part in the eastern side is undulated plain with isolated hillocks having sharp peaks falling towards east shown in figure 3.

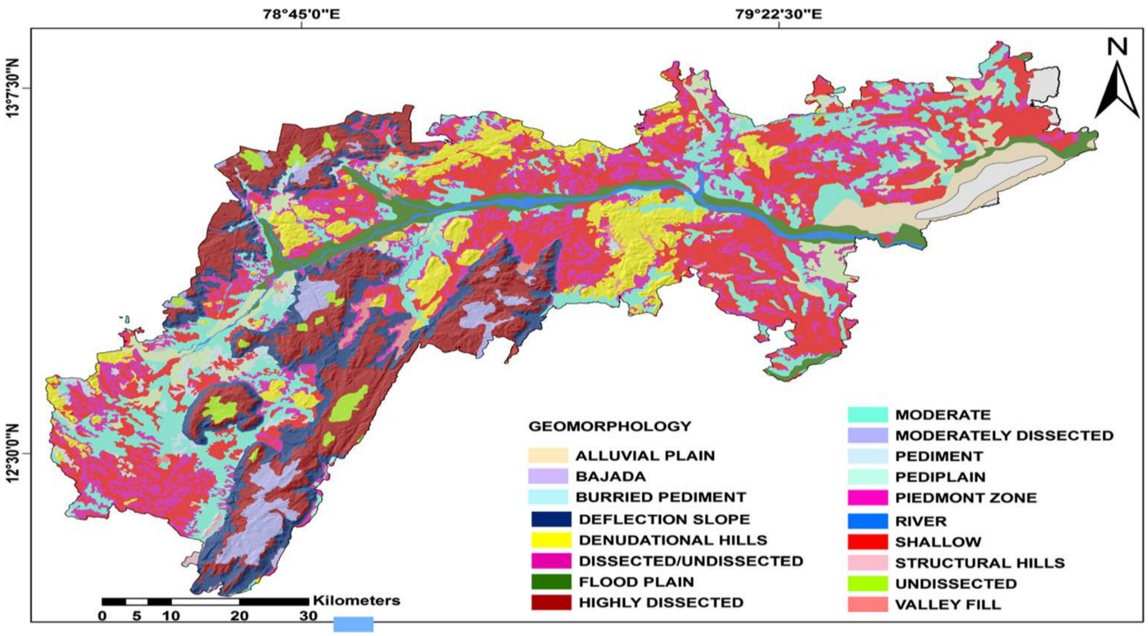


Figure-3: Geomorphology

3.4. Soils

Soils plays a vital role in adopting the percolation wells as percolation wells are mostly suitable where the rainfall infiltrates more and soil can absorb more rainfall waster as it is recommended and verified more penetrate soil are mostly sandy soil which infiltrate more water in it hence the percolation should be adopted where there is sandy soils. Generally soils are classified into 1) Sandy soil 2) Sandy loam soil 3) Red loam 4) Clay 5) Clayey loam 6) Black Cotton communicated in table 1 in high altitudes majorly red loamy soils are observed whereas black cotton invariably occupies the valley areas.

3.5 Drainage

The main source of drainage in district is Palar river which flows towards east covering distance of about 295km shown in figure 4 which is flowing parallel hill ranges of eastern Ghats for most of its voyage in lower Ghats it possess a vast flood plain in lower reaches built remains dry for maximum part of year.

In the district the major tributaries are Ponnaiyar, Cheyyar and Malattar which influence the drainage of Palar River. The entire stream is having short life span and has structural control.

Table-1: Soil Type of District Map

Sl. No	Taluk	Sandy& sandy loam	Red loam soil	Clay & Clay Loam	Black Cotton Soil
1	Arakonam	12234 14.53%	36711 43.6%	20495 24.34 %	1393 1.65%
2	Walajapet	6065 10.09%	24539 40.83%	13667 22.7 %	170 0.28%
3	Arcot	6261 19.32 %	10852 2 0.8%	17956 57.9%	2232 4.27%
4	Vellore	4902 9.16 %	12461 23.3 %	11832 22.1 %	-
5	Gudiyatham	5119 4.98%	29997 26.5%	24814 21.96%	-
6	Vaniyambadi	8657 10.32%	29228 34.79%	9397 11.18 %	-

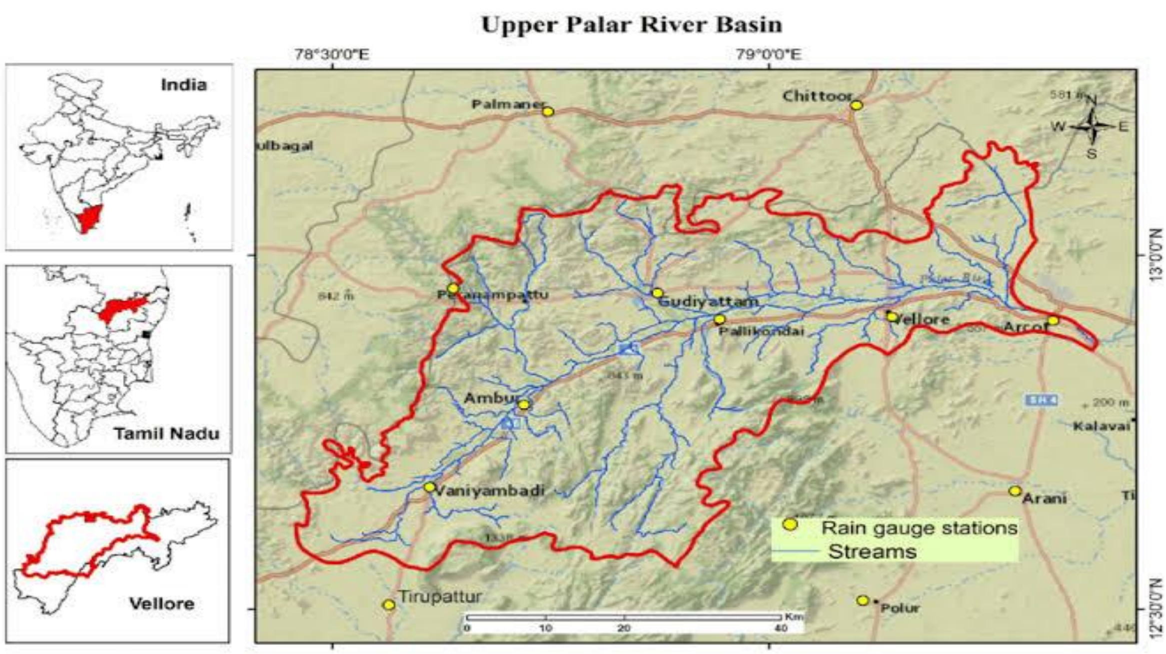


Figure-4: Palar river basin

4. Water Demand Estimation

As per IS Specifications: IS 1172:1993

Water Demand for one person: 135litres/day

annually water demand for each person: 365*135

=49275liters

= 1740 cusec

as per census (2011): Vellore population:

= 3936331

annually total water demand: 365*135*3936331

= 193*10^9 litres

Total area of Vellore District in sqm:

= 18.88*10^8sqm

Therefore the annually water demand is estimated as

= 193.96*10^9 liter

= 6849*10^6 cusec

The area wise estimation of Vellore district is calculated in which the rainfall and runoff coefficient is taken into account table 2 provides the runoff coefficient values for various areas which are as under

Table-2: Runoff coefficient Table

Area description	Runoff coefficient	Area description	Runoff description
Residential		***Industrial***	
Single family	0.30-0.50	Light	0.50-0.80
Multiunit attached	0.40-0.60	Heavy	0.60-0.90
Multiunit detached	0.60-0.75	Parks	0.10-0.25
Residential	0.25-0.40	Playgrounds	0.20-0.35
Apartment	0.50-0.70	Railroads	0.20-0.35
Pavement		***Lawns and parks***	
Asphalt and concrete	0.70-0.95	Flat,2 percent	0.05-0.10
Bricks	0.70-0.85	Average, 2-7percent	0.10-0.15
Roof	0.75-0.95	steep,7 percent	0.15-0.20

Rainwater harvesting by rooftop area:

Total aerial/rooftop area of Vellore district (A)

= 1888*10^9sqm

Average annual rainfall in Vellore district in mm (R)

= 795.00mm

Average annual rainfall in Vellore district in mm (R)

= 0.795m

Runoff coefficient for residential sector (C) = 0.40

From Formula:

Rainwater harvesting potential= Area of catchment*Average annual rainfall*coefficient value

annually water harvesting potential by total rooftop area = A*R*C

= 1374045.123*0.795*0.4

= 436946.349m^2

Total number of liters harvested = 4369463*10^3 liters

Rainwater harvesting by surface drainage:

Rainwater harvesting potential= Area of catchment*Average annual rainfall*coefficient value

annually water harvested potential by surface drainage = A*R*C

= 2465.157*0.795*0.95

= 1910.804m^2

Total number of liters harvested

= 1910.804liters

= 67 cusec

In final step net rainwater harvested from Rooftops and surface drainage is estimated by combination both the quantity of rainwater harvested in liters i.e

Annually total net rainwater harvesting annually total rainwater harvested:

{Total rainwater harvested by rooftop area}+{Total rainwater harvested by surface drainage}

{4369463490}+{1910.804}

annually total rainwater harvested =4369*10^6liters

Hence total amount of harvested water is estimated as = 4369*10^6 liters

=154*10^6 cusec

Average annual Rainfall in mm(R) = 0.795 mm

While harvesting the rainwater from the catchment and after storing the harvested water there are losses

Total losses in potential of rainwater harvesting:

(Evaporation losses)+(Evapotranspiration losses)+(Seepage losses)+(Interception losses)+(Depression losses)

To calculate the evaporation losses the Penman (1963) formulae has been used to estimate evaporation loss.

$$E = \frac{\Delta H + \alpha E_a}{\Delta \alpha}$$

Where,

E= Evaporation loss

Δ= the gradient of the saturated vapor pressure curve against air temperature

α = psychometric constant assumed equal to 0·49

H= Height above MSL

$$\Delta = \frac{4098\, e_{as}}{(237.3 + T)^2}$$

$$E_{a=0\cdot35(1+v/100)}\,(e_a - e_d)$$

v = wind velocity in miles per day

e_a= saturated water vapor pressure at average air temperature

e_d= actual water vapor pressure

T = Temperature

Runoff coefficient for roads/pavements(C)

= 0.82

Total road/pavement area of Vellore district (A) = 6.077*10^6 sqm

$e_a = 611 exp\ (17.27 \frac{T}{237.3})$

The gradient of the saturated vapor pressure curve at 30°C with e_{as}= 4245 Pa for T 30°C

$$\Delta = \frac{4098 * 4245}{(237.3 + 30)^2}$$

= 243.64pa/°C

To find out the saturated vapor pressure @ average temperature

$e_a = 611\text{exp}\ (17.27 \frac{30}{237.3})$

= 611exp (2.18)

= 5405pa

To determine Actual water vapor pressure

$e_a = \frac{Rhes}{100}$

Where,

Rh = average relative humidity

e_a = saturated vapour pressure

e = $\frac{57.9*5405}{100}$

e=3129pa

E_a=0·35(1+188.05/100) (5405−3129)

= 2294.48pa/mile

Determining evaporation losses in total harvested water

E = $\frac{243.64*214+0.49*2294.48}{243.48*0.49}$

= 446mm

To calculate evapotranspiration losses in Vellore district the value is obtained from NRSC VIC MODEL DATA which is equals to 811mm

Table 3: Provides the interception losses to various cover types in different seasons

Cover type	Season	Interception (%)	Reference
Conifers			
Pinusabies	Year	48	Leyton et al. (1967)
Tsuga Canadensis	Summer	33	Voigt (1960)
Pseudotuga	Year	36	Aussenac and boulangeat (1980)
Pseudotuga	Summer	24	Rothacher (1963)
	Winter	14	
Pinuscaribaea	Year	13	Waterloo et al. (1999)
Pinus radiate	Year	26	Feller(1981)
Pinus radiate	Year	19	Smith(1974)
Pinusresinosa	Summer	19	Voigt (1960)
Pinus strobes	Year	16	Helvey (1967)
Pinustaeda	Year	14	Swank et al. (1972)
Evergreen hardwoods			
Notofagusspo.	Year	33	Aldridge and Jackson (1973)
Notofagus	Summer	30	Rowe (1979)
Anacia	Winter	21	

Eucalyptus regnans	Year	19	Beard(1962)
Melaleucaquinquenercervia	Year	19	Feller(1981)
Moist tropical forest	Summer	19	Woodall(1984)
Mixed eucalyptes	Summer	16	Jackson(1971)
	Year	11	Smith(1974)
Deciduos hardwoods			
Carpinus sp.	Year	36	Leyton et al. (1967)
Fagusgrandfolia	Summer	25	Voigt(1960)
Fagussilvatica	Summer	21	Aussenac and Bpoulangeat(1980
Liriodendron	Winter	6	
	Year	10	Helvey (1964)
Grass			
Themeda sp.	Year	13	Beard(1962)
Cymbopogon sp.	Year	13	Beard(1962)
Source: woodall (1984)			

Likewise table 4 and table 5 provides the detailing about the depression losses and seepage losses separately.

Table-4: Typical Depression Storage Quantities

Surface type	Depression storage(mm)	Reference
Pavement:		
Steep	0.5	Pecher (1969),viessan et al.
Flat	1.5-3.5	(1977)
Impervious areas	1.3-2.5	Pecher (1969),viessan et al.
Lawns	2.5-5.1	(1977)
Pasture	5.1	Tholin and kiefer (1960)
Flat roofs	2.5-7.5	Hicks (1944)
Forest litter	7.6	ASCE (1992)
		Butler and Davies (2000)
		ASCE (1992)

Table- 5: Soil types and their Seepages Rates

Natural soil type	Seepage water losses in mm/day
Sand	25.00-250
Sandy loam	13.00-76
Loam	8.00-20
Clayey loam	2.50-15
Loamy clay	0.25-5
Clay	1.25-10

Total losses in potential of rainwater harvested (mm)

= $(4369*10^9 - (446+811+76+3.5))$

= $(4368*10^9)$ mm^3

= 436800 litres

= 436800*0.13

= 56784 litres = $380*10^3$ litres

=13.419*10^3 cusec

The outcome of the water estimation is to find the gap in between the water demand or water consumption and in water supply. By referring the official website Tamil Nadu water supply and drainage board (TWAD BOARD) it is reported total water supply in Vellore district is as under:

Table-6: Urban Towns water supply status (1.8.2019)

S.No	Name Of Towns	Population	Present Water supply (Lpcd)
Corporation			
1	Vellore	185803	115
Municipalities			
2	Walajepettai	47498	87
3	Ranipet	50764	89
4	Tiripathur	64125	91
5	Arakonam	78395	95
6	Arcot	55955	97
7	Gudiyatham	91558	90
8	Ambur	114608	93
9	Vaniyampadi	95061	87
10	Melvisharam	44786	92
11	Pernampattu	51271	88

By referencing the above the table 6, it is reported that the presently water supply for Vellore district is 115 lpcd. As per IS codes the water demand for person is 135 liter/day. The difference in the demand and supply gives us the conclusion to the objective to

Total presently water supply in Vellore district

= 115lpcd

Total present population in Vellore district

= 3936331

Total number of liters supplied

= 365*115*3936331

= 165.227*10^9liters

fulfill the missing gap in between demand and supply. Since there is gap of 20 lpcd which should be fulfilled by filling the difference gap. By estimation the number of liters of water is determined by converting the lpcd into liters which gives the water required.

= 5834*10^6 cusec

Net difference in between demand and supply = 28733*10^6 liters

= 1041*10^6 cusec

5. RESULT AND DISCUSSION

TABLE- 7: MAXIMUM. MIMINUM, AVERAGE TEMPERATURE°*C* VELLORE DISTRICT 2017- 2019

Year	Max	Min	Avg	Year	Max	Min	Avg	Year	Max	Min	Avg
Jan17	30	17	22	Jan18	30	18	23	Jan19	30	18	25
Feb17	32	16	23	Feb18	32	19	25	Feb19	33	21	28
Mar17	35	21	28	Mar18	35	22	28	Mar19	33	24	32
Apr17	40	25	32	Apr18	38	25	31	Apr19	40	27	34
may17	40	27	33	May18	38	28	33	may19	41	30	37
Jun17	35	26	30	Jun18	36	28	32	Jun19	38	28	34
Jul17	36	26	31	Jul18	35	27	31	Jul19	35	26	31
Aug17	34	26	30	Aug18	35	26	30	Aug19	33	25	30
Sep17	33	25	29	Sep18	34	25	29	Sep19	31	23	28
Oct17	32	27	30	Oct18	32	22	28	Oct19	30	23	27
Nov17	29	21	24	Nov18	30	21	26	Nov19	27	21	26
Dec17	28	23	23	Dec18	30	20	25	Dec19	27	19	24

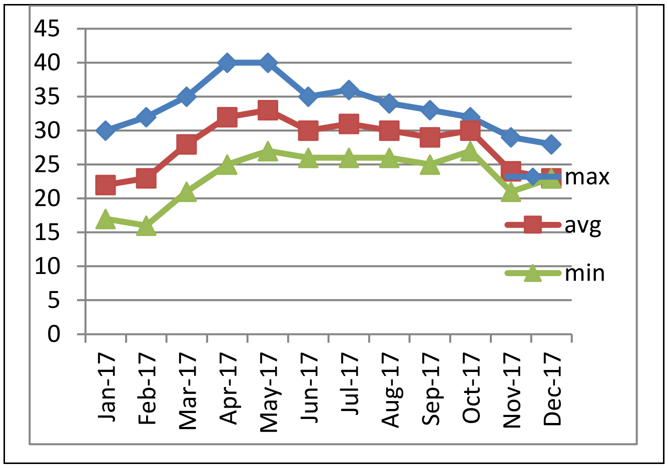


Figure-5: Annual Temperature of year 2017

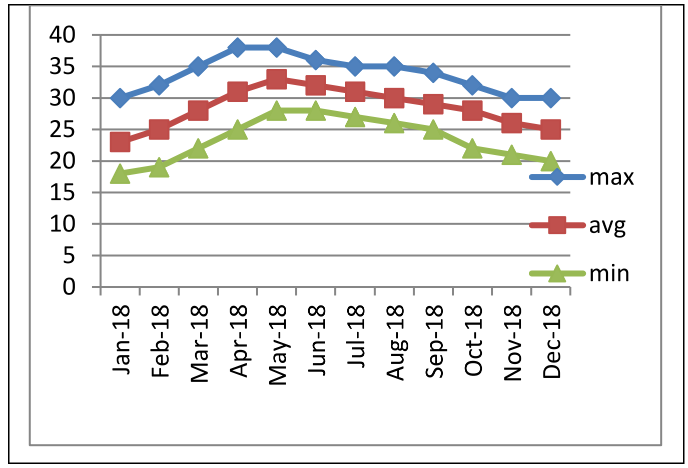


Figure-6: Annual Temperature of 2018

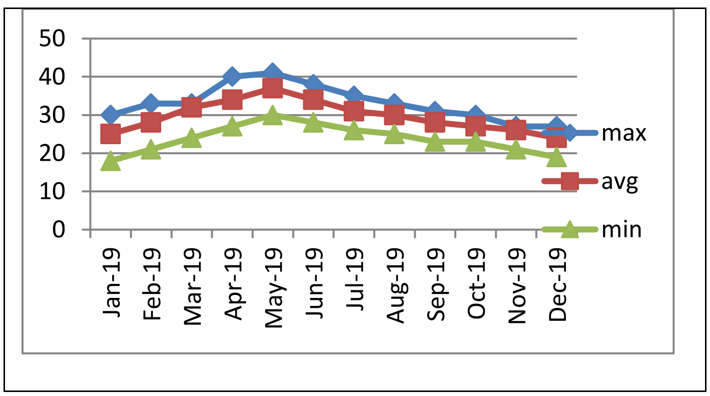


Figure-7: Annual Temperature of year 2019

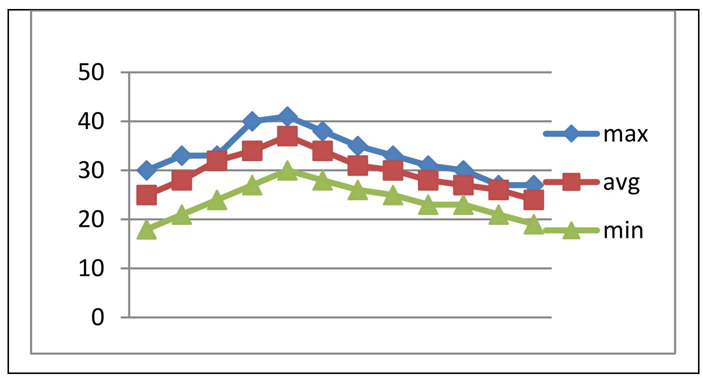


Figure-8: Combined Average Temperature 2017-19

From the table 7 the temperature reading are recorded in the Vellore district in consecutive years from 2017-2019. In year 2017 the average annual temperature is recorded as 27.91 degrees in 2018 temperature is recorded as 28.41 degrees and in 2019 annual temperature is recorded as 29.66 degrees as far as the temperature is concerned there is minute variation in temperature in three years of temperature is likely to hot as compared in first and last stage of the year. The mid section of the year is likely giving a boost are separately drawn in year 2017, 2018 and 2019 showing the temperature variations in the months A combined annual graph is drawn in which all year graphs are merged each other to create a new graph which shows annual temperature of entire years.

From the table 8 rainfalls is recorded in several years from 2015-2019 in which the rainfall is recorded in mid-section of the years in year 2015, from January to June the rainfall is recorded as 17.61mm while from July to December it is recorded 69.35mm. In year of 2016 the rainfall in the month of January to June it is recorded as 22.30mm while in moths from July to December it is recorded as 54.47. in years 2017 and 2018 the rainfall in the months are recorded as 15.34mm, 57.47mm,14.13mm and 110.76mm is recorded respectively. In year 2019 the rainfall is recorded in January to nun moth as 78.73mm and from above observations it is said in the starting month of all July to December recorded as 213.18mm. Hence by the years the rate of precipitation is lesser than the mid and ending months of year. Hence the major supply is stored in the end months of the year and can be distributed in the water shortage months when there is low precipitation. Vellore receives an average annual rainfall of 795 mm on which north east monsoon shares 535mm of rainfall and south west monsoon shares 442 mm of rainfall and humidity in the region in summer varies from 40%-63% while in winter ranges from 67%-83%.

Table- 8: Rainfall in Vellore District 2015-2019

MONTHS	RAINFALL IN (mm)
JAN-JUN 2015	17.61
JUL-DEC 2015	69.35
JAN-JUN 2016	22.30
JUL-DEC 2016	54.69
JAN-JUN 2017	15.34
JUL-DEC 2017	57.47
JAN-JUN 2018	14.13
JUL-DEC 2018	110.76
JAN-JUN 2019	38.73
JUL-DEC 2019	213.18

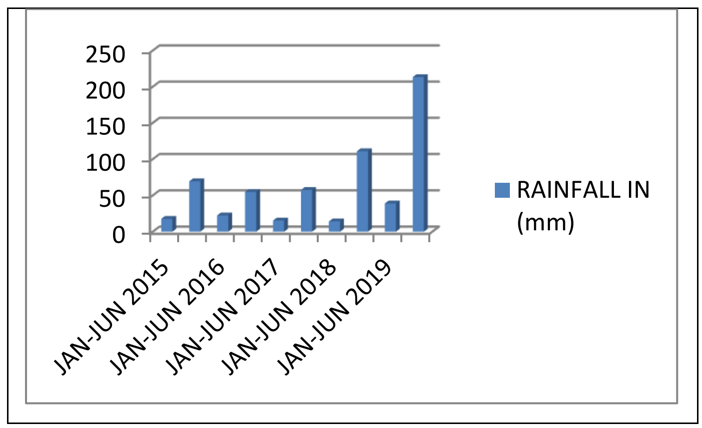
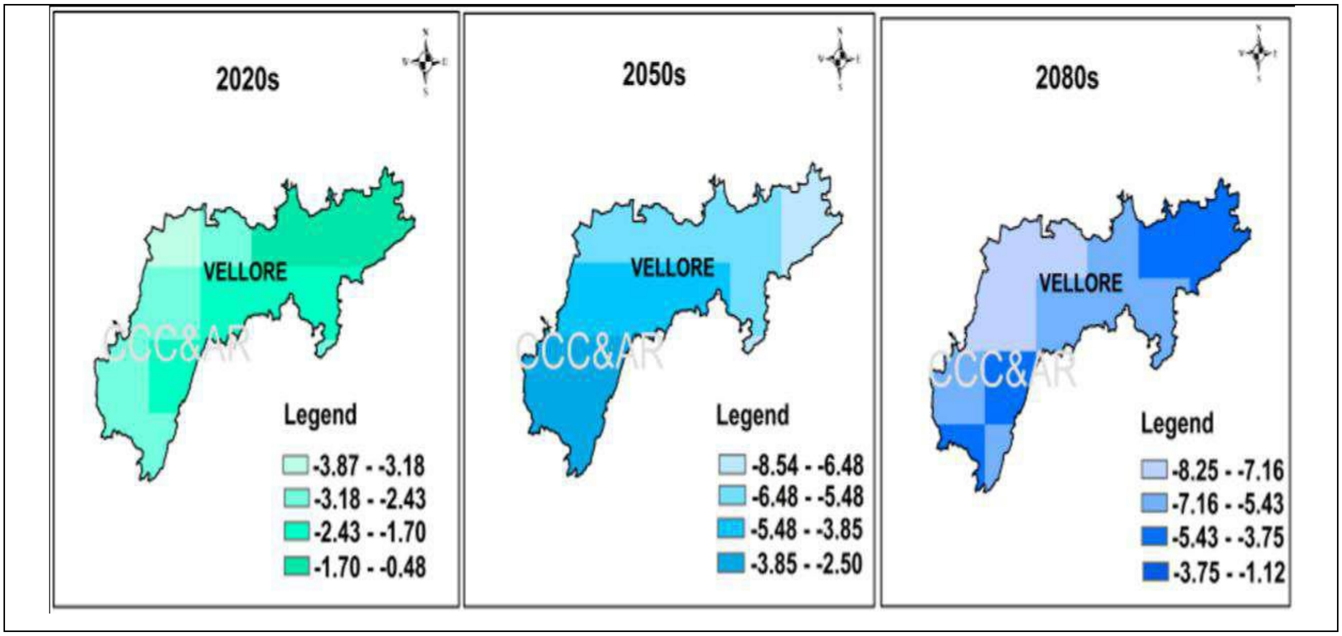


Figure-9: Average Annually Rainfall Data 2015-19



Source: center for climate change and disaster management-Anna University

Figure-10: Change in annual rainfall (mm) projections for 2020-2050, 2050-2080 with reference to baseline (1970-2000)

Table-9: Change in percentage wise in rainfall with reference to 1970-2000 annual temperature

parameter	2020's	2050's	2080's
Annual Rainfall	-2.0%	-5.0%	-5.0%

As per the sources and researches from Tamil nadu state climate change cell department. It is said that the annual rainfall reduces up to by 5.0% in Vellore by the end of the century referenced in figure 10 and table 9.

6. RESULT

Author deliberate about study area which mainly collects annually 13.419*10^3 cusecs of water, the gigantic water can be diverted and stored in percolation wells after treating. Since percolation wells are to be used to intake rainwater.

In case if there is high intensity of rainfall the overflow water can be directed to main percolation well through the pipeline network. From the above result, we can harvest water and increase both quantity and quality of groundwater.

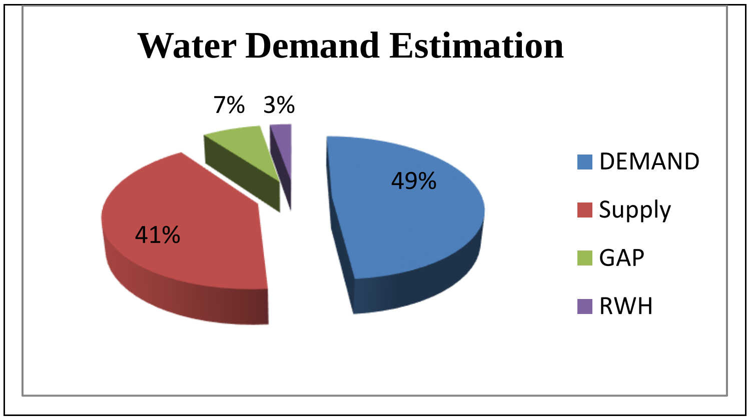


Figure-11: Demand, Gap, Supply, and RWH of Vellore District

7. CONCLUSIONS

In this paper, we had studied artificial recharging of ground water through rainwater harvesting system, we had chosen a specified district namely Vellore district that can collect 13.419*10^3 cusec of rainwater harvesting technique. By the above whole system and process towards a goal would be acknowledge the essence of rainwater harvesting. This should not only include rooftop rainwater harvesting but also storm water harvesting system. our vision is simple in ways that each and every drop of water, we have to catch in any possible way and every possible place where it falls. It can be concluded from above findings that proper preservation and conservation as well as utilization of rainwater harvesting technology can be effective tool of replenishing ground water resource .we can harvest 13.419*10^3 cusecs of water which is 16% of total demand by using above method the harvested rainwater in aquifer and can increase ground water depth. By conclusion total amount of water harvest is 13.419*10^3 cusec of water which is 16% of total water demand so by using this technique we can store the harvested rainwater in aquifers and in percolation wells.

DECLARATION OF INTEREST

The Authors declare no competing interests. We had done this work without any financial assistance the authors declare that there is no conflict of interests with any financial Organization regarding the material discussed in the manuscript.

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