



Impact of climate change on land use/land cover and rainfall in Annamayya District, Andhra Pradesh: A geospatial analysis

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Abstract

The research centres on the study of changes in land use and land cover in Annamayya District in Andhra Pradesh, which is made up of 25 mandals and occupies an area of 7,951 square kilometres. The research employs Sentinel-2 L2A data to investigate the changes in land cover between 2017 and 2024. The geographical location of Annamayya has diverse geographical attributes. Furthermore, Annamayya is an important agricultural region. Rainfall data is obtained from Indian Meteorological Department. The study analyzes the spatial distribution of rainfall in 25 mandals. The study findings reveal that rangelands and crops are the major types of land uses in Annamayya. Furthermore, the results indicate the presence of urbanization, which poses a threat to agricultural lands. In 2017, the results show that 55.31% of the land in Annamayya is used for rangeland, whereas 38.42% is for crops. In 2024, the area of land under cultivation declines slightly to 44.61% with the constant area for rangeland being 44.47%. Built-up areas are on the rise in Annamayya, reaching 6.95% in 2024. Besides, it has variable rainfall, ranging from very low to very high rainfall. Thus, it can be seen that Annamayya needs sustainable land management practices. In addition, the study identifies the spatial distribution of agriculture lands, rangelands, urban areas, and water sources.

Keywords: Land use, land cover, rainfall (mm), RS & GIS

Introduction

Climate change is one of the factors influencing land use and land cover (LULC) in India as demonstrated by different researches that have examined climate change impacts on agriculture and urbanization. For instance, according to the Intergovernmental Panel on Climate Change (2021), climate change leads to changes in precipitation and temperatures resulting in changes in agricultural practices, which eventually yield both positive and negative consequences (Kumar & Kumar, 2018) ^[1]. For example, in the state of Andhra Pradesh, climate change and population increase have contributed to the worrying conversion of agricultural lands into urban areas as evidenced by Reddy and Reddy (2019) ^[3]. Additionally, the patterns of rainfall, as examined by Prasad and Reddy (2020) ^[4], negatively affect agricultural productivity. Therefore, there is a need to implement efficient mechanisms for dealing with climate change consequences. Climate change not only affects patterns of temperature and precipitation but also the patterns of the monsoon season that adversely affect food and water security in India, according to Ghosh and Dutta (2020) ^[5]. The introduction of remote sensing and GIS technology has changed the nature of LULC research significantly due to effective monitoring of changes in land cover and land use (Singh & Kumar, 2021) ^[6]. In the study carried out by Rao and Reddy (2017) ^[7], quantitative analysis of changes in land use/land cover was performed along with examination of their impact on the ecosystem. Moreover, the connection between land use and climate change is considered in detail in the research carried out by Mishra and Singh (2019) ^[8], and the importance of adopting effective analytical methods is

emphasized by the author. Similarly, Sahu and Sahu (2021) ^[9] argue for the adoption of an integrated approach to studying LULC changes and climate change, while Kaur and Singh (2022) ^[10] examine the benefits of geospatial technology in planning for sustainable urban development.

Study Area

Annamayya District, situated in the south-eastern part of the Rayalaseen region in Andhra Pradesh, is described as follows: The geographical co-ordinates of the District are 13° 19' 55" to 14° 42' 32" N Latitude and 78° 18' 55" to 79° 20' 26" E Longitudes. The District occupies an area of 7,951 Sq. Kms. The District is surrounded by YSR Kadapa District in the North, Chittoor District in the South, Anantapur District in the West, and Nellore and Chittoor Districts in the East. According to the 2011 Census, the District population is 1,697,308. The rural population is 1,305,797 and the urban population is 391,511. This gives us a population density of 213 persons per square kilometre. The land utilization in Annamayya District is classified as follows Forests, Barren Lands, and Lands used for Agriculture. The District is blessed with many Natural resources like Palakonda and Nallamalai Hills, which are rich in bio-diversity and support many species like Bonnet monkey and Tiger. The region enjoys natural resources like the Palakonda and Nallamalai hills that contain vast biodiversity and have creatures like bonnet monkey and tiger residing within them. The soil type of the region is red ferruginous and black soil. Black clay soil is the most fertile soil among them. The average rainfall is 738.5 mm. This is very helpful for Agriculture, especially in South-West Monsoon (fig.1).

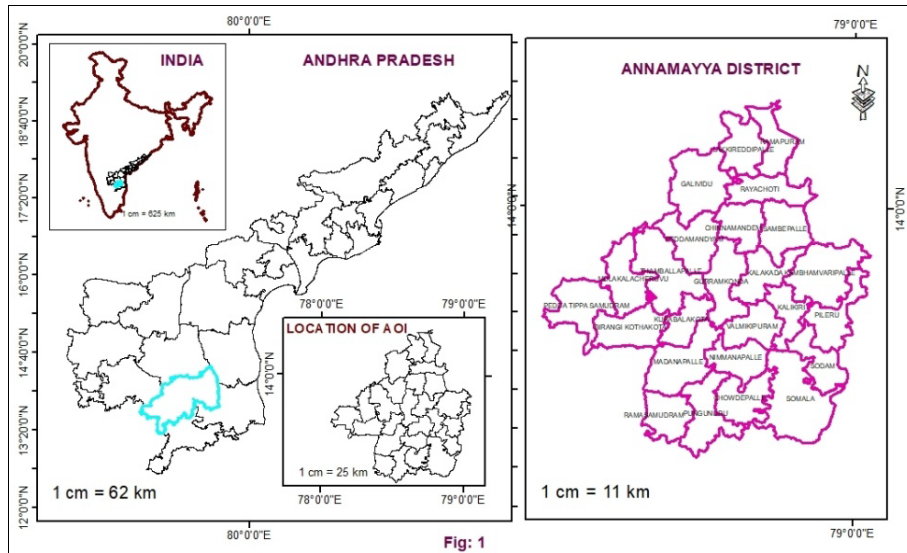


Fig 1

Objectives

- To examine the changes in the land-use/land-cover dynamics and change detection in Annamayya District between 2017 and 2024 with the use of Sentinel -2 L2A imagery.
- To examine the spacial pattern of rainfall (mm) between 2017 and 2024 in Annamayya district for 25 mandals, with NetCDF data having high spacial resolution from IMD, Pune.

The research uses a scientific approach in the collection and processing of the secondary data collected from the satellite images. The data collected includes Sentinel-2 L2A and the high-resolution gridded rainfall data set developed by the Indian Meteorological Department. The data set ranges from 1901 to 2024 and provides daily rainfall data in millimetres. The pre-processing stage of the research involves the application of algorithms for the correction of the data collected from the satellite images.

Software used: ArcGIS 10.3 and M.S. office

Methodology & Data Collection

Result & Discussion

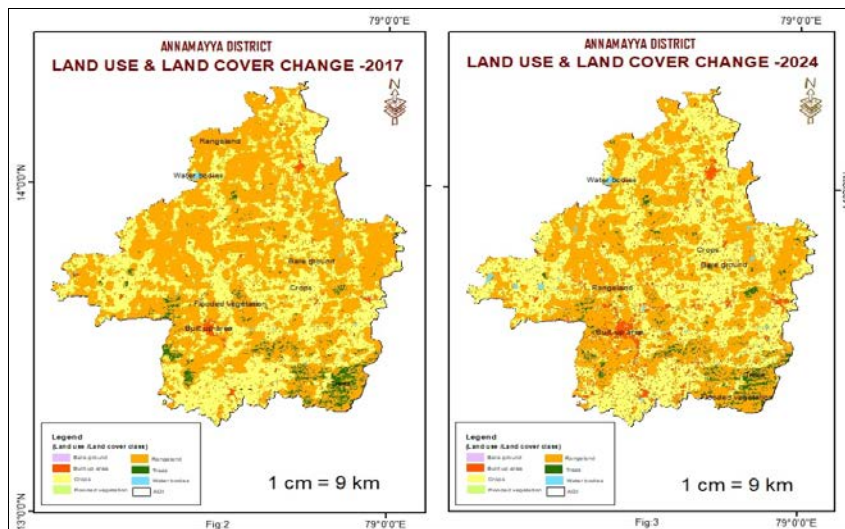


Fig 2

Table 1: LULC change in Annamayya District -2017

s.no	Name of the class	Area sq km	%
1	Water bodies	19.68	0.31
2	Trees	201.03	3.13
3	Flooded vegetation	0.09	0
4	Crops	2471.33	38.42
5	Built up area	179.05	2.78
6	Bare ground	3.44	0.05
7	Rangeland	3558.28	55.31

various kinds of land covers in this region. Based on the results, it can be argued that the most dominant kind of land use is rangeland. This kind of land cover occupies an area of 55.31% or 3,558.28 km². The results obtained mean that a large portion of the area of Annamayya District consists of grassland and shrubland, which plays an important role in the development of biodiversity in the region (fig.2 & table.1).

In addition, it should be noted that the second most important kind of land use is crops. This particular kind of land cover occupies an area of 38.42% or 2,471.33 km². The presence of this kind of land cover in the region suggests

An in-depth analysis of the changes in LULC of Annamayya District in 2017 with regard to the presence of

that farming plays an important role in the economic development of this region. In this case, the analysis of crops in the region is crucial, as this region has a specific economic structure, where agriculture has a dominant position in terms of economic activity. Meanwhile, other kinds of land covers, such as trees, built-up, and water bodies, can be considered insignificant in Annamayya District. For example, the total area occupied by built-up is equal to 179.05 km² or 2.78%.

Tree cover, which includes forests, covers an area of 201.03 square kilometres or 3.13% of the land. This indicates to there is some vegetation that could be used in maintaining stability in the ecosystem. However, despite the fact that water is essential in maintaining ecosystems that provide agricultural products and drinking water, it only covers 19.68 square kilometres or 0.31% of the land. This could be a concern in terms of water management in the region, especially in relation to climate change.

Also, as per the table, there are 0.09 square kilometres of flooded vegetation, which cannot be considered a notable part of the area. Moreover, bare grounds are 3.44 square kilometres or 0.05% of the area. This shows that there is very little unused land in the region. This shows that the region consists of rangelands and agriculture lands. The map LULC in Annamayya District for the year 2017 has provided a lot of relevant information regarding the use of land in the region. This has been made possible because of the dynamics of the region concerning its environment and economic activities. These dynamics are crucial when it comes to the management of the region's land.

Table 2: LULC change in Annamayya District -2024

s.no	Name of the class	Area sq km	%
1	Water bodies	63.68	0.99
2	Trees	188.42	2.93
3	Flooded vegetation	0.23	0
4	Crops	2869.93	44.61
5	Built up area	447.38	6.95
6	Bare ground	2.29	0.04
7	Rangeland	2860.97	44.47

A detailed analysis of LULC changes in Annamayya District for the year 2024, with emphasis on the distribution of land classes in the region. The data is provided in both square kilometres and proportion of total land coat (fig.3 & table.2).

Among the land course that encompass been recognized in Annamayya District, crops have been recorded in an area of

2,869.93 square kilometres, which is approximately 44.61% of the total land cover. This indicates that farming is an essential economic activity in Annamayya District, with crop cultivation playing a significant role in the region. Rangeland is also significant in Annamayya District, covering an area of 2,860.97 square kilometres, which is approximately 44.47% of the total land cover. This indicates that livestock is an essential economic activity in Annamayya District, with rangeland playing a significant role in supporting economic activities in the region.

However, the built-up area, which includes infrastructural and urban development, covers 447.38 square kilometres, which is only 6.95% of the total land cover. This shows that urbanization is still in its early stages of development in comparison to agricultural and rangeland activities. The presence of water bodies such as lakes, rivers, and other aquatic sites is also indicated, covering an area of 63.68 square kilometres, which is only 0.99% of the total area. This shows that the presence of water resources is still very low in the area, which could affect agricultural activities and biodiversity in the area of interest. The presence of trees is also indicated in the area of interest, covering 188.42 square kilometres, which is only 2.93% of the total area. This shows that although trees are present in the area of interest, their presence is still very low in comparison to other land covers in the area of interest. The presence of other land classes such as flooded vegetation and bare ground is also indicated in the area of interest, but their presence is very low, with only 0.23 square kilometres of flooded vegetation and 2.29 square kilometres of bare ground, which is only a negligible proportion of the sum land cover in the region of interest.

From the data on land employ and land group in the Annamayya District in 2024, it is obvious to the district is mainly dominated by agricultural and rangeland activities, while the presence of urbanization and water resources is still very low in comparison to other land classes in the area of interest.

LULC Change Detection in Annamayya District: 2017-2024

A detailed analysis of land employ and land coat changes in the Annamayya District over a seven-year period, from 2017 to 2024. The data is organized to illustrate the transitions between various land cover types, quantified in square kilometres. Each row indicates a specific change from one land cover type to another, providing insights into the dynamics of land use in the region (fig.3).

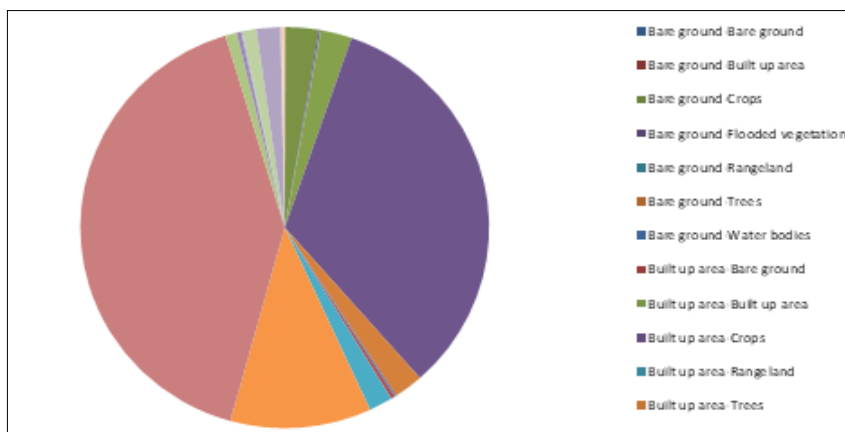


Fig 3: LULC Change Detection: 2017-2024

One notable feature that is copied from the information is that close by is a vast area under crops, and it is remarkable that it has remained almost constant with a total change in area of 2,135.56 sq km. However, it is notable that crops have increased in area by 157.94 sq km, which resources that to hand is an increase in urbanization in area that were previously worn for crops. Moreover, Crops have also been converted to rangeland by 148.4 sq km.

Built up areas have also increased significantly, as it has remained constant at 167.27 sq km as built-up areas. However, it is notable that it has also increased in other areas, especially crops and rangeland, converting 7.97 sq km and 3.23 sq km, respectively. This is notable as it indicates to convenient is urbanization in the Annamayya District.

Lying on the previous hand, the rangeland category shows a large area of 2,638.05 sq km remaining stable. However, it also indicates an increase in crops of 717.76 sq km and built-up areas of 120.04 sq km. This indicates a possible decrease in rangeland areas due to an raise in crops and built-up areas. In calculation, the transitions of trees and water bodies are relatively low. There is almost no change in these areas. For example, trees have shown transitions to

rangeland areas of 69.79 sq km. This indicates a possible decrease in forest areas in favour of rangeland areas. On the other hand, water bodies show relatively stable conditions with minor changes. This indicates the stability of water bodies in favor of land coat transitions.

The examination of the transitions in Annamayya District indicates the complexities of balancing agricultural activities, urbanization, and ecological stability. Consequently, it is obvious that sustainable land executive practice are required to balance urbanization with agricultural activities to ensure ecological stability in the region.

Spatial Distribution of Rainfall (in mm) in Annamayya District

Spatial Distribution of Rainfall (in mm) 2017

The first category, which is termed very low, covers rainfall ranging from 722 mm to 786 mm. Under this category, mandals such as Valmikipuram, Madanapalle, Nimmanpalle, Guramkonda, and Kurabalakota were identified. The regions experienced the least rainfall during that particular period.

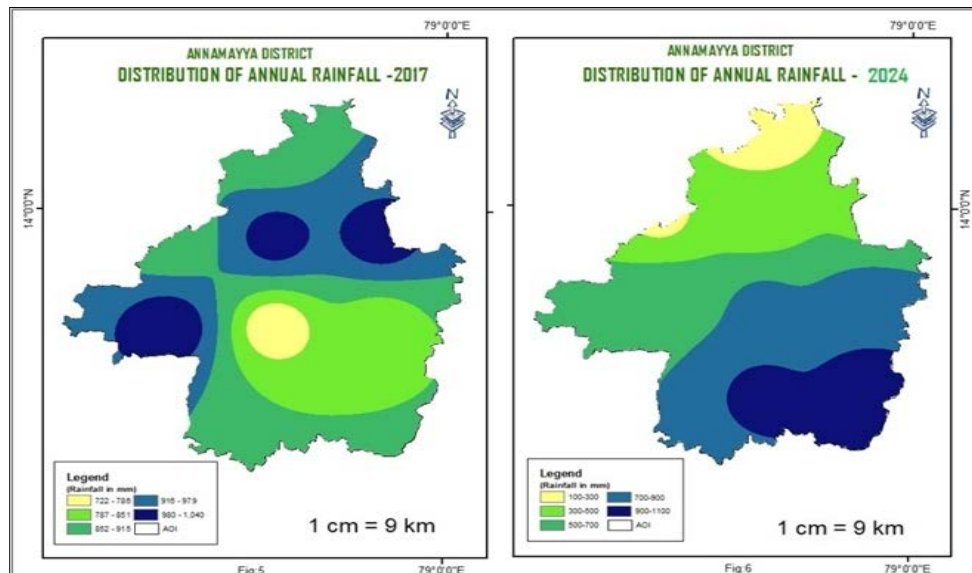


Fig 4

Coming to the low category of rainfall, which ranges from 787 mm to 851 mm, more mandals have been covered. Apart from the above-mentioned mandals, other mandals that have been covered in this category include Kalikiri, Pileru, Sodam, Somala, Chowdepalle, Pungunuru, Kalakada, Guramkonda, and Thamballapalle. The regions have experienced a somewhat higher amount of rainfall, but not up to the mark.

The moderate category of rainfall, which ranges from 852 mm to 915 mm, includes a number of mandals. Some of the mandals that have been covered in this category include Madanapalle, Kalikiri, Pileru, Sodam, Somala, Chowdepalle, Pungunuru, Ramasamudram, Kambhamvaripalli, Kalkada, Guramkonda, Pedamandyam, Kurabalakota, Mulakalacheruvu, Thamballapalle, Rayachoti, Ramapuram, Lakkireddipalle, and Galividu. For that indicates area have experienced a additional balanced amount of the rainfall.

Further, in the high rainfall category, where rainfall amounts range from 916 to 979 mm, the mandals of Madanapalle, Ramasamudram, Kambhamvaripalli, Kalkada, Guramkonda, Chinnamandyam, Pedamandyam, Kurabalakota, Birangi Kothakota, Mulakalacheruvu, Peddatippasamudram, Thamballapalle, Sambepalle, Rayachoti, Ramapuram, Lakkireddipalle, and Galividu are observed. The occurrence of these mandals in the high rainfall category may imply that these mandals are more prone to the effects of heavy rainfall.

In addition, from the table above, there are also 0.09 square kilometres of flooded vegetation, which cannot be considered to make any significant proportion of the area. In addition, bare ground covers 3.44 square kilometres or 0.05% of the area. This implies that there are only minimal proportions of uncultivated areas in the region. The above implies that the region is made up of mainly rangelands and agricultural areas. The LULC map for the Annamayya District in the year 2017 has offered much insight into how

the land is used within the region. This has been facilitated by the dynamic nature of the region in terms of environmental and economic aspects.

Spatial Distribution of Rainfall (in mm) 2024

In this case, the spatial distribution of rainfall in Annamayya District in 2024 divides rainfall into several categories, and within each category there are particular mandals. This implies that there is variation of rainfall in the region. Variation of rainfall is important in understanding the hydrological cycle in the region. (fig.6)

From the above map, it is clear that the regions that have been classified under very low rainfall which implies that such regions have received rainfall in the range of 100-300 mm are: Ramapuram, Lakkireddipalle, Galividu, Rayachoti, and Peddamandyam. There is much water scarcity in this region. Therefore, there might be low productivity of crops in the region.

Regions that have been classified under low rainfall, which implies that the rainfall range is between 300-500 mm are Thamballapalle, Mulakalacheruvu, Guramkonda, Chinnamandyam, Sambepalle, Ramapuram, Lakkireddipalle, Galividu, Rayachoti, and Peddamandyam. This shows that there is an increase in rainfall in certain regions. In this situation, the region has good climatic conditions which favor agricultural productivity, but there is a problem of drought.

Moderate rainfall implies that the rainfall range is between 500-700 mm and regions include Thamballapalle, Mulakalacheruvu, Peddatippasamudram, Madanapalle, Birangi Kothakota, Kurabalakota, Guramkonda, Chinnamandyam, Sambepalle, Kambhamvaripalli, Pileru, Kalakada, Ramapuram, Lakkireddipalle, Galividu, Rayachoti, and Peddamandyam. The region is characterized by good climatic conditions in that there is enough rainfall to promote agricultural activity in this region.

High rainfall implies that the rainfall range is between 700-900 mm. In this case, mandals include Madanapalle, Kurabalakota, Gurramkonda, Kambhamvaripalli, Pileru, Sodam, Somala, Kalikiri, Valmikipuram, Kalakada, Nimmanapalle, Pungunuru. This rainfall could cause an increase in the amount of vegetation, thereby increasing agricultural productivity, but there could be problems of soil erosion.

Lastly, very high rainfall ranges from 900-1100 mm, the mandals include Pileru, Sodam, Somala, Nimmanapalle, and Pungunuru. This is the region which receives heavy rainfall, and therefore could result in flooding of the lands, thus affecting agricultural activities, but there would be increased agricultural productivity in the area due to increased moisture content in the soil.

Conclusion

Hence, based on all the information presented above, it is clear that in summary, the study related to the changes in land use and land cover (LULC) in Annamayya District between 2017 and 2024, coupled with rainfall patterns in the area, is a valuable contribution to the understanding of the ecology and socio-economic conditions in the region. According to the data given in the assignment, it is possible to say that there is quite a bit of stability regarding agricultural land use, as well as crops that are central in terms of land usage in the region. In addition, rangeland is an important component of land usage in the region.

Nevertheless, it is a matter of significant concern that urbanization has led to expansion in relation to agricultural lands in Annamayya District. Moreover, the results of rainfall analysis demonstrate that there are considerable differences in rainfall patterns in the mandals of the area.

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