

## Groundwater Resource Andhra Pradesh

### Executive Summary

Andhra Pradesh, the third largest State of the country with a geographical area of 2,75,068 Sq Km. has a forest cover of 23 %. Table 1 gives the Administrative set up of the State. The State shares its boundaries with Orissa, Tamil Nadu, Chattishgarh, Maharashtra and Karnataka, and on the eastern side is the Bay of Bengal.

<b>Table –1 ADMINISTRATIVE SET UP</b>	
Districts	23
Revenue Divisions	81
Mandals	1128
Inhabited Villages	26613
Uninhabited Villages	1510
Towns	210

### Rainfall

Although the normal annual rainfall is 940 mm, it has a wide range. In the drier and interior southern district Ananthapur, it is as low as 552 mm while north western coastal regions record normal of more than 1200 mm. The rainfall record shows that droughts are fairly recurrent in the state. The analysis of rainfall during 1974-2007 indicates deficit rainfall in all the 22 years in one or the other parts of the State. The State receives about 66% of rainfall from south-west monsoon (June-September) and about 25% from north-east monsoon (October-December). The remaining 9% is received during winter and summer months. The state has received good rainfall from 2004-05 onwards till date after consecutive droughts.

### Rivers of the state vis-à-vis watersheds

The state has 3 major rivers the Godavari, the Krishna and the Pennar, besides a number of small but splendid rivers of eastern-ghats. The River Godavari with its tributaries Pranahita, Manjeera, Maneru, Indravati, Kinnerasani, Pamuleru and Sileru drains through the northern parts

of the State into Bay of Bengal. The river flows through Adilabad, Karimnagar, Nizamabad, Medak, Warangal, Khammam, Krishna, East & West Godavari and Visakhapatnam districts. The River Krishna with its tributaries Tungabhadra, Vedhavati, Hundri, Musi, Palleru and Munneru flows through the central parts of the State. It drains Anantapur, Kurnool, Mahabubnagar, Ranga Reddy, Nalgonda, Guntur and Krishna districts into Bay of Bengal. The River Pennar, the third biggest river, with its tributaries Chitravati, Papaghni, Cheyyeru and Pincha drains Rayalaseema region and Nellore district.

### **National codes for major river basins of the state**

The Godavari river basin is designated as **E**, the Krishna river basin is designated as **D**. The Pennar river basin is a part of a catchment designated as **C**. The area between the Godavari river basin and the Mahanadhi river basin encompassing the eastern-ghats is defined as basin **F**. It lies in Srikakulam, Vizianagram, Visakhapatnam and East Godavari districts. The area between the Godavari and the Krishna basins is grouped as basin **I**. It lies in Krishna, Khammam and West Godavari districts. Similarly the area on the south of the Krishna catchment and including the catchment of the Pennar is designated as basin **C**. It covers Chittoor, Anantapur, Cuddapah, Kurnool, Prakasam and Nellore districts.

There are in all 40 rivers that drain directly into the sea, and 81 sub basins are recognised as accounting units for the water. However, these sub basins which range in size from 90.65 km<sup>2</sup> to 15699 km<sup>2</sup> are generally not ideal for estimation of dynamic groundwater resources. The ideal recommended size of groundwater estimation unit i.e. the catchment is 300 km<sup>2</sup>. Hence, in 2002, for the purpose of groundwater estimation these accounting units were further sub-divided into 1193 drainage basins that are called watersheds in consonance with the decision of the Groundwater Estimation Committee. However, these divisions are modified in 2004 and arrived at 1229 groundwater assessment units (watersheds) in the State.

### **Soils and agro-climatic zones**

The soils are broadly red, black, alluvial, lateric and coastal sandy types. They support large variety of natural vegetation and in general good for agriculture and horticulture. The climate, rainfall and soil divide the state into 7 climatic zones, which are based as much on the water availability as on the type of agriculture that the area can support. Hence, these are properly referred as agro-climatic zones.

## **Geological and Hydrogeological characteristics**

The state is covered by

1. The unclassified Archaean crystalline rocks mainly the granitic, but in eastern ghats comprising granulite suites locally called as khondalites and kodurites,
2. The Middle–Upper Proterozoic the Cuddapahs and its equivalents;
3. The Mesozoic the coal bearing Gondwana strata
4. Eocene lava flows (the deccan traps) and
5. The semi-consolidated or unconsolidated tertiary and recent rocks

### **Hard Rocks**

Archaeans, Pre-Cambrians, Cuddapahs, Kurnools and Deccan traps are categorised as *Hard Rocks* from *groundwater* point of view. These rocks have negligible primary porosity. The development and management of aquifers in these diverse formations requires similar techniques. These rocks cover nearly 85% of the State that is about 2.332 lakh km<sup>2</sup>. The remaining 15% of the area that is 41,160 km<sup>2</sup> is underlain by soft rocks Gondwanas, Rajahmundry formations, Recent Alluvium, etc.(Figure 1: Geological map of Andhra Pradesh).

Figure: 1

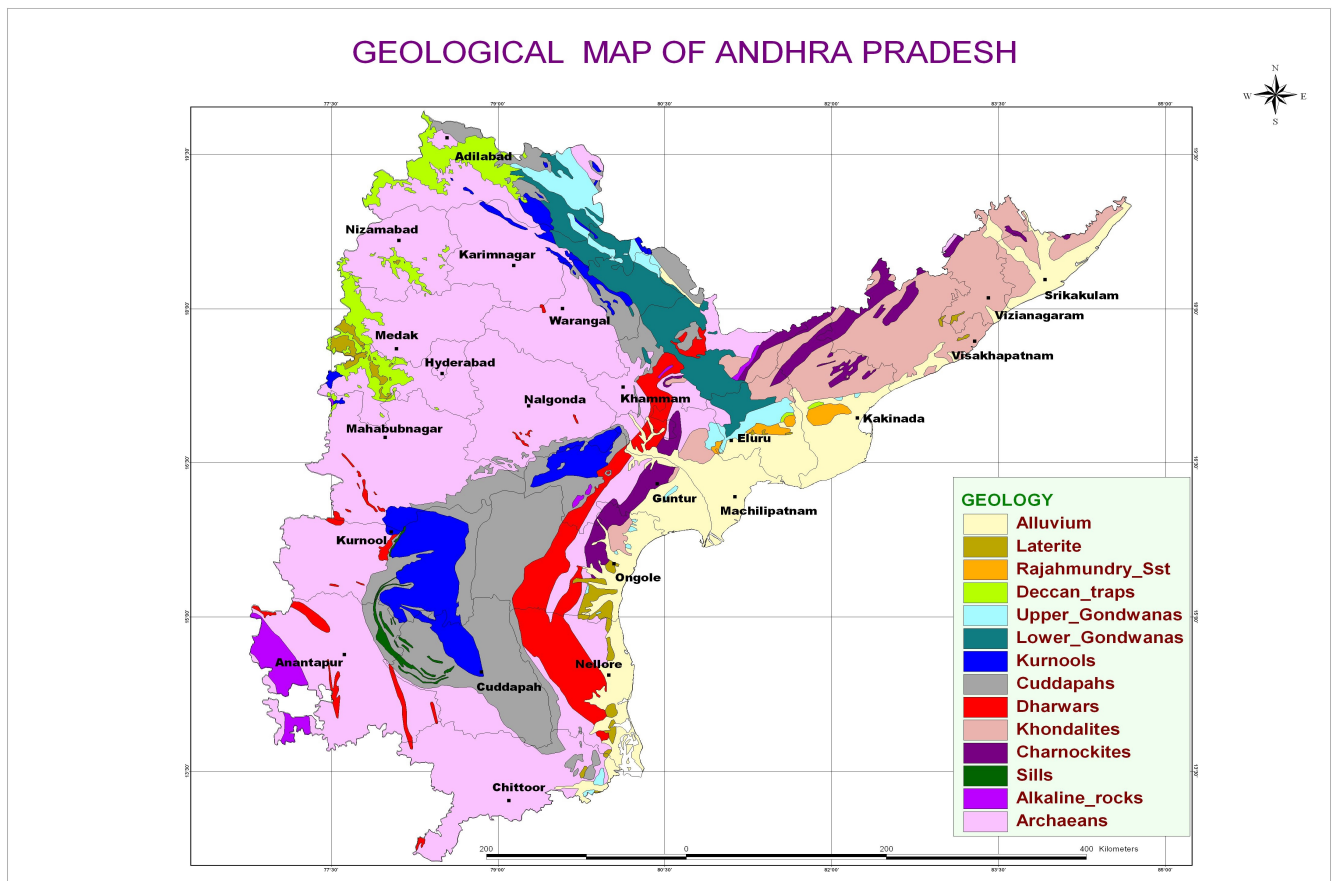


Figure 1: Geological Map of Andhra Pradesh

In hard rocks average well yields ranging from 75 to 150 l/m are recorded. However, present day mean well yields are around 0.50 ha.m per annum and they are skewed towards lower side. History of the wells shows that till 1970s there were mostly dug wells. Some of them could irrigate up to 10 or 15 acres (4 to 6 ha) of paddy in good monsoon years, especially if the area was served by small irrigation tanks. Wells that could sustain up to 5 acres (2 ha) were quite common. In 1980s the technique of drilling wells was well entrenched and initially some of the dug wells were converted to dug – cum – bore wells along and progressive farmers took up drilling of bore wells. Still it was quite common to find wells (now bore wells) irrigate 5 acres. The mean yield of the bore wells during this period was 2.47 ha.m and that of the dug wells with pumping facility was 0.91 ha.m. But with state's support through financial institutes for well sinking programme in 1990s, the number of bore wells started proliferating. And simultaneously, during this decade the mean well yields started showing a decline. During this decade (2000s), it is common to see bore wells irrigate less than an hectare of land due to decrease of well yields and deep water table. **An implication of this change is tragic wastage of energy.** Dug wells that pumped accumulated water from storage required just an hour of pumping to irrigate

2 acres of crop like groundnut. Present day bore well takes 6 to 8 hours of excruciatingly slow pumping to irrigate the same field.

### **Soft and unconsolidated Rocks**

**Gondwana rocks** form extensive aquifers and sustain well yields quite beyond their annual replenishment. Tube wells constructed in these rocks have yielded 100 to 1000 l/m for drawdowns ranging from 12 to 38 m. The open wells tapping these formations yield from 10 to 20 m<sup>3</sup>/day.

The **Kamthi** Sandstones beyond the depth of 250 m bgl are intercalated with shales and clays. Tube-wells constructed within the 200 m depth range yield from 100 l/m to 1000 l/m for drawdowns of 9 to 30 m. Transmissivity of the aquifer varies between 28 and 950 m<sup>2</sup>/day. The yield of tube wells in the Chinthalapudi Sandstones constructed down to 50 and 150 m bgl vary from 200 to 600 l/m and the transmissivity of the aquifer varies between 150 and 303 m<sup>2</sup>/day. These aquifers are confined and in some cases potentiometric surface lies above the ground surface giving rise to flowing wells / springs.

**Rajahmundry** sandstones are also good aquifers; the yields of tube-wells tapping these tertiary aquifers down to depths of 300 m vary from 200 to 1500 l/m for drawdowns of 6 to 15 m and transmissivity of the aquifer varies from 90 to 2500 m<sup>2</sup>/day indicating that these are the finest aquifers in the state.

The alluvial aquifers have high porosity and permeability. Filter points are most common in this formation. Filter points drilled down to 1.5 to 20 m bgl yield between 150 to 1500 l/m.

In Krishna-Godavari delta the alluvium attains a thickness of more than a few hundreds of metres. However, the deeper aquifers are found to contain highly saline water. The static water level in these formations is generally shallow. Groundwater in the coastal alluvium occurs both under water table and confined conditions and is generally developed by means of dug-wells, filter points and shallow tube wells. The depth to water table in dug wells varies from near surface to about 5 m bgl. Usually the quality of water is the main problem in coastal alluvium. Fresh water bodies occur as pockets and lenses in the top 20 m bgl. Deeper wells can lead to up-coning of salt water and fresh water interface, which can damage the groundwater irretrievably. Hence, the depth of the wells must be restricted to 4 or 5 m bgl. In Delta region of

Krishna, it is found that the sediments have connate water, which is not completely flushed out, and as a result the water quality is poor in deeper aquifers – mostly beyond 60 metres bgl.

The vast potential of these aquifers in terms of their ability to give huge quantum of water even when annual abstraction (usage) far exceeds recharge is a cause for concern. It is a political and administrative challenge that the civilised society must address thoughtfully. **At present however, a decline of 1 metre per annum is considered quite reasonable for next 25 years and it is hoped that by that time there will be a big shift from agriculture dominated society to industry dominated society that can take better care of its water resources. But studies are needed to devise measures to prevent the depletion and plan artificial recharge with full vigour in these areas. The economy as well as the rainfall of the region should make this easily possible.** The decision therefore is to allow well construction in all the soft rock areas of the state unhindered except in aquifers where quality of the water deteriorates rapidly with depth.

### **Chemical quality**

The **chemical quality** of groundwater exhibits considerable variations from place to place. The geological environment, climate and drainage have profound influence on its quality. Of late pollution by number of sources including the farm chemicals, etc is doing lot of harm and damage to groundwater system. The groundwater in Archaean crystalline rocks is in general neutral to alkaline and the chloride content ranges from 30 to 525 ppm. The quality of groundwater in Cuddapah and Kurnool formations is generally poor and TDS in some of these places exceeds 1000 ppm. The quality of groundwater from Gondwana formations is generally good except in some local patches. The groundwater from Gondwanas in parts of Karimnagar and Warangal is generally alkaline and in places excessively hard. The TDS of groundwater from trap rocks ranges from 200 to 300 ppm in upland areas and from 400 to 700 ppm in valley portions. Groundwater is often brackish to saline in black cotton soils associated with traps.

In Krishna and Godavari delta the quality of groundwater varies widely. The quality in the shallow zone is generally within potable limits, but deteriorates rapidly with depth.

Totally, 30 Mandals (East Godavari 10, Guntur 7 and Krishna 13) are categorized as poor quality areas and estimated separately. The groundwater quality in general is found to be not suitable for irrigation practices in these areas. However, some localized poor groundwater quality areas, identified in Anantapur, Kadapa, Kurnool, Nellore, Guntur and Vishakapatnam are not included in poor groundwater quality areas as groundwater is in use for irrigation. The

groundwater quality may vary from place to place and hence there may be pockets of better and usable groundwater in these otherwise poor quality groundwater areas.

### **Groundwater Estimation Methodology**

Groundwater assessment in India is made using computation techniques evolved mainly by the Central Ground Water Board, which actively co-ordinates with all the premier research institutes in the country and the NABARD. Besides, it also involves many state government agencies, and calls for individual opinions from across the country. In 1997 a detailed methodology along with guidebook giving all the computations needed for assessment was published by a high power committee of the MOWR, the Groundwater Estimation Committee. This is often referred as the **GEC 1997** methodology.

### **The State level committee for estimation of groundwater**

Government of Andhra Pradesh constituted a State level Groundwater Estimation Committee with 21 members, drawn from different Organisations dealing with groundwater and Universities, with the Principal Secretary, Irrigation and Command Area Development Department as Chairman and Director, Groundwater Department, as the Convenor vide G.O.Ms.No.321, dated 20<sup>th</sup> September, 1998 and G.O.Ms.No.156, dated 5<sup>th</sup> August 1999. The responsibility of Assessment of groundwater resource for the State was vested with the Ground Water Department.

The members of the Committee constituted at the State level for estimation of groundwater resources are given in Table-2

Table 2: The members of the Committee constituted at the State level for estimation of groundwater resource

1	Principal Secretary, Irrigation and Command Area Development Department, Government of A.P.	Chairman
2	Vice-chairman and Managing Director, AP State Irrigation Development Corporation Ltd., Hyderabad.	Member
3	Director, Agricultural Department, Govt. of A.P., Hyderabad.	Member
4	Joint Secretary (Inter State) Irrigation and Command Area Development Department, Government of A.P.,	Member
5	Chief Engineer (RWS), Panchayat Raj Department, Hyderabad.	Member
6	General Manager [Irrigation] National Bank for Agriculture and Rural Development, Hyderabad.	Member
7	Commissioner, Command Area Development Authority, Govt. of A.P.,	Member
8	Chief Engineer, Minor Irrigation, Govt. of A.P.	Member
9	Director, National Geophysical Research Institute, Govt. of India, Hyderabad.	Member
10	Director, National Remote Sensing Agency, Govt. of India, Hyderabad.	Member
11	Professor and Head, Department of Agronomy, Acharya N.G.Ranga Agricultural University, Hyderabad.	Member
12	Professor and Head, Department of Geology, Andhra University, Waltair.	Member
13	Professor and Head, Department of Geology, Osmania University, Hyderabad.	Member
14	Professor and Head, Department of Geology, Sri Venkateswara University, Tirupathi.	Member
15	Regional Director, Central Groundwater Board, Govt. of India, Hyderabad.	Member
16	Director, Directorate of Economics and Statistics, Hyderabad.	Member
17	Chief Engineer[REC], Andhra Pradesh State Electricity Board, Vidhyut Soudha, Hyderabad	Member
18	Managing Director, Andhra Pradesh Scheduled Castes Cooperative Finance Corporation Ltd., Hyderabad	Member
19	Managing Director, Andhra Pradesh State Cooperative Rural Irrigation Corporation Ltd., Hyderabad	Member
20	Chief Project Manager, Rural Electrification Corporation, Vidhyut Soudha, Hyderabad.	Member
21	Director, Groundwater Department, Hyderabad	Convenor
	Special invitees Commissioner WCM and Special Commissioner WALAMTARI	

Considering the requirement of enormous data and the constraints in obtaining the reliable data from various sources, a small 'Technical Group' was constituted with NABARD, Department of Economic and Statistics, CGWB and APSGWD to deliberate and evolve procedures for collecting the required data, validating the data, and for estimating the resource using the



available data. In addition to the three State level meetings, the technical group met 8 times during 1999-2001 and the following decisions were taken based on the recommendations of both groups:

- Unit draft can be based on field inventory in 5 to 10 sample villages in each district.
- Number of wells to be taken from the Chief Planning Offices, Mandal Revenue Offices and the records maintained by the Department of Economics and Statistics and A.P.Transco figures for comparison.
- Recent Minor Irrigation Census data can be adopted, wherever latest figures are not available and to apply growth rate as applicable. Growth rate shall be based on growth of power connections under irrigation sector as given by APTransco.
- Wherever, available APTransco's data giving number of electrical connections under the irrigation section can be used straight away as equal to the number of wells.
- To use area irrigated under surface water sources, wherever, data on canal releases is not available.
- To use a spreadsheet programme developed by the department, tested and the approved by the technical committee.
- The recommendation are likely remain valid in future except those on year of M.I. Census (where new data from future censuses should be used) and these can be adopted for all future estimations too.

### **Data collection and data base constraints**

The computations of groundwater draft and recharge are dependant on village level statistical information collected from various sources which include irrigation and drinking water well population and energisation information collected from Mandal Revenue Officer, A.P.Transco, Chief Planning Officer, Panchayat Raj Department; Rainfall data collected from Mandal Revenue Officer, India Meteorological Department and Chief Planning Officer. Surface water canal and distributaries details which includes length, type of canal, days of canal operation, wetted area etc., collected from Irrigation Department, groundwater and surface water irrigated area with cropping pattern collected from Irrigation Department, Mandal Revenue Officer and Agriculture Department; Number of Tanks and ponds with details of water spread area, days of water available etc., collected from Irrigation and Command Area Development Department, Panchayat Raj Department and derived from Toposheets, details of recharge structures which include storage volume, number of fillings etc., collected from Irrigation, Panchayat Raj Department

Rural Development, Forest and other departments. The inaccuracies in the database available, particularly in the well census data is validated to some extent through field checks, comparing with APTransco and adopted validated figures based on the field checks done by the Departmental officers.

### **The water level record**

The spatial and temporal changes in groundwater levels are monitored through a network of observation wells, spread over the State. The water levels and the fluctuations noticed seasonally, annually and over long term are related to factors such as rainfall, drought and extraction of groundwater in the area and reports compiled on monthly and annual basis.

The monitoring network of the state's observation wells and Piezometers is shown in the Table 3.

Table 3 Monitoring network of the Observation Wells and Piezometers

1	Observation wells in non-command areas	1141
2	Observation wells in command areas	1647
3	Piezometers	1017
4	Piezometers with AWLRs	888

The CGWB is also monitoring the changes in groundwater through their own network of 1000 observation wells and 200 piezometer wells and the data is also being integrated and utilised with the State Ground Water Department's data.

### **Groundwater estimates:**

Groundwater Estimates are being carried out by Ground Water Department from time to time to facilitate the planners, implementers and users of ground water resource.

The present(2007) estimations are done for command & non-command and shown in the table 4.

**Table: 4****Groundwater Resource 2007**

<b>Sl. No</b>	<b>Description</b>	<b>Com-mand</b>	<b>Non-com-mand</b>	<b>Poor ground water quality area</b>	<b>Total</b>
<b>1</b>	<b>Area considered for recharge in Sq.Kms.</b>	<b>58765</b>	<b>179498</b>	<b>6964</b>	<b>238263</b>
<b>2</b>	<b>Net annual groundwater availability in MCM</b>	<b>16814</b>	<b>17886</b>	<b>2623</b>	<b>34700</b>
<b>3a</b>	<b>Current gross annual groundwater draft for Irrigation in MCM</b>	<b>3310</b>	<b>9774</b>	<b>-</b>	<b>13084</b>
<b>3b</b>	<b>Current gross annual groundwater draft for Domestic and Industrial needs in MCM</b>	<b>276</b>	<b>752</b>	<b>-</b>	<b>1028</b>
<b>3c</b>	<b>Current gross annual groundwater draft for all uses in MCM</b>	<b>3586</b>	<b>10526</b>	<b>40</b>	<b>14112</b>
<b>4</b>	<b>Net annual groundwater availability for future use in MCM</b>	<b>13228</b>	<b>7360</b>	<b>-</b>	<b>20588</b>
<b>5</b>	<b>Stage of development (%)</b>	<b>21</b>	<b>59</b>	<b>-</b>	<b>41</b>
<b>6</b>	<b>Allocation for domestic and industrial needs in MCM</b>	<b>740</b>	<b>2075</b>	<b>-</b>	<b>2815</b>

The district wise details are presented in the statements that follow this text. Figure: 2 gives a summary of these results separated into command, non-command and total resource.

**Figure: 2**

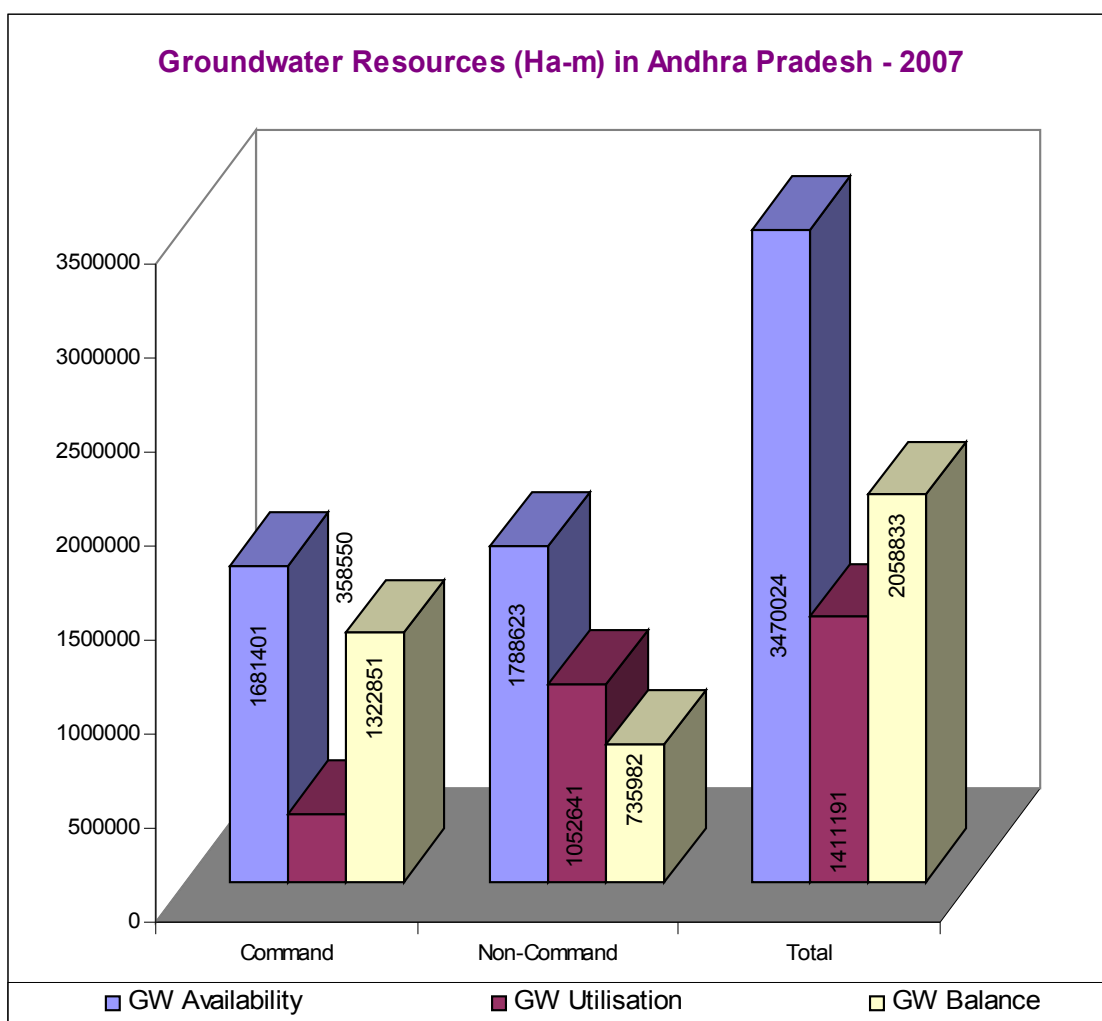


Figure 2: Ground water resource of Andhra Pradesh

Mean hydrograph of the state records a fall of 1.90 metres (Hydrograph) in last 9 years. The fall of hydrograph (1.90m) is not much varying from what was recorded (1.95m) during GEC-2005, because the average stage of development in the state has come down to 41% compared to 45% reported during GEC-2005. On the whole there is an increase of ground water utilisation in only 5 districts Anantapur, Chittoor, Krishna, Guntur and Srikakulam by 1% to 18% compared to previous stage of development.

In coastal districts the stage of ground water development ranges from 11% (Guntur) to 38% (Nellore). The three districts of coastal area Srikakulam, Guntur and Krishna show an increase in stage of development compared to previous estimates and in all other six districts of coastal regions the usage of ground water is decreased marginally.

In Ryalseema region the stage of development ranges between 37% (Kurnool) and 90% (Anantapur). The Anantapur shows an increase in stage of development and other three districts Kurnool, Kadapa and Chittoor show decrease in stage of development compared to previous estimates.

In Telangana region the stage of ground water development varies from 18% (Khammam) to 99% (Rangareddi). In Nalgonda district there is an increase in use of ground water and stage of development raised from 52% to 53%. In all the eight other Telangana districts the stage of development is decreased by 2% (Khammam) to 13% (Mahabubnagar) compared to previous estimates.

The estimates of 2005 were made taking the data from APTANSCO and Statistics Department and applying reasonable corrections based on the experience of Groundwater field officers. Presently, 2007 assessment is carried out by collecting the required statistics from APTRANSCO, Revenue Department and Irrigation Department and applying reasonable correction factors based on the field observations.

The assessment shows that the districts can be grouped into four categories (Figure: 3).

- a. The *very high usage* (over all stage of development >70%) districts comprising RangaReddy (Hyd), Anantapur, Nizamabad and Medak.
- b. The *high usage* districts (over all stage of development >50% & <70%) Kadapa, Chittoor, Warangal and Nalgonda.
- c. The *moderate usage* (over all stage of development >30% & <50%) districts Mahabubnagar, Karimnagar, Adilabad, Nellore, Kurnool and Prakasam.
- d. The *low usage* (over all stage of development <30%) districts Krishna, Srikakulam, West Godavari, Visakhapatnam, Vizianagaram, East Godavari, Khammam and Guntur

**Fig: 3**

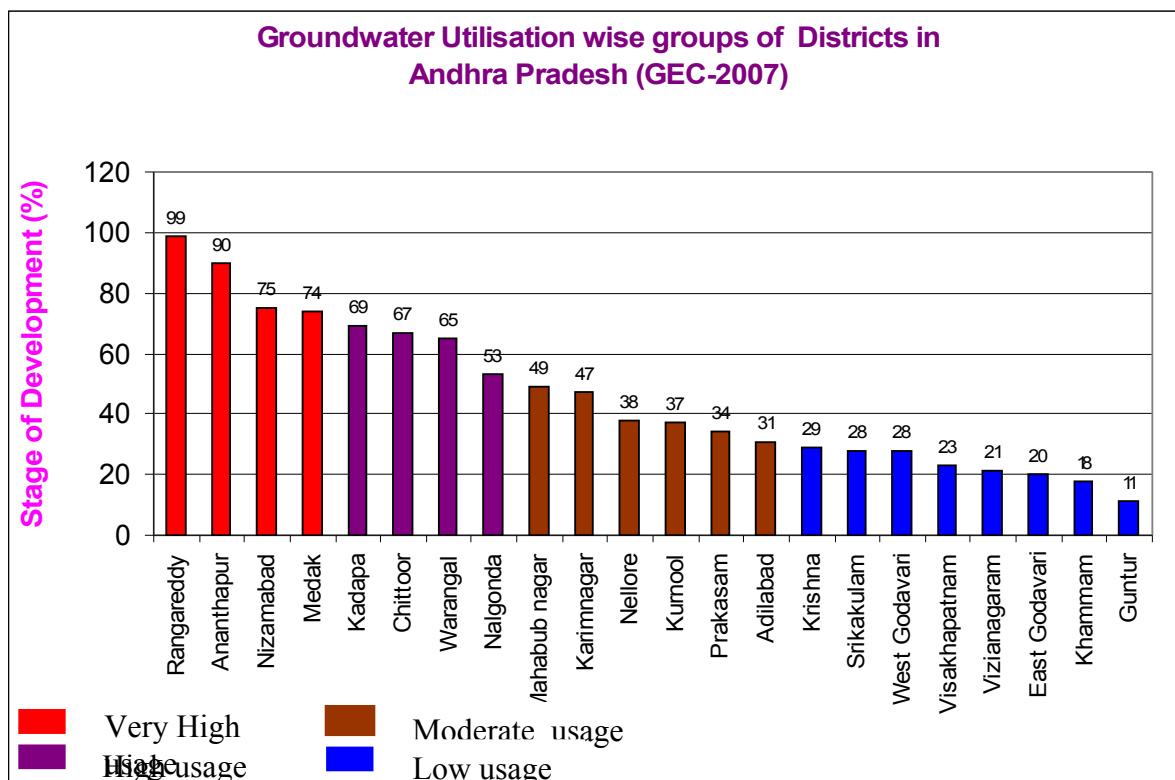


Figure: 3 GW utilisation wise groups of districts in A.P.

**Fig: 4**

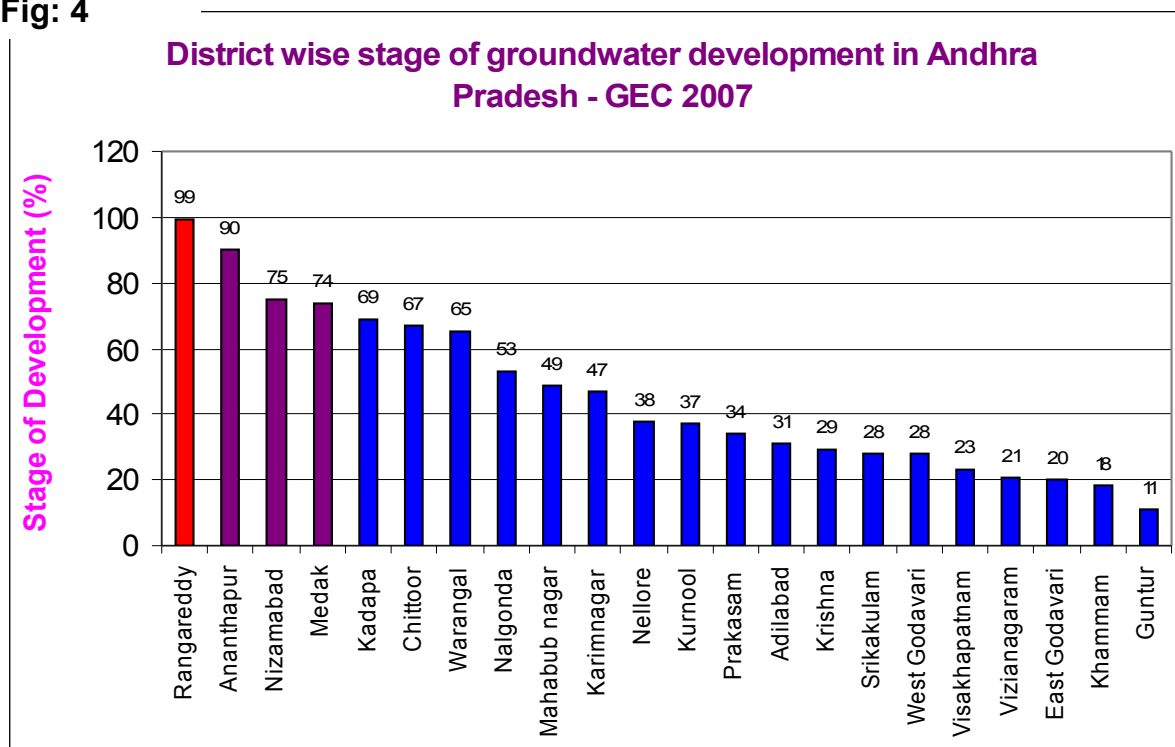


Figure: 4 District wise stage of ground water development in descending order.

Based on the present **Stage of development**, the State has 132 units under *over exploited* category, 89 units under *critical* category, 175 units under *semi-critical* category and 833 under *safe* category groundwater watersheds(Figure 5). The following table-5 shows the number of watershed in different categories for the year 2007.

**Table – 5: No.of watersheds in different categories**

S.No	Categroy	No.of Watersheds
1	Over Exploited	132
2	Critical	89
3	Semi Critical	175
4	Safe	833

**Fig: 5**

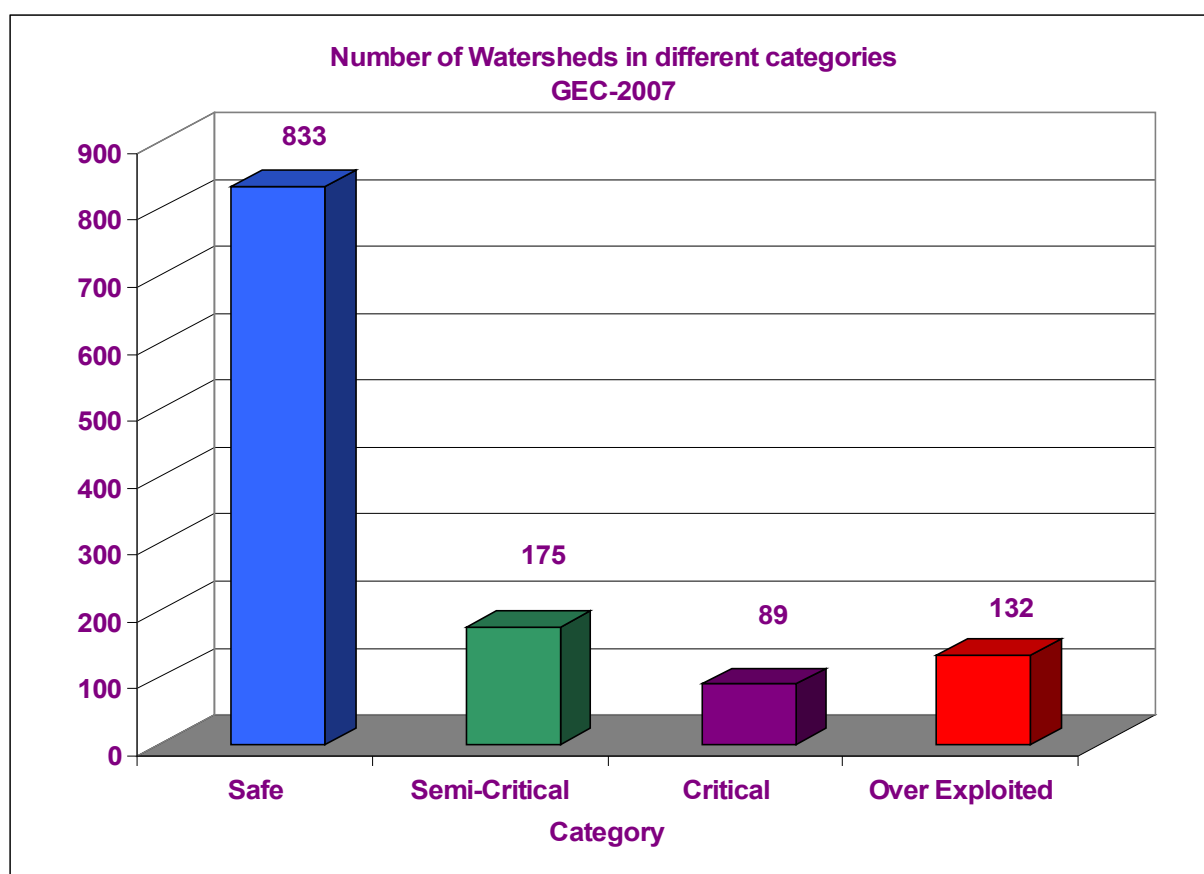


Figure: 5 No.of watersheds in different categories

Groundwater resources have reached a very critical stage in Non-Command areas and thoughtful use, conservation and management is required. All the areas of the state that are not served by canal command including the areas in districts like West Godavari to districts like Ananthapur are showing very high usage of the available groundwater and it is reflected in the stage of development which exceeds 70% and which is perceived as the limit to which the aquifers can be safely exploited. Although, the choice would be 40 to 50% if the environmental considerations are applied too.