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Original Research Paper

Geology

Comprehensive Study for Development Of Water Resources Using GIS in Pulivendula Area, Kadapa District, Andhra Pradesh, India

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ABSTRACT

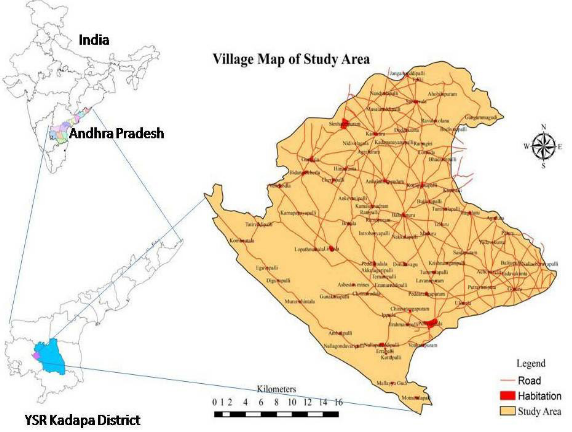
Abstract: The present study focused on scope of groundwater development in the study area. Average dependable rainfall in the study area is 463 mm; which is resulting about 111.53 MCM of runoff. About 580 Water Harvesting Structures (WHS) with storage capacity of 7.77 MCM was constructed. About 1186 locations has been identified to construct new WHS resulting 3.50 MCM of water will be stored. Natural recharge through rainfall is 31.1MCM, by existing WHS about 15.34 MCM, and 3.73 MCM of water going in to sub surface due to proposed new structures. Deep water levels recorded in pre (51.1 meters) and post monsoon (27.1 meter) in Chinagudala, Pulivendula 17.6 meters in pre monsoon and 15.1 meter in post monsoon and Balapanuru (28 meters in pre and 17.2 meter in post monsoon) and shallow water levels recorded in Thonduru Mandal (5.6 meters in pre and 4.6 meter in post monsoon).

KEYWORDS : Artificial recharge structures, Pulivendula, Rainfall, Runoff, GIS

Introduction: The sustainable development of ground water resource requires precise quantitative and qualitative assessment and management based on reasonable valid scientific principles. Rainfall is the principle source of input for ground water recharge. The ground water recharge is essentially governed by nature of rainfall like its intensity, quantity and frequency. The high intensity and short duration will cause more run off vice versa the low intensity and long duration rain fall results comparatively more recharge to ground water. Ground water flow in subsurface generally follows the topography of the surface. The occurrence and movement of ground water is mainly controlled by lithology, geological structure, and geomorphology and recharge condition. Topography, weathering, surface water bodies, geologic setting, rainfall and water conservation methods are very important in availability of groundwater. In Kadapa district, of the 51 mandals four are over exploitation mandals, 13 are semi critical mandals, and 34 are safe mandals. In this contest the comprehensive study was conducted focused on the part of over exploited mandals of Pulivendula area of YSR Kadap district, Andhra Pradesh to ensure the develop groundwater resources.

Study area: Geographically the study area falls between north 77˚57 ›52.56" to 78˚22' 25.68" and east 14˚19› 40.44» to 14˚41' 39.84". It is covering 84 habitations of 60 villages of 46 panchayats of four mandals Lingala, Pulivendula, Simhadripuram, Vemula, Thoduru. This area is sharing parts in toposheet no 57J/2, 57J/3, 57J/6 and 57J/7 of survey of India toposheets of 1: 50,000 scale maps. Figure 1 shows the location of the study area.

Figure 1 Location of the study area



Climate: The basin belongs to the Southern agro-climatic zone of Andhra Pradesh. This zone is receives 600 mm to 1000 mm of rainfall in southwest monsoon; maximum temperature varies in between 28⁰C to 40⁰C and the minimum 13⁰C to 27⁰C.

Material and method: A holistic strategy had been adapted during the survey in all parts of the study area. Rainfall data from 1974 to 2011 was collected from Pulivendula mandal revenue office. Based on the average dependable rainfall (75 % of the normal rainfall) runoff was calculated by using strange formula. Water levels were collected from the district groundwater department of YSR kadapa district. A transact walk was conducted with watershed committees, farmers, opinion leaders along the stream courses and plan lands to identify the present water harvesting and soil moisture structures over the study area. During survey water storage capacity of each structure was measured by mathematical method: multiplication of length and breadth of water storage and water column of the each structure. On the other hand feasible locations for construction of new structures and their expected storage capacity also estimated. Location of the existing and proposed structures picked up with GPS. GIS is used for preparing geology map, location map of existing and proposed structures and geomorphological map. Geological survey of India (GSI) maps are used for preparation of geological map of the study area. Survey of India toposheets 57J/2, 57J/3, 57J/6 and 57J/7 are used for preparation of drainage map. Quantity of water recharged through rainfall and Water Harvesting Structures (WHS) is calculated by the GEC-97 methodology.

Soils: Red and black soils are distributed over the basin. Thickness ranges from 0.30 to 1 meter.

Geology: The study area comprises of Vempalli and Chitravathi group of Cuddapah Systems. Figure 2 shows the geology of the study area. Two groups are divided by the unconformities. Vempalli group of rocks are lies above the eparchaean unconformity; which lies above the Archaeans. Vempalli group with Gulcheru quartzite, Vempalli quartzite and Vempalli dolomite formations formed at upper portions of study area. Pulivendula quartzite with conglomerate followed above the Vempalli group. Basic intrusives were encroached in the Tadiparthi shale of Chitravathi group. Tadipatri shale of Chitravathi group extended in the total basin which formed below the Tadiparthi dolamite which followed by Tadiparthi quartzite. Faults are formed along the Vempalli quartzites. Geology map is shown in figure 2.

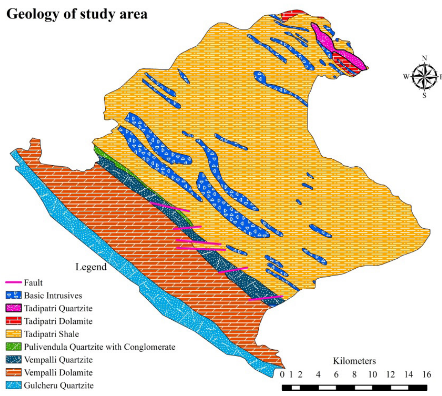
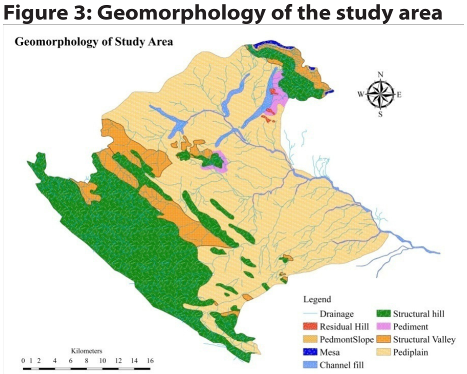


Figure 2: Geological formations

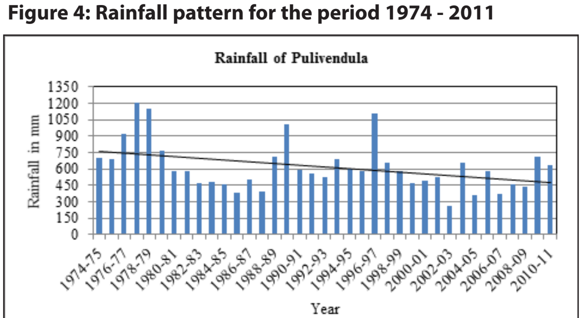
Geomorphology: First order streams started on structural hills originated along south west margin; and meso type of geomorphological features exhibiting Tadiparthi quartzite and Tadiparthi dolomite at north east edge of the study area. Figure 3 reflects the geomorphological features of the study area. Structural hills made up of Gulcheru quartzite where highest elevation spotted as 658 meters above mean sea level at Eguvapalli habitation. Lowest elevation is 190 m above mean sea level found at Kondrediipalii habitation where drainage of the study area joining into Maganuru Eru. Streams are exhibiting dendritic pattern most majority of the streams flow towards east from west ultimately joins Maganuru Eru. Channel filling formed along the course of Maganuru Eru in study area. Structural vallies are formed in between structural hills; pediment slopes with pediment noticed in the north east of the study area; Residual hills are north east corner.

Figure 3: Geomorphology of the study area



Rainfall and runoff: Thirty seven years of Pulivendula mandal rainfall data is analyzed for understanding rainfall pattern and available runoff of the study area. Figure 4 shows the rainfall of the study area. It reveals that average rainfall received is 616.7 mm. Trend of the rainfall shows declining trend over the period and stress the need for additional water harvesting structures. Based on the strange's formula water availability as runoff is 111.53 MCM.

Figure 4: Rainfall pattern for the period 1974 - 2011



Water table: Water level data is collected from the district groundwater department of YSR kadapa district; representing Pulivendula station of Pulivendula mandal, Chinagudala station of Lingala mandal, Balapanuru station of Simhadripuram mandal and thonduru station of Thonduru mandal. Figure 5 represents the change in water levels during May (pre monsoon) and November (Post monsoon).

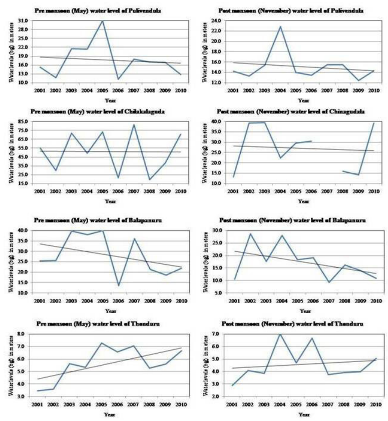


Figure 5: Pre and post monsoon water levels (2001-11)

The Ground water Department has four observation wells - Pulivendula, Chinagudala, Balapanur and Thondure villages. From figure 5 falling tred in water table is observed for both pre and post monsoon in Pulivendula and Balapanuru villages, and increasing trend in Thonduru. No change is observed in Chinagudala in Pre monsoon and decreasing trend in post monsoon. Table 1 shows the annual water levels in the study area.

Table 1: Annual water levels in May and November (in meters)

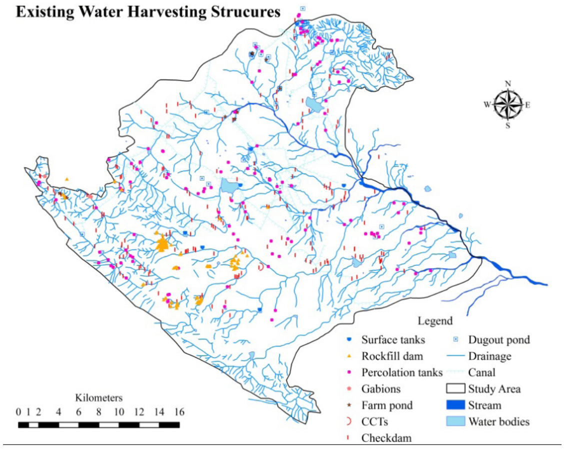
Year	Pulivendula in meters		Chinagudala in meters		Balapanuru in meters		Thonduru in meters	
	May	November	May	November	May	November	May	November
2001	15.2	14.2	55.0	13.2	25.4	10.5	3.5	2.9
2002	11.7	13.3	29.9	39.3	25.6	28.7	3.6	4.1
2003	21.5	15.4	72.0	39.4	39.7	17.7	5.6	3.9
2004	21.3	22.8	49.1	22.3	37.9	27.9	5.4	7.0
2005	31.0	14.0	73.5	29.5	40.0	18.2	7.3	4.7
2006	11.1	13.5	21.5	30.4	13.4	19.0	6.6	6.7
2007	18.0	15.5	81.5		36.1	9.2	7.0	3.7
2008	17.0	15.5	19.4	15.9	21.4	16.1	5.3	3.9
2009	16.9	12.5	38.3	14.2	18.5	14.0	5.6	4.0
2010	12.8	14.3	70.7	39.3	21.8	10.9	6.7	5.0
Average	17.6	15.1	51.1	27.1	28.0	17.2	5.6	4.6

(*Source: District groundwater department, YSR kadapa District, Andhra Pradesh, India*)

From Table 1 it is observed that the average water levels are varying between 5.6 m to 28 m in of May and in November 4.6m to 51.1m. So, the deeper water table necessitating the recharge of high quantum of ground water.

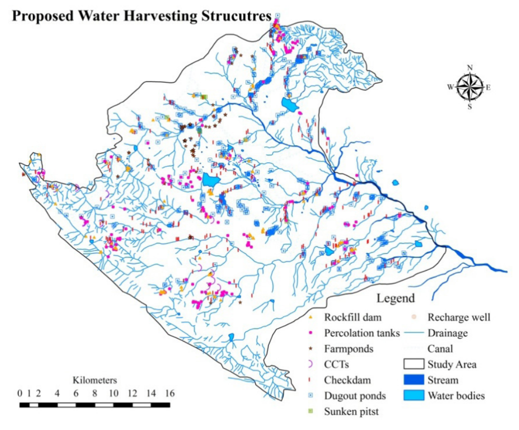
Existing Water Harvesting Structure (WHS): In the study area it is identified that 580 water harvesting structures had identified. Out of these, eight are surface tanks (Cheruvu) which are using for irrigation. About 179 rock fill dams and 3 gabions were constructed along the drainage course. About 124 percolation tanks and 216 check dams were built over the study area for recharging the water in to sub-surface. About 13 farm ponds were excavated at farmer's field as well as 36 dugout ponds at waste and fallow lands were unearthed and one Continuous Contour Trench (CCT) along slopes of hills were dugout in the study area. Location of existing structures is shown in figure 6.

Figure 6: Location of Existing Water harvesting Structures



Proposed Water Harvesting Structures (WHS): During the field survey along the course of stream and on the land, it has been found that about 214 rock fill dams, 145 percolation tanks, 69 farm ponds at farmer fields, 171 check dams, 569 dug out ponds in waste and fallow land and 18 CCTs at hill slopes and 16 sunken pits are proposed additionally. Location of proposed structures is shown in figure 7.

Figure 7: Location Map of Proposed Water Harvesting Structures in the Study Area



Storage capacity of existing WHS: Storage capacity was also calculated during the survey. It is found that about 7.77 million cubic meters (MCM) of water has been storing in about 580 water harvesting structures. About 0.56 MCM of water at check dams as well as 1.91 MCM of water at surface tanks also has been stored in the study area. Excavation of dug out ponds and farm ponds resulted to store 0.02 MCM and 0.004 MCM. Due to percolation tanks about 5.27 MCM of runoff obstructed for groundwater recharge and irrigation purpose; similarly about 0.006 MCM and 0.0008 MCM of runoff stored at rock fill dams and gabions. About 0.0002 MCM of water have been obstructing in CCTs along hill slopes. Storage capacity of different water harvesting structures is shown in table 2.

Table2: Water Storage Capacity of proposed and existing Water Harvesting Structures

Sl.No	Type of Structure	No. of Structure		Water Storage in MCM	
		Existing	Proposed	Existing	Proposed
1	Surface tanks / Cheruvu	8	0	1.91	0.00
2	Percolation Tank	124	145	5.27	1.24
3	Check dam	216	171	0.56	0.05
4	Dugout pond	36	569	0.02	2.17
5	Farm pond	13	69	0.004	0.02
6	Rock fill dam	179	214	0.006	0.006
7	Gabion structures	3	0	0.0008	0.01
8	Continuous contour trench	1	18	0.0002	0.001
9	Sunken pit	-	16	-	0.004
Total		580	1186	7.77	3.50

Estimated water storage capacity at proposed new structures: It is calculated that about 3.50 MCM of water can be stored in 1186 structures. Of this, at checkdams 0.05 MCM, 0.006 MCM at rock fill dams, 0.014 MCM at sunken pits, 2.17 MCM at dugout ponds, 0.02 MCM at farm ponds, 0.05 MCM at check dams, 0.001 MCM at CCTs and 1.24 MCM at percolation tanks in the study area.

Natural recharge of groundwater: Natural recharge is calculated using GEC-97 methodology. Table 3 shows the calculation of rainfall recharge. As per the GEC classification massive poorly fractured rock coined Gulcheruvu Quartzite, Vempalli Quartzite and Tadipatri quartzite; consolidated limestone representing Tadipathri dolomite, Vempalli dolomite and Quartzite with Conglamerate ; whereas shale representing Tadipatri shale in the study area.

Table 3: Natural recharge through rainfall

Average Dependable rainfall in the Study Area = 0.46 meters				
S.No	Geology	Area in Sq.m	% of Recharge	Estimated Recharge in MCM
1	Gulcheruvu quartzite	98,985,118	1	0.5
2	Vempalli quartzite	52,147,371	1	0.2
3	Tadipatri quartzite	10,195,286	1	0.05
4	Tadipatri shale	1,032,832,893	4	19.1
5	Tadipathri dolomite	64,038,506	6	1.8
6	Quartzite with conglomerate	7,328,492	7	0.2
7	Vempalli dolomite	283,792,333	7	9.2
Total		1,549,320,000		31.1

Table 3 revealed that 31.1 Million Cubic Meters (MCM) of groundwater formed due to average rainfall in the study area. Out of this 19.1 MCM of the groundwater has been occurred at Tadipathri shale, followed by Vempalli dolomite 9.2 (MCM), Tadipathri dolomite 1.8 (MCM), Gulcheruvu quartzite 0.5 (MCM), Vempalli quartzite 0.2 (MCM), Quartzite with conglomerate 0.2 (MCM) and Tadipathri quartzite 0.05 (MCM).

Recharge through WHS: Recharge calculated through both existing structures and proposed structures by using Groundwater Estimated Committee-97(GEC-97) norms. Table 4 shows the cumulative groundwater recharge in the study area. A total of 15.34 MCM of water percolated into the ground through the existing WHS in the study area. Out of this, 0.09 MCM through surface tanks, 11.85 MCM percolation tanks, 0.05 MCM through dugout ponds, 0.01 MCM through farm ponds, 0.0006 MCM through CCTs, 0.09 MCM through rock fill dams, 3.24 MCM through check dams and 0.006 MCM through Gabion structures.

Table 4: Cumulative groundwater recharge

S.No	Type of Structure	Groundwater recharge in MCM		
		From Rainfall	Through Existing WHS	Through Proposed WHS
1	Natural process	31.1	-	-
2	Surface tanks / Cheruvu	-	0.09	0.00
3	Percolation Tank	-	11.85	2.72
4	Check dam	-	3.24	0.32
5	Dugout pond	-	0.05	0.54
6	Farm pond	-	0.01	0.04
7	Rock fill dam	-	0.09	0.06
8	Gabion structures	-	0.006	0.00
9	Continuous contour trench	-	0.0006	0.002
10	Sunken pit	-	0.00	0.05

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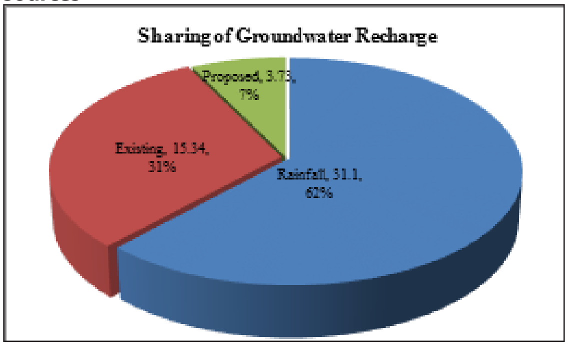
Total	31.1	15.34	3.73

It is estimated that 3.73MCM of groundwater through proposed WHS structures. Out of this, 2.72 MCM through percolation tanks, 0.54 MCM dugout ponds, and 0.04 MCM farm ponds, 0.002 MCM CCTs, 0.06 MCM rock fill dams, 0.32 MCM check dams and 0.05 MCM sunken pit.

Figure 8: Groundwater recharges sharing from different sources



It is understand that 69% water recharges from rainfall (Table 8) and 25% due to WHS. The proposed WHS will add 6% more percent groundwater to the subsurface.

Conclusions

This type of detailed study across natural drainage and land resources is necessary to rejuvenation of groundwater table in critical, semi critical and critical area. Long term rainfall (about thirty seven years) is showing the downward trend which indicating the need of attention in this type of study. General trend of water levels in the study area is showing down ward trend. In Thonduru mandal water table is shallow, but it is found that trend of the water levels is exhibiting upward trend in pre and post monsoon also; so this type of study is useful for reducing the ground water levels in this type of scenario. Of the available 111.53 MCM of runoff only 11.27 MCM (10 % of total) of runoff is obstructed for groundwater recharge at all WHS. Expected total recharge including natural (rainfall) and artificial (WHS) is 60.47 MCM. Of this majority (68.5 %) has been happened due to rainfall, existing WHS shared 25.4 % and remaining 6.2 % come into true by proposed water harvesting structures in the study area. Apart from construction of new structures management of these structures such as de-silting when they filled with sediments transported by storm and repairing of when it need is very crucial for development of sustainable water resources. Once this type of integrated survey has been conducted the management of water resources will enable to sustainablity.

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