



## **Spatial Dynamics of Forest Cover in Y.S.R District Andhra Pradesh, India**

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### **Authors' contributions**

*This work was carried out in collaboration between both authors. Author PJS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author KV managed the analyses of the study and managed the literature searches. Both authors read and approved the final manuscript.*

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### **ABSTRACT**

Forest is a significant industry and a major environmental resource in India which grew at 0.22% annually over 1990-2000, and has grown at the rate of 0.46% per year over 2000-2010, after decades where forest degradation was a matter of serious concern. In 2010, the United Nations estimated India's forest cover to be about 68 million hectares, or 24% of the country's area. In 2013, Forest Survey of India indicated the forest cover increased to 69.8 million hectares by 2012 as per satellite data. India is the world's largest consumer of fuel-wood, as 80% of rural people and 48% of urban people; use fuel-wood. Unless India makes major, rapid and sustained effort to expand electricity generation and power plants, India will continue to meet their energy needs through the unsustainable destruction of forests and fuel wood consumption. India's dependence on fuel-wood and forestry products as a primary energy source is not only environmentally unsustainable; it is a primary cause of India's near-permanent haze and air pollution. The forest or natural vegetation is

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indeed a priority in land protection measures for producing food, preserving biodiversity and facilitating the natural management of water systems. The underlying biophysical and anthropogenic causes of land degradation are multiple and overlapping. To effectively tackle desertification, land degradation and drought conditions should be addressed and instruments designed to incentivise the sustainable management of lands. The forest cover of YSR district of Andhra Pradesh is no exception. Different forest types have been analysed using Remote Sensing Satellite data with non-spatial data of forest information.

*Keywords: Natural-vegetation; land-resource; bio-physical; land-degradation.*

## 1. INTRODUCTION

The forests are natives of ecosystems, biomes, soils, and species etc., which are helpful to human beings. We live in the environment of live gas (O<sub>2</sub>) realised by trees with soak up CO<sub>2</sub> from the atmosphere. The forests are economic benefits to mankind and certain spices of forests are more economical than minerals. The change of climate gives drastic impact on forests with respect to area, locality of trees, ecosystems, biomes etc. The areal extent forest depends upon the prevailing climate over a particular region and the area covered by forests is very likely to change under climate change, with shifts occurring between forest types due to changing temperature and precipitation regimes. Currently, however, it is very difficult to separate forest area change due to climate change from area changes due to other factors (Lucier) [1]. The change of forest area is due to economic and social effects. The effects may be much longer lasting and devastating - degraded and young forests are easily converted into agricultural land and pastures (Williamson) [2]. The forests enact the various ecosystems in different parts of the world depending upon the prevailing climatic conditions in a particular zone. The ecological life zones are limited by temperature, precipitation and humidity (Holdridge) [3]. Several researchers have attempted to estimate the impact of climate change on the forests of Central America, based on estimated shifts of the life zone boundaries like Nicaragua and Costa Rica (Mendoza) [4]. The forest species are distinct from one part of the world to another. The change of climatic condition over prevailing forest results the geographical shifts of species mainly because some species are able to adapt better to changing conditions (Breshears) [5]. In general, many species tend to move to higher latitudes or higher altitudes (Rosenzweig) [6].

Climate change is expected to increase the frequency and intensity of extreme weather events, such as hurricanes, torrential rains and droughts. Rural people often depend on

emergency supplies during or just after such events. Forests, in many cases in the past, have provided such emergency supplies or safety nets (Osman-Elasha) [7]. Forests have long been recognised as contributing to water and soil protection and in several countries, this has been translated into systems that pay for these services (Postel and Thompson) [8]. Their positive influence on water regulation, however, is still discussed by foresters and hydrologists (Kaimowitz) [9].

Reducing deforestation and forest degradation in the tropics (REDD+) is an emerging priority in the global environmental agenda [10]. A large literature on policy options for REDD+ focuses primarily either on evaluating REDD+ readiness activities [11]. Few systematic studies have examined what past forest policies can tell us about the potential efficacy of different options (but see Busch and Ferretti-Gallon, 2017) [12]. In contrast with the views of many REDD+ policy designers who see government action and international cooperation as keys to reducing forest loss, many scholars in the political ecology tradition see these as primary causes of forest destruction [13]. In the global payment for ecosystem services aspect the states like Costa Rica and Mexico are global pioneers in the use of payments for ecosystem services, and indeed, a recent global review found that the only spatially explicit econometric studies of payments for ecosystem services in the world were from these two countries [14].

Postel, S.L, Thompson, B.H [15] assessed the value of forest land for source water mitigation of total organic carbon (TOC) through the use of linked watershed and reservoir simulation models and cost-based valuation economics. Kaimowitz, D [16] pointed out that Forest management and Climate change: A literature review, climate change will effect forest conditions in terms of area, health and vitality and biodiversity, allowing increases in growth rates in some areas while endangering the survival species and forest communities in

others. Venugopal B. & Geetha R [17] quoted that Climate change is altering the world's water resources.

Forest Cover is defined as all lands, more than one hectare in area, with a tree canopy density of more than 10%. Following are the forest types used in the research purpose:

1. Dense Forest: [Bifurcated into Very Dense Forest & Moderate Dense Forest]
  - Very Dense Forest: All lands, with a forest cover with canopy density of 70% and above
  - Moderately Dense Forest: All lands, with a forest cover with canopy density of 40-70 %
2. Open Forest: All lands, with forest cover with canopy density of 10 to 40%
3. Non Forest Land: defined as lands without any forest cover
4. Scrub Forest: All lands, generally in and around forest areas, having bushes and or poor tree growth, chiefly small or stunted trees with canopy density less than 10%

Topographically, the YSR district is suitable for natural vegetative cover due to the presence of undulating relief structure with the impact of Eastern Ghats. The relief is predominant of mountains, valleys and plateaus which are more suitable for forest cover. However, forest cover refers to all lands more than one hectare in area, with a tree canopy density of more than 10 per cent irrespective of ownership and legal status. While fulfilling this definition, the total forest cover is noticed as 5,20,203 hectares constituting about 33.88 per cent of the total geographical area of 15,35,900 hectares of the district.

The forest area of YSR district of Andhra Pradesh is divided broadly into three forest divisions viz., Kadapa, Proddutur and Rajampet. Kadapa forest division lies in the central part of district covering an area of 2,18,553 hectares constituting about 14 per cent of the total forest area. Proddutur forest division has an area of 1,57,537 hectares stands second with a percentage of 10 and lastly, the Rajampet forest division which is located in the southern and southern eastern parts of district with an area of 1,44,113 hectares constituting of about 9 per cent of the total forest area.

### 1.1 Objectives

1. To analyze the natural vegetative cover
2. To examine the temporal variations of forest types

3. To co-relate different forest types in YSR District

## 2. METHODOLOGY

The Satellite data is collected from National Remote Sensing Centre, ISRO, Department of Space Government of India, Andhra Pradesh State forest department and Chief Planning Office of YSR district. The districts' forest cover has been analyzed using Indian Remote Sensing Satellite data of IRS-1C, 1-D and P-6 with LISS-III sensors having a resolution of 23.5 metres. The FCC [False Colour Composite] of the satellite data has been classified using Erdas Imagine software to map forest cover in the district forest division-wise initially. The scale of the rectified satellite data is 1: 50,000. The classified data is presented in the GIS environment using ARC/GIS version 10.0 for generation of various maps upon analysis of spatial and non-spatial data of forest information.

### 2.1 Study Area

The study area YSR district is one of the four districts of Rayalaseema region of Andhra Pradesh state. The district lies approximately between 13° 43' to 15° 14' North Latitudes and 77° 55' to 79° 39' of East Longitudes.

The annual rainfall is less than 600 mm sometimes being as low as 550 mm. The West and North-west parts receive about 300 to 350 mm from the South-west Monsoon and 150 to 200 mm from the North-east Monsoon.

The study revealed that:

1. The western and north-western parts more prone to drought than the rest of the district.
2. YSR district may be classified as drought district exclusively.
3. The probability of drought occurrence in YSR district once in seven years.
4. The Meteorological droughts years and famine years in most of the cases coincide.
5. About 36 famines have occurred over a period of 183 years, from 1790 to 1972.

In the first half of the period the drought years are eleven and in the latter half, they are twenty five. The probability of drought during the former is once in eight years while the latter it is once in three to four years [47 months]. From this it is clear that the study area received comparatively less rainfall in the 20<sup>th</sup> century than in the 19<sup>th</sup> century.

'The Great Famine of 1876 – 78' has been one of the most disastrous famines that had ever visited this district including the neighbouring districts. It was cataclysmic in its effects. It killed over hundreds of thousands of besides leaving many millions disabled [physically and mentally]. Severe millions of rupees worth of property were lost in the terrible calamity. This famine, like such other scourges in the past and since then, had been caused by a drought of three successive seasons. The rainfall of 1874 had been unusually excessive [about 40 inches] causing damage to standing crops and breaching several tanks. The rainfall of 1875 was deficient and of 1876 a near failure. A little of over 7 inches of rainfall in 1876 was less than 30% of the normal [27 inches]. The failure of NE monsoon of 1876 and the SW Monsoon of 1877 was so complete that not a blade of grass could be grown. The total absence of work in agriculture had created a serious problem of survival to the agricultural population. Failure of crops caused an unprecedented rise in process of food grains keeping food beyond the reach of the multitude. Prices of the staple grains such as Jonna, Ragi etc., registered a 2/3 percent rise by the beginning of 1877. At the height of the famine more than 0.5 million people were in receipt of relief. The partial rains of September-October 1877 and the breaking of the SW Monsoon rains 1878 had brought the famine to a close. Relief works were closed by October 1878 as many of the affected people could find work in land. The great famine had demonstrated that Indra and Vayu still hold the key to the misery or progress of the people.

## 2.2 Analysis

The satellite data pertaining to 9 years viz., 2000, 2002, 2003 2005 to 2010 is used for the analysis part and the observations in the form of forest types like Dense Forest, Open Forest, Scrub Forest and Non-Forest respectively. The averages of the forest types are as follows; Dense Forest accounts for 11 per cent with an area of 51,542 hectares of the total forest area, Open Forest with an area of 2,50,703 hectares constitute about 53 per cent is considered to be the dominant forest type. The Scrub Forest having an area of 1,46,552 is the second highest category with 31per cent while the Non-Forest is only 22,000 hectares having the least share of 5per cent respectively. During the course of the analysis, the Non-Notified areas are not taken into account though it represents about 17,000 hectares in the YSR district (Table 1).

The change detection is made on satellite data to observe forest cover changes from 2000 to 2010. The changes do appear not only for the total area of the forest cover but also for different forest types of the district. The dynamic change on the positive side is observed in dense and open forest cover, dense forest cover (VDF [very dense forest] and MDF [medium dense forest]) increased 7.78 per cent in 2000 to 13.69 per cent area in 2010; while in open forest cover increased from 50.12 per cent to 52.66 percent [2000 to 2010]. The negative change is detected in scrub forest areas because of the conversion of these lands into agriculture and other economic activities in the district. In open forest, the decrease forest cover around 10 per cent is observed from 2000 to 2010.

### 2.2.1 Kadapa forest division

Kadapa forest division lies between 13°50' to 14°40' North latitudes and 78°14' to 79°39' East longitudes. Different forest types have been identified by using satellite data for 9 years, starting with the year 2000. The highest percentage of forest cover in this division is Open forest accounting to about 1,13,737 hectares contributing to 52 per cent of total forest of the division, followed by Scrubs spreading an area of 81,378 hectares (37%) and Dense forest cover of 15,009 hectares (7%). The remaining area in this division is the Non-forest lands considered as blanks and water bodies (Table 2).

The change detection in Kadapa division is observed from 2000 to 2010 [except 2001 & 2004]. The change is majorly found in dense forest types including both very dense forest area and moderate dense forest area. The percentage of dense forest cover increased from 2000 to 2010 which is around 5 per cent. The highest dense forest cover is observed in 2008 with around 10 per cent, followed by 9.86 per cent in 2007. The positive change is also identified in Open forest type, which is increased from 45 per cent in 2000 to 52 per cent in 2010 to the total forest cover in division. The highest open forest is recorded in 2008, which is around 60 per cent, followed by 2007 with 58 per cent. The negative change is recognized in scrub forest area, because of the reason that the species of this lands are majorly uses for fire-wood and other economic purposes, hence the decrease of scrub forest in Kadapa division, which is around -10 per cent (Table 2).

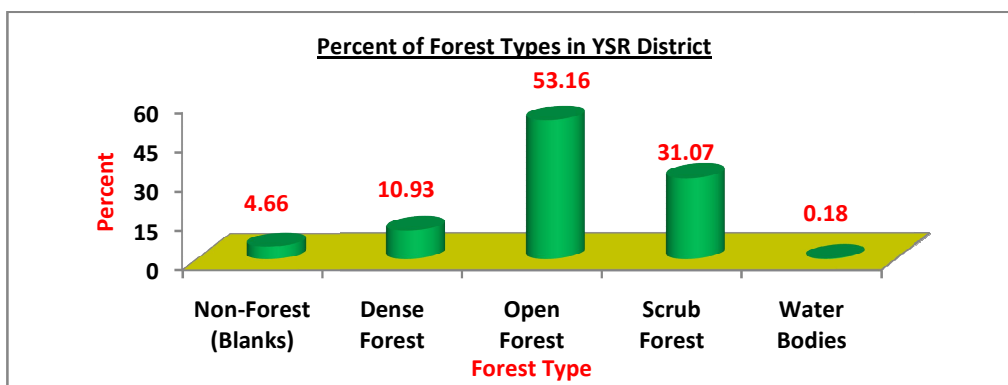


Fig. 1. Different forest types in YSR district of Andhra Pradesh state

Table 1. Forest types in YSR District

Percentage of forest types in YSR district, 2000, 2002-2003 & 2005-2010							
S. no.	Year	Total forest area (Hectares)	Non-forest (Blanks)	Dense forest	Open forest	Scrub forest	Water bodies
1	2	3	4	5	6	7	8
1	2000	4,74,435.49	1.82	7.78	50.12	40.24	0.05
2	2002	4,74,664.65	2.64	8.08	53.38	35.86	0.04
3	2003	4,71,660.30	2.23	8.69	53.41	35.62	0.04
4	2005	4,74,483.75	1.50	9.19	54.17	35.09	0.06
5	2006	4,74,358.63	1.39	9.28	54.28	34.99	0.06
6	2007	4,65,703.60	7.21	13.97	53.74	24.81	0.26
7	2008	4,59,436.29	7.33	14.10	54.00	24.33	0.23
8	2009	4,74,896.48	8.99	13.70	52.68	24.22	0.41
9	2010	4,75,079.28	8.98	13.69	52.66	24.21	0.45
10	Average	4,71,635.39	4.66	10.93	53.16	31.07	0.18

Source: Chief planning office, Kadapa

Table 2. Forest types in Kadapa Forest Division

Percentage of Forest Types in Kadapa Forest Division-2000, 2002-2003, 2005-2010							
S. no.	Year	Total forest area (Hectares)	Non-forest area (Blanks)	Dense forest	Open forest	Scrub	Water bodies
1	2	3	4	5	6	7	8
1	2000	1,71,571.00	3.21	4.50	45.09	47.18	0.01
2	2002	1,72,130.50	5.15	4.03	47.94	42.87	0.01
3	2003	1,71,654.00	4.61	4.54	48.26	42.58	0.01
4	2005	1,71,655.00	2.84	4.92	48.42	43.79	0.04
5	2006	1,71,653.10	2.49	4.94	48.38	44.15	0.04
6	2007	1,67,121.40	2.62	9.86	58.26	29.14	0.12
7	2008	1,60,961.00	2.65	10.08	59.16	28.04	0.07
8	2009	1,71,471.80	5.29	9.61	56.77	28.30	0.03
9	2010	1,71,653.60	5.28	9.60	56.71	28.27	0.13
10	Average	2,18,553.10	3.80	6.87	52.04	37.23	0.05

Source: Chief planning office, Kadapa

### 2.2.2 Proddutur forest division

Proddutur forest division located on the northern part of the YSR district lies between 14°19' to 15°13' North latitudes and 77°14' to 79°38' East

longitudes. Different forest types have been examined and the highest percentage of forest cover in this division is Open forest accounting about 67,205 hectares contributing to 43 per cent to the total forest of division, followed by Scrubs

spreading an area of 51,163 hectares (35%) and Dense forest cover of 25,417 hectares (16%). The remaining area is shared by Non-forest lands and water bodies (Table 3).

The change detection in Proddutur division indicates majorly in dense forest and open forest types. The positive changes occurred exclusively in dense forest type, which is around 10 per cent increment and is the second largest forest land in this Proddutur division with around 28 per cent. It was in third place from 2000 to 2006, later drastic changes have taken place to protect these forests by state and central government policies. There is a negative growth rate in open and scrub forest types. The highest negative growth rate is recorded in scrub forest because these forests are majorly used for economic purposes like mining, fire-wood etc. The second highest negative growth rate is recorded in open forest type, which was 45 per cent during 2000 and fell down to 35 per cent in total forest cover of

Proddutur division. The non- forest lands have been drastically increased in this particular Proddutur forest division from 1 per cent in 2000 to 17.9 in 2010 (Table 3).

### 2.2.3 Rajampet forest division

Rajampet forest division which is located in the southern and southern eastern parts of the district lies between 13°46' to 14°23' North latitudes and 78°44' to 79°28' East longitudes. The different forest types have been examined and the highest percentage of forest cover in this division is Open forest consisting an area of 95,036 hectares contributing to 66 per cent of total forest cover in this division, followed by Scrub forest type with 32,094 hectares (22%) and least percentage shared by Dense forest type with 14,451 hectares (10.03%). The remaining percentage shared by Non-forest lands and Water bodies (Table 4).

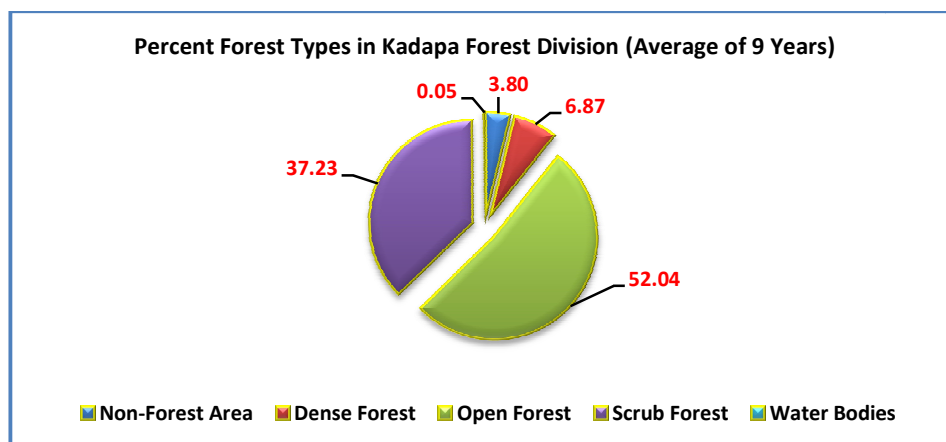


Fig. 2. Forest types in Kadapa Forest Division

Table 3. Forest types in Proddutur Forest Division

Percentage of Forest Types in Proddutur Forest Division in 2000, 2002-2003 & 2005-2010							
S. no.	Year	Total	Non-Forest Areas (Blanks)	Dense Forest	Open Forest	Scrub	Water bodies
1	2	3	4	5	6	7	8
1	2000	1,57,669.8	1.02	6.36	45.70	46.87	0.05
2	2002	1,57,333.3	1.46	6.44	48.66	43.39	0.04
3	2003	1,57,634.8	0.76	7.21	49.54	42.45	0.03
4	2005	1,57,636.1	0.74	7.92	49.73	41.57	0.04
5	2006	1,57,511.5	0.73	8.10	49.95	41.17	0.04
6	2007	1,57,511.7	17.79	27.30	35.10	19.24	0.57
7	2008	1,57,511.3	17.86	27.30	35.10	19.24	0.50
8	2009	1,57,511.7	17.90	27.30	35.07	19.17	0.57
9	2010	1,57,511.7	17.90	27.30	35.07	19.17	0.57
10	Average	1,57,536.9	8.46	16.13	42.66	32.48	0.27

Source: Chief Planning Office, Kadapa

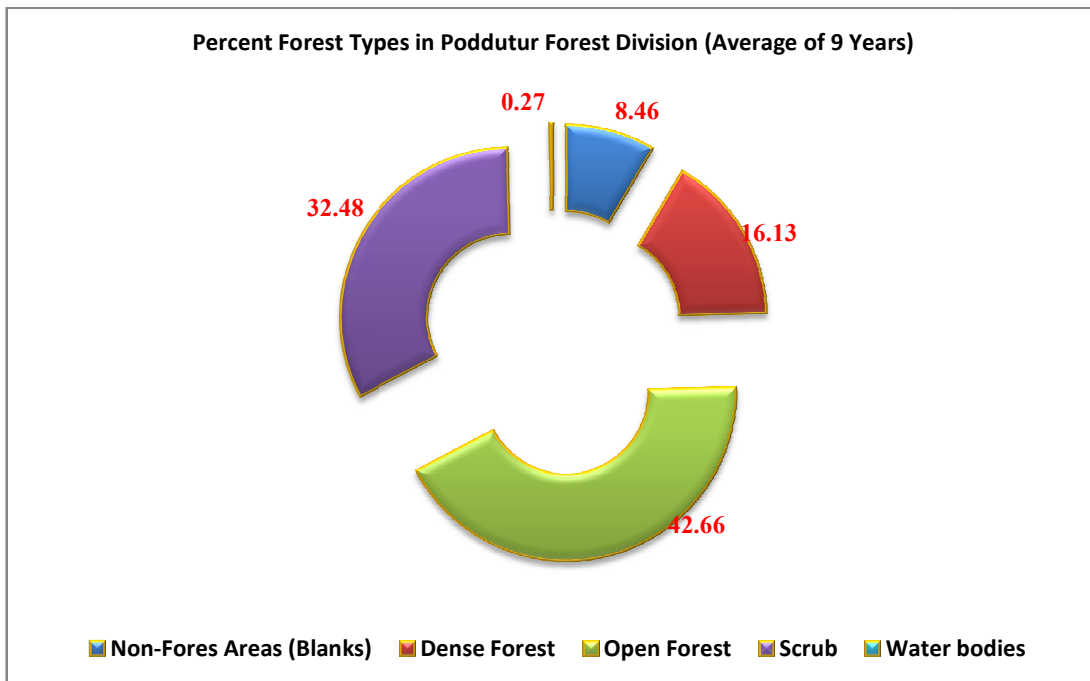


Fig. 3. Forest types in Poddutur Forest Division

Table 4. Forest types in Rajampet Forest Division

Percentage of Forest Types in Rajampet Forest Division in 2000, 2002-2003 & 2005-2010							
S. no.	Year	Total	Non-Forest Area	Dense Forest	Open Forest	Scrub	Water bodies
1	2	3	4	5	6	7	8
1	2000	1,45,194.7	1.03	13.22	60.85	24.82	0.09
2	2002	1,45,200.9	0.94	14.65	64.93	19.39	0.09
3	2003	1,42,371.5	1.00	15.32	63.92	19.67	0.09
4	2005	1,45,192.6	0.74	15.64	65.78	17.75	0.09
5	2006	1,45,194	0.81	15.70	65.95	17.44	0.10
6	2007	1,41,070.6	0.85	3.95	69.19	25.91	0.10
7	2008	1,40,964	0.92	3.95	69.24	25.79	0.10
8	2009	1,45,913	3.71	3.82	66.89	24.89	0.69
9	2010	1,45,914	3.71	3.82	66.89	24.89	0.69
10	Average	1,44,112.8	1.53	10.03	65.95	22.27	0.23

Source: Chief Planning Office, Kadapa

The change detection identified in Rajampet forest division since 2000. It is observed that majority of changes have appeared only in open forest type while the remaining forest areas indicate almost static. But there is dynamic decline in dense forest type in this Rajampet forest division. There is a positive change in open forest type with 6 per cent increase from 2000 year. The highest percentage of open forest cover identified is in 2007 & 2008 with 69

per cent of total forest cover in this region. Scrub forest occupied the second largest forest cover in Rajampet forest division, has come down to 17 per cent in 2005 & 2006 and arose with existing percentage of 25 per cent. In dense forest type, the drastic decline is from 13 per cent to 4 per cent from 2007 to 2010. The non-forest land has been increasing and reached 4 per cent and there is not much change in water bodies (Table 4).

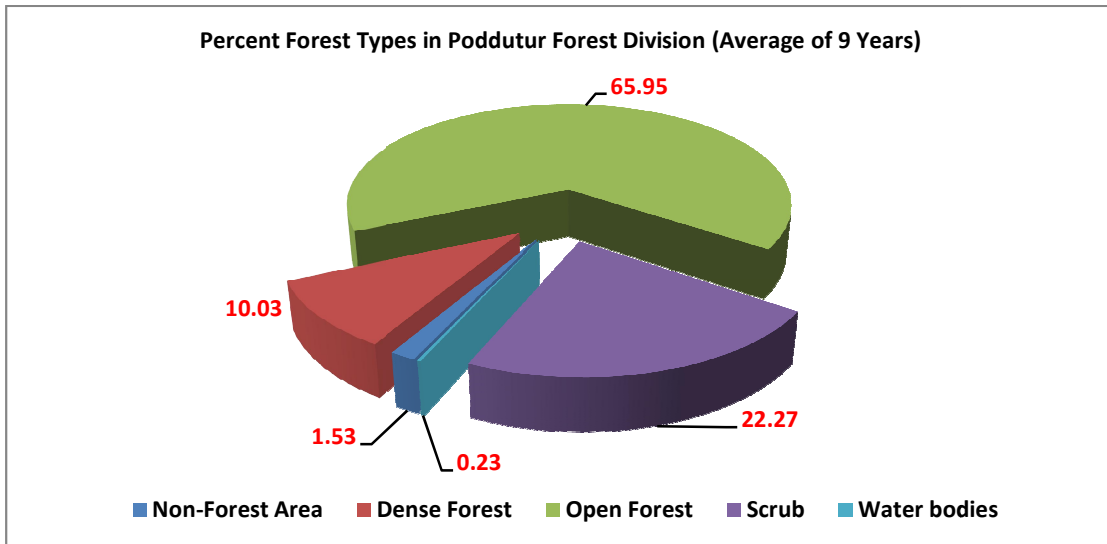
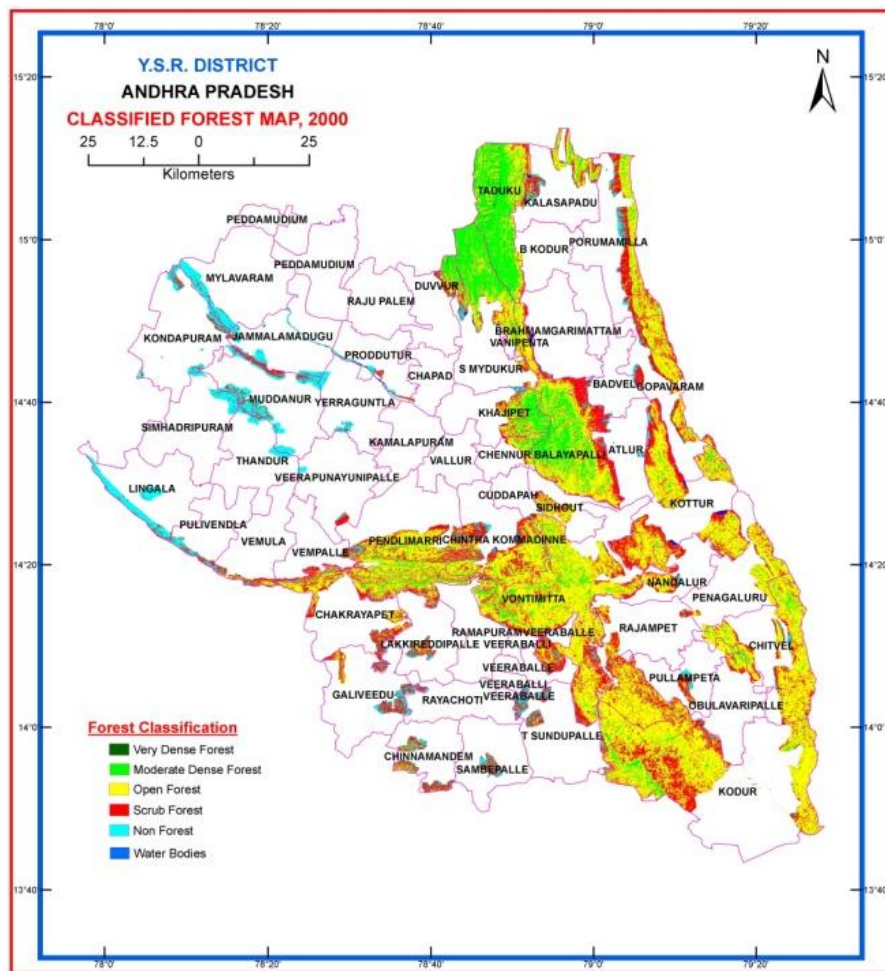
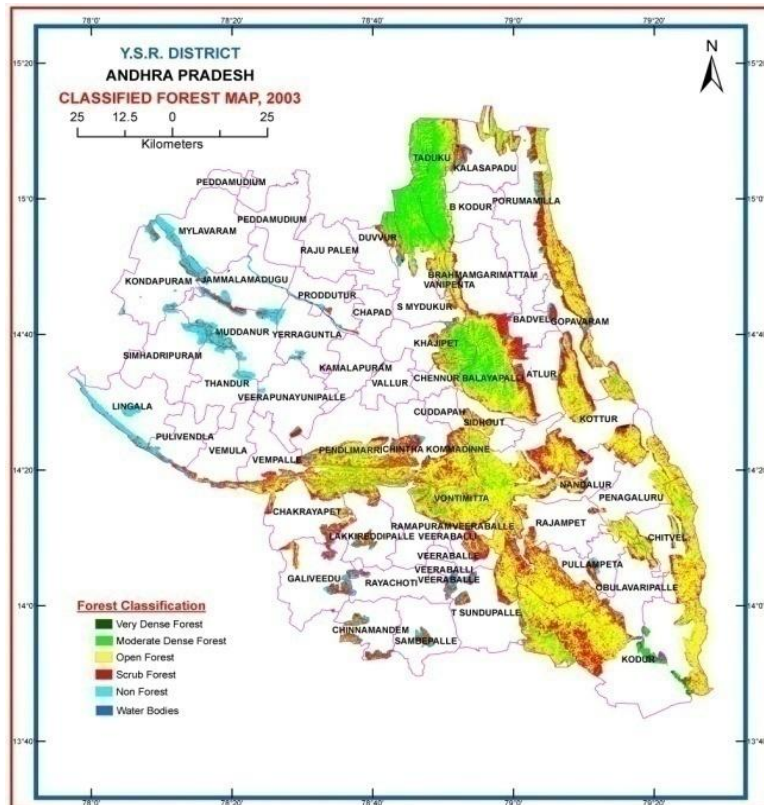
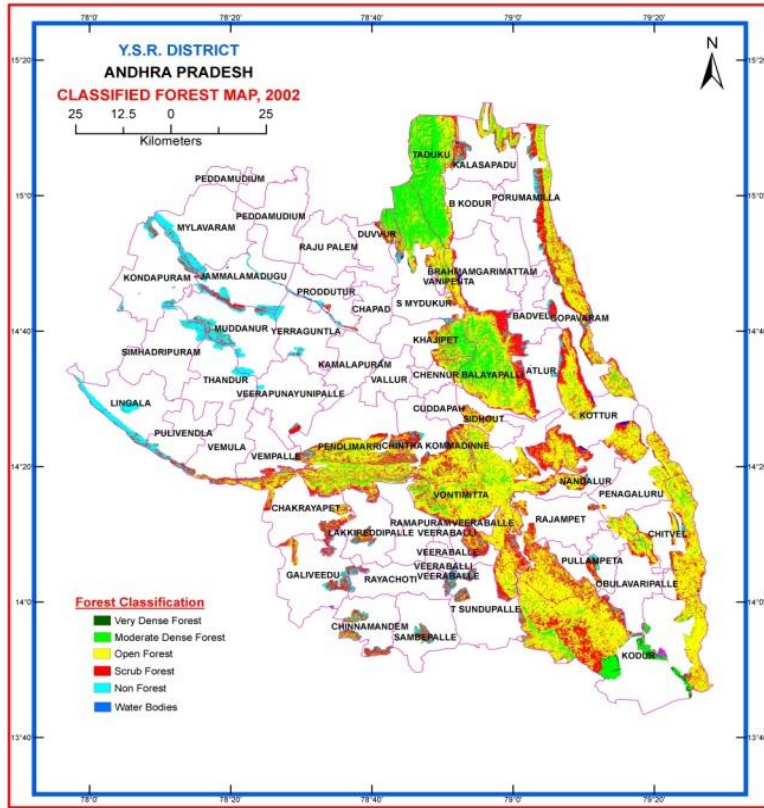
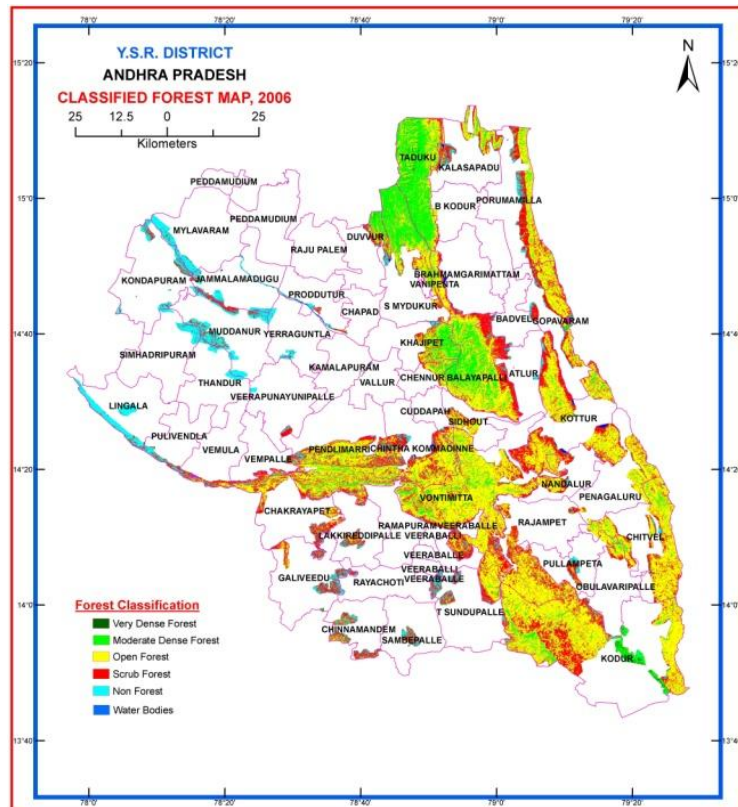
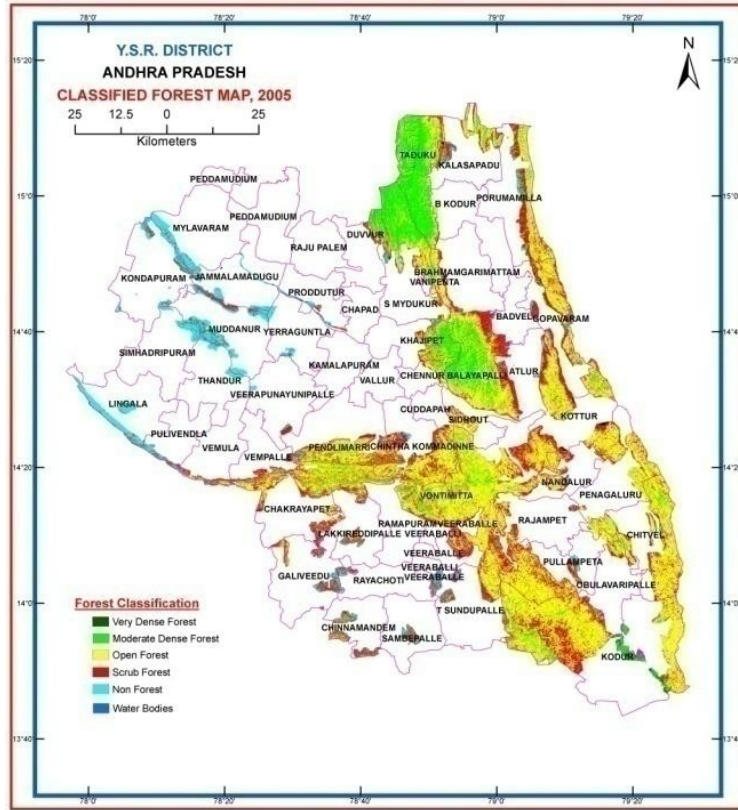


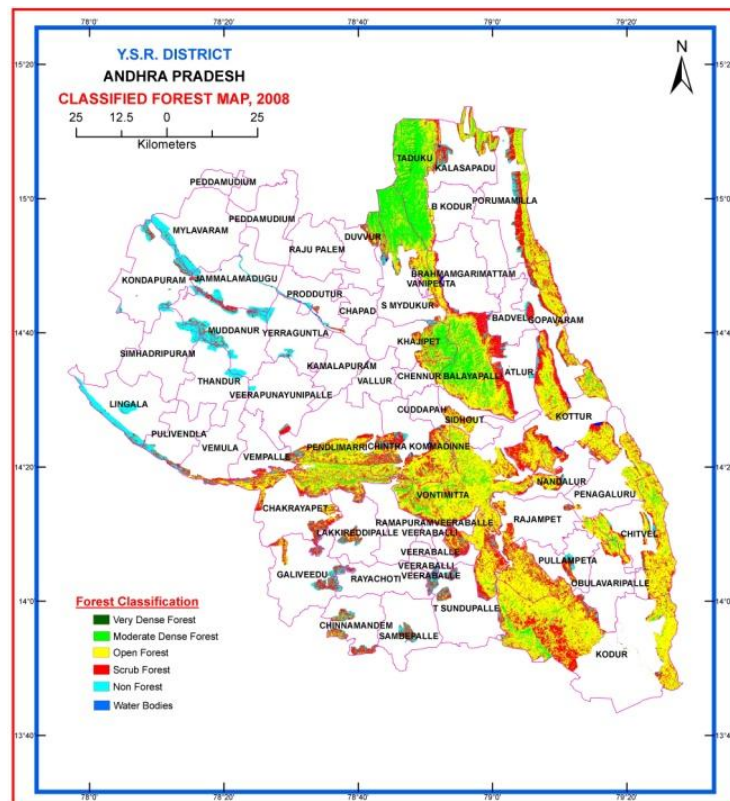
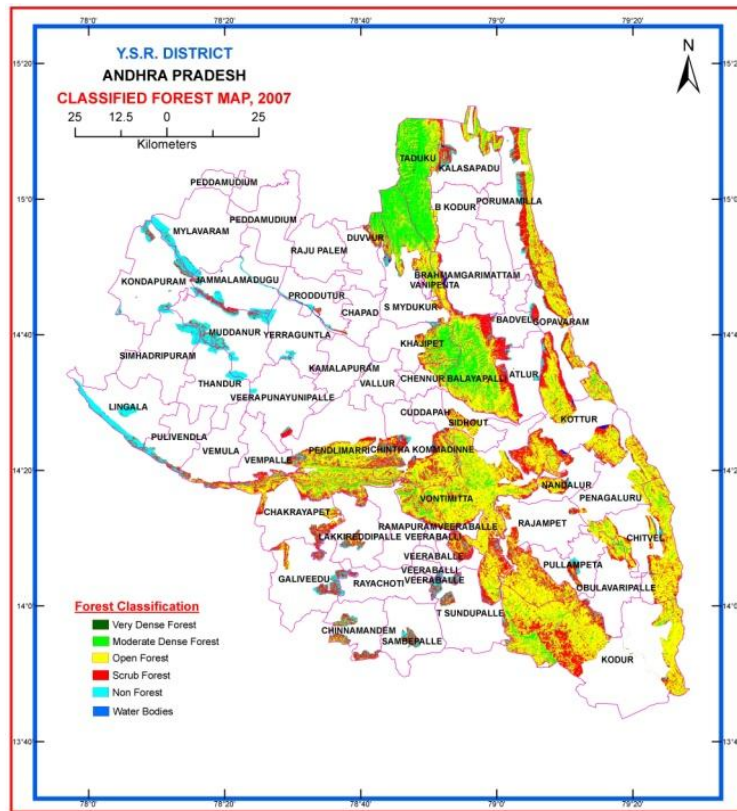
Fig. 4. Forest types in Poddutur Forest Division

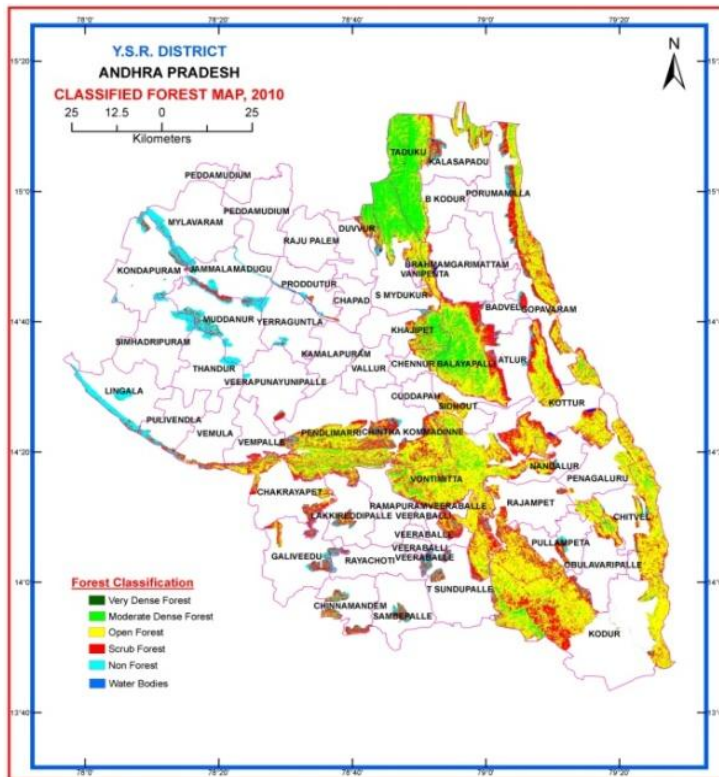
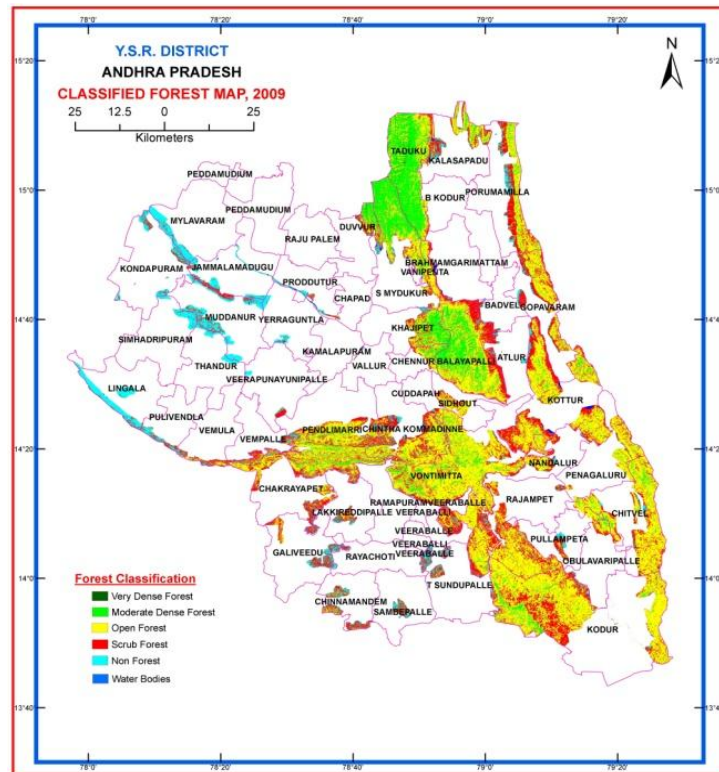












Map 1. Classified Forest Maps from 2000, 2002, 2003, 2005 to 2010 Satellite Imageries  
Source: NRSC & Forest department, Hyderabad Maps 1-9

### 3. RESULTS

Keeping aside the Water bodies and Non-Forest Area, it is observed that in Proddutur Forest Division is having the highest proportion of 16.13 of Dense Forest against its total forest area followed by Rajampet Forest Division with 10.03 per cent and Kadapa Forest Division with only 6.87 per cent. Likewise, in the Open Forest; Rajampet Forest Division tops with 65.95 per cent of its total forest area followed by Kadapa Forest division with 52.04 per cent and Proddutur Forest Division with 42.66 per cent. And lastly, the Scrub Forest is predominantly found in Kadapa Forest Division with 37.23 per cent of its total forest area, followed by Proddutur Forest Division with 32.48 per cent and Rajampet Forest Division with 22.27 per cent respectively.

### 4. DISCUSSION

#### 4.1 Dense Forest

The predominance of Dense Forest is found in Proddutur Forest Division with 16.13 per cent as against its total forest area. And more so, in the same Forest Division during 2007 to 2010 years the Dense Forest is established to be 27.30 per cent consequently for four years, while the least production of 3.82 per cent is observed in Rajampet Forest Division in 2009 and 2010 years. Thereby establishing a difference of 23.48 per cent of Dense Forest from maximum to minimum. Division-wise, it is found that Kadapa Forest Division has a range of minimum Dense Forest from 4.03 per cent in the year 2002 to a maximum of 10.08 per cent in the year 2010. Proddutur Forest Division has a minimum of 6.36 per cent in the year 2000 to a maximum of 27.30 per cent from 2007 to 2010 consequently. Rajampet Forest Division is recorded with a minimum of 3.82 per cent in 2009 & 2010 and a maximum of 15.70 per cent in the year 2006.

#### 4.2 Open Forest

The highest proportion of Open forest of 65.95 per cent as against its total forest area is found in Rajampet Forest Division and the highest of 69.24 per cent is observed in the year 2008. In addition, it is to mention that throughout the period of research, Rajampet Forest Division has more than 60 per cent of Open Forest. The least proportion of 35.07 per cent is observed in Proddutur Forest Division during 2009 & 2010; Thereby establishing a difference of 34.17 per cent of Open Forest from maximum to minimum.

Division-wise, it is found that Kadapa Forest Division has a range of minimum Open Forest from 45.09 per cent in the year 2000 to a maximum of 59.16 per cent in the year 2008. Proddutur Forest Division has a minimum of 35.07 per cent in the year 2009 & 2010 to a maximum of 49.73 per cent in 2005. Rajampet Forest Division is recorded with a minimum of 60.85 per cent in 2000 and the maximum of 69.24 per cent in the year 2008.

#### 4.3 Scrub Forest

The Utmost proportion of Scrub Forest of 37.23 per cent as against its total forest are is found in Kadapa Forest Division and the highest of 47.18 per cent is also found in this region during 2000 year followed by 46.87 per cent in the same year is found in Proddutur Forest Division. The least proportion of 17.44 per cent & 17.55 per cent is found in Proddutur Forest Division in the years 2006 & 2005. Thereby establishing a difference of 29.74 per cent of Scrub Forest from maximum to minimum. Division-wise, it is found that Kadapa Forest Division has range of minimum Scrub Forest from 28.27 per cent in the year 2010 to a maximum of 47.18 per cent in the year 2000. Proddutur Forest Division has a minimum of 19.17 per cent in the year 2009 & 2010 to a maximum of 46.87 per cent in 2000. Rajampet Forest Division is recorded with a minimum of 17.44 per cent in 2006 and the maximum of 25.91 per cent immediately in the subsequent year 2007.

### 5. CONCLUSIONS

It is estimated that the forest cover in YSR district reveals various forest types spread in almost all the parts of the district. The geographical area under different forest type indicates that Open forest area is predominated, followed by Scrub forest type and dense forest type. The scenario almost repeated in all the three forest divisions Kadapa, Proddutur and Rajampet of district's, but the criteria were exempted in Rajampet forest division, where the largest portion is under Open and Dense forest type. It also examined that, the dynamic changes in forest types in three divisions reflected into two facets in positive and negative growth rates. The conversion of scrub forest into Blank areas or Non-forest land in the district and three forest divisions is also examined. Firstly, the positive growth rate appeared in Open and Dense forest land and in another side the negative growth in scrub forest area. The overall scenario of forest cover in YSR

district is well established and growth rate in dense and open forest area is the one way of symbol of consideration in sustainable environment development from district to global world.

### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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