Vulnerability of Land Resources due to Land Transformation & Fragmentation in Medak district of Telangana in the past two decades

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Abstract **This research paper focuses on explaining the severity of land cover – landuse (LULC) changes in terms of the land transformation (LT) and land fragmentation (LF) to identify the most vulnerable land-types in Medak district of the Indian states of Telangana which is situated at the tableland of Deccan Trap in the southern part of the Indian sub-continent. It is intended to address to what extent various types of land resources have been exploited and gradually becoming vulnerable in due course of time over a period of past two decades between 2000 and 2020. For this study, the LULC has been extracted from the historical Landsat imageries obtained from United States Geological Survey (USGS) through its online data distribution gateway. LULC change (LULCC) has become very common technique to explain the differences between the past and present but this research paper adopts the method of assessing the vulnerability by computing the difference between each land-type in the present transformed from the past and each land-type of the past fragmented into multiple land-types in the present. The overall findings revealed that the forest lands are the most vulnerable land-types in the district which has a difference of 16.71% of decrease over the past two decades while the surface waterbodies ranked the second with the difference of 15.16% of loss in its extent within the district between the same period. The rangelands also lost the actual extent of at least 10.56% of its original extent during the same period. At the same time the actual expansion of farmlands and built-up lands were 7.34% and 60.68% which was exchanged with the decrease of the other three land cover types. So, it was concluded that the natural land cover are the most vulnerable land-types in the districts while this decrease is trading-off with the cultured land covers. And if it is not managed today, then it can pose sever threats in future.**

Keywords **— Land Resource, LULC, Land Transformation, Land Fragmentation, Vulnerability**

I. INTRODUCTION

Other than the economic or commercial view point, the ecological value of the lands is even getting adversely affected by the recent trends of rapid landuse and land cover changes. Fragmentation and transformation of lands have become every now and then matter of concern. In due course, individual classes of lands from past are seen fragmenting into multiple types of classes on the other hand the individual land categories of the present time are found to be transformed from many other classes of the past. Transformation and fragmentation of lands are known to be vice-versa process of change. Since change is an obvious process, land transformation and fragmentation are acceptable till then until any specific class of landuse or land cover is not in a vulnerable state. Here vulnerability of a landuse or land cover category means, it is seen in some cases, the extent of land of a specific class that fragmented from the past is measured not to be equal with the extent of the other lands transformed into the same class in the present. This likely to poses a threat to the existence of the landuse or land cover category in long run. Progressive downsizing or phased drawdown of any landuse and land cover could result the vulnerable class to disappear in future which could be a serious matter of concern for the ecological balance. It is observed that the intensive transformation of lands has resulted in degrading the economic as well as environmental value of some classes. Ironically, the commercial value of some lands is upgrading at higher pace.

So, it is an addressable issue and a matter of concern that indiscernibly the commercial upgradation of certain lands is being achieved by trading off the community-specific socioeconomic loss and land degradation by means of

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ecological and environmental unsustainability of some other types of lands while the consequences are ignored. Hence the landuse and land cover change in terms of the efficiency of the land management practice has become questionable.

Land Transformation (LT) and Land Fragmentation (LF) are often used interchangeably but in reality, both the terms are conceptually completely different. Land Transformation can be defined as for a particular type of land in the present time, how much percentage of it was the same type of land in the previous time and how much percentage of it is grabbed from other type of lands from the past period. While the concept of Land Fragmentation is quite opposite to Land Transformation. Land Fragmentation can be defined as how much percentage of a particular type of land in the past remained unchanged in the future and how much percentage of it converted to different types of land in future. In this case, the amount or percentage of LT does not necessarily will be the same with LF even though the type of land and the period of change is same.

II. MATERIALS AND METHODS

A. *Review of Literature*

From farmers' perspective, approximately three-fourth of them were unwilling to let their farmlands be converted to any other type in future rather four-fifth of them even were planning to increase the extent of their agricultural lands in future which an ultimate indication that more land cover is going to be converted into farmlands. It is therefore can be predicted that in future the forest cover is going to be decreases by 5.65% per annum. Undoubtedly, it would highly affect the ability of carbon sequestration which is essential for the environmental health where all plants including agricultural plants also grow healthy with higher productivity. To avoid such futuristic disaster, it is suggested to implement appropriate LULC policy which could conserve the natural greenery but by intensifying the cropping activity with proper awareness and training can lead to a sustainable future for both the environmental ecology and cultural farm practices (Enoch Bessah et al – 2018). The conversion of lands is traded off with pasturelands, scrublands and other marginal land units for which explosive population increase, rainfall scarcity, unplanned and inappropriate land management practices in order to meet the food demands were responsible which is causing the decrease of total cultivated area and per capita croplands. The shortage of croplands is exerting pressure on the food security and hence the extent of croplands is increasing. Also, implications of LULC change include land degradation, rural–urban migration, farm land fragmentation, climate change, crop yield reduction and soil erosion (Alem-meta Assefa Agidew et al – 2017). In some cases, for survival, reducing poverty and to ensure food security as the croplands decreased with the expansion of built-up areas people have started adopting other methods of livelihoods. People are engaging themselves in soil mining and keeping improved stock-farm breeds for more profit. Due to rapid increase in population size in the recent past, the agricultural lands have been fragmenting and the acreage has started reducing as people have started realizing the potential of croplands. But increased intensive agriculture, loss of fertility and soil erosion have become more common. Reduced pasture and scrublands resulted in reduced stock farming too (Walingo et al – 2009). Noticeable changes in community livelihoods have been observed due to increased cultivation, overgrazing on the river banks, wetlands exploitation, shrinking and fragmenting forest cover as well as scrublands and volatility of built-up areas. Hence, the common resources have become scarce leading the farmers go for diversified as well as intensive cropping as they were practicing traditional cropping techniques (Albinus M.P et al – 2008).

B. *SOI Toposheets & Satellite Imageries*

Spatial matching of the administrative boundaries and cross-verifying the satellite imagery driven data either with the existing high-resolution base map or authentic government maps such as Survey of India Toposheets are two most important tasks in the field of Land cover and Landuse studies. For this study, SOI toposheets on 1:50000 scale is used for the purpose of matching the LULC with the data extracted from the satellite imageries of the year 2000. The specification of the data is given below in the table 1.

Table 1. List of Toposheets used for spatial matching and LULC extraction

Toposheet No.	Year of Survey	Projection (Datum)
E43L/16, E43R/13, E44G/04, /08, /12, E44M/01, /02, /05, /06, /09, /10	Surveyed between 1965-88, updated in 2005-06	Universal Transverse Mercator (WGS 1984)

Multi-temporal **M**ultispectral **S**atellite **I**mageries (**MSI**) of Landsat 4/5 TM, Landsat 8 OLI/TIRS at 30m spatial resolution of the row 144 and path 47, 48 are used. The details of the scenes used for the research are listed below in the table (Table 2.).

Table 2. Specification of MSI products used for Land cover-Landuse generation

DOA	Mission	Product	Nos.
2020/01/11	Landsat-8 OLI	C2L2SP	1
2020/01/27			1
2020/03/15			1
2020/03/31			1
2020/10/25			1
2009/10/27	Landsat-5 TM	GFCC-SR	2
2010/01/31		C2L2SP	2
2010/04/21			2
1999/04/07			2
2000/01/12	Landsat-7 ETM		2
2000/02/29			2
2000/11/11			1
2001/10/29	Landsat-5 TM	GFCC-SR	2

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C. Formula used for LT & LF computation

The Land Transformation and Land Fragmentation was computed using the following formula for every individual LULC class.

$$Percentage\ of\ LT_{xp} = \left(\frac{AL_{xp} - UAL_{xp}}{AL_{xp}}\right) \times 100$$

Where:

'LT_{xp}' is Land Transformation of X-type land in the present period.

'AL_{xp}' is the total area of X-type land in the present period.

'UAL_{xp}' is the unchanged area of X-type land from the past period.

$$Percentage\ of\ PLF_{x} = \left(\frac{PAL_{x} - UAL_{x}}{PAL_{x}}\right) \times 100$$

Where:

'PLF_x' is Fragmented part of X-type land from the past in the present period.

'PAL_x' is the area of X-type land in the past period.

'UAL_x' is the unchanged area of X-type land from the past to the present period.

D. Software used

For the post processing of the acquired satellite imageries such as Color Infrared image composition (Band layer stacking) and Image Classification, Recoding of the Classified Images ERDAS Imagine 2013 is used while to extract the vector features from the reclassified images and further cartographic refinements, ArcGIS 10.3 has been used. For the accuracy assessment of the extracted information for the period 2010 and 2020, Google Earth Pro historical imageries have been used.

III. THE STUDY AREA

If Medak is the 13th largest district out of 33 districts, situated in the west-central part of Telangana. The district extends between 77.79448 °E - 78.589635 °E longitude and 17.66339 °N - 18.217521 °N latitude occupying a spatial extent of 2757km² of area within the state. The district is a part of the former Medak district prior to 2016 which split into three smaller districts after the formation of the State (Figure 1.1). The present district shares its boundary with four neighbouring districts i.e., Kamareddy in the north, Sangareddy in the west and south, Medchal-Malkajgiri in the southeast and Siddipet in the east (Figure 1).

The present Medak district is bifurcated from the erstwhile Medak district under the government order of G.O.M.S 239 (Dated on 11-10-2016) by the Government of Telangana. The district is divided into three Revenue Divisions i.e., Medak, Narsapur and Toopran. The three divisions are comprised of 21 mandals which are parts of 15 Mandal Praja Parishads (MPP). MPP is a different entity from mandal. Following is the 15 MPPs of the present Medak district: Shankarampet (A), Papannapet, Medak, Ramayampet, Chegunta, Shankarampet (R), Kulcharam, Tekmal, Alladurg, Regode, Kowdipalle, Yeldurthy, Toopran, Shivampet and Narsapur. The district is further divided into 320 Gram panchayats which comprised of 381 Revenue Villages as per the official information given by the district administration. This is different from 2011 census as the erstwhile Medak district was not bifurcated during 2011. At present four towns in the district have received Municipality civic status which are: Medak, Narsapur, Toopran and Ramayampet.

As per the official information, in present Medak district, out of 381 revenue villages, 373 villages are inhabited and only 8 villages are uninhabited. As per 2011 census, the total population of the district is 767428 individuals out of which the male population is 378654 and female population is 388774. The density of population in the district is 278.38 persons per square kilometre. The average household size is estimated to be 5 persons per house in the district. Nearly 7.67 percent of the total population in the district lived in urban areas while the rest 92.33 percent lived in rural areas. As per SKS survey conducted by the state government on 19-08-2014, the total population of the district was 789074.

According to 2011 census, the sex ratio of the district was 1027 females per 1000 males. The literacy rate was 56.12 percent in the district. Of the total population, 16.68 percent was Scheduled Caste which increased to 17.92 percent as per and 9.5 percent was Scheduled Tribe which increased to 10.33 percent as per SKS survey. As per the SKS records, the Backward Caste population in the district was 62.6 percent. As per SKS records the net workforce of the district shared 48.89 percent of the total population out of which 82.6 percent of the workers were categorized as main workers and only 17.4 percent of the workers were marginal. Paddy, Maize, Sugarcane, Pulses and Cotton are the major crops cultivated in the district. As per the government information the 240 key industrial units are there in the district.

The district has an average elevation of 510m from mean sea level (MSL). The topography can be characterized as rugged terrain due to uneven relief throughout the district. Tropical deciduous dry forest covers nearly one-third of the district area. The Manjira is the main river flows through the district which is a tributary of the Godavari River. Nizamsagar dam is constructed on this river to the north-western border of the district. Haldi and Kudlair are other two main tributaries of the river Manjira that flow through the district. The climate of the district is characterized as tropical dry hot except for the monsoon period. The local temperature varies from 11.5 °C to 45.3 °C in the district subsequently during the winter and summer season. The district receives minimum 542mm to maximum 1987mm

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annual with an average of 934mm rainfall.

IV. RESULTS

As a result of two-way Land Transformation (LT) and Land Fragmentation (LF) the vulnerable land-types in the study area are assessed by comparing the difference between the final LT and LF of each LULC class over a period of twenty years between 2000 and 2020 after analyzing the decadal differences which is given in the table (Table 3) below.

Table 3. Percentage difference between LT & LF in Medak district

Between 2000 and 2010		
Sl. No.	**LULC**	**LT - LF**
1	**Agricultural Lands**	4.85
2	**Built-up Lands**	44.89
3	**Forest Cover**	-19.12
4	**Open/Scrub/Pasture Lands**	17.69
5	**Waterbodies**	-51.81
6	**Total (2010)**	**0.00**
Between 2020 and 2010		
Sl. No.	**LULC**	**LT - LF**
1	**Agricultural Lands**	2.38
2	**Built-up Lands**	28.65
3	**Forest Cover**	2.31
4	**Open/Scrub/Pasture Lands**	-22.50
5	**Waterbodies**	40.38
6	**Total (2020)**	**0.00**
Between 2000 and 2020		
Sl. No.	**LULC**	**LT - LF**
1	**Agricultural Lands**	7.34
2	**Built-up Lands**	60.68
3	**Forest Cover**	-16.71
4	**Open/Scrub/Pasture Lands**	-10.56
5	**Waterbodies**	-15.16
6	**Total (2020)**	**0.00**

As seen in the table above, it can clearly be understood that the percentage of land fragmentation was consistently less than the land transformation throughout both the decades for agricultural and built-up landuse. The difference between the LT and LF for agricultural lands was comparatively less during the second decade while the overall difference of LT and LF between 2000 and 2020 for this type of landuse is higher than any decade. Unlike agricultural landuse, for the first decade, the LT was more than LF in case of built-up landuse. This percentage difference declined from 44.89 to 28.65 by the next decade but as a matter of fact, overall, this difference was 60.68% between 2000 and 2020 as seen in the table. In case of forest cover, the fragmentation was more than the transformation during the first decade while it reverted during the second decade. But the overall difference between the LT and LF for a period of 20 years, the fragmentation was seen more than the transformation for forest cover. In case of open/scrub/pasturelands, the decadal scenario was quite opposite to the scenario of forest cover. However, during past two decades, ultimately the net open/scrub/pasturelands fragmentation was more than the net transformation. In case of waterbodies also during the first decade the LF was more than LT which reverted in the next decade. But the analysing the overall difference, the LF was more than LT in case of waterbodies in the district.

The above table and discussion revealed that for all the natural land cover i.e., Forest cover, Open/scrub/pasturelands, the land fragmentation was more than the transformation which is above 10% for each class. This indicates that the natural resources are gradually fragmenting and it could have significant impact on the people whose occupations are primarily dependent on such type of natural resources. On the other hand, it was found that the transformation of built-up landuse was higher compared to the transformation of agricultural landuse in the district. Even though the net percentage difference between the LT and LF for agricultural lands is only 7.34%, but the impact of increased built-up landuse could have higher impact on agricultural activities. This is because, with the increase in urban activities the agricultural activity significantly decreases immaterial of the time period or place.

V. DISCUSSION

To assess the vulnerability of the land resources, it is needed to understand the difference between the LT and LF of each LULC class during each decade. In the first place it has to be decided how the vulnerability will be assessed? Which one is more important between transformation and fragmentation. Contextually, both kind of changes are important. On simplifying these two terms, it can be interpreted as transformation is ‘converted from’, there fragmentation is ‘converted to’. Transformation is vitally important for landuse while fragmentation is important for land cover. This means, if the transformation is more in case of agricultural or built-up lands, then it’s a matter of concern while if the fragmentation is more in case of natural land cover such as forest cover, spatial extent of surficial waterbodies, open/scrub/pasturelands etc, it becomes a matter of concern. So, in this session the LT and LF that has occurred in the district over the past two decades is discussed in details and given in the tables (Table 4 to 9) below.

Land Transformation (LT) and Land Fragmentation (LF) are often used interchangeably but in reality, both the terms are conceptually completely different. Land Transformation can be defined as for a particular type of land in the present time, how much percentage of it was the same type of land in the previous time and how much percentage of it is grabbed from other type of lands from the past period. While the concept of Land Fragmentation is quite opposite to Land Transformation. Land Fragmentation can be defined as how much percentage of a particular type of land in the past

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remained unchanged in the future and how much percentage of it converted to different types of land in future. In this case, the amount or percentage of LT does not necessarily will be the same with LF even though the type of land and the period of change is same.

The below tables (Table 4 to 6) give a detailed account of the LT and tables (Table 7 to 9) show the LF occurred within the district between each decade as well as over a period of two decades for each type of LULC in which the cells highlighted in green colour represent the area of the particular LULC-type remained unchanged in both the period of study. The method of computing the LT and LF is described in the methodology section earlier in the 'Research Design' chapter. The LT tables reveal that the percentage of agricultural lands during 2010 that was transformed from other three types of lands was 15.16 which moderated by the end of 2020 and became 13.09%. Overall, the transformation of agricultural lands was 14.81% between past two decades and notably, during the first decade, maximum transformation for agricultural landuse was from surface waterbodies while it was more from the open/scrub/pasturelands during the second decade. However, at the end of 20 years, most of the scrub/open/pasture lands of the year 2000 transformed to agricultural lands by 2020 while the conversion of forest cover and waterbodies were at the second and third case respectively in this case.

As discussed above, the built-up landuse goes on increasing year-by-year. So, there is no doubt that the built-lands in the later period is always a result of transformed lands from the former period. In case of Medak district, during the first decade, the growth of built-up lands was rapid as a result it can be seen in the table (Table 4) that there was a 44.89% of the built-lands of the year 2010 was transformed from mostly agricultural lands while some parts of the open/scrub/pasturelands and waterbodies also were converted to built-up lands. Almost the same scenario was observed during the second decade where 28.65% of the built-up lands were converted from the same type of lands as in the previous decade but this decade the conversion of other types of lands for built-up purpose was not as vast as the previous decade. Assessing the total percentage of LULC converted into built-up type over a period of 20 years, it was observed that 60.68% of the built-up areas in the year 2020 were taken from 50.13 km² of agricultural lands and 9.28 km² of lands from other three types of LULC classes.

From the table (Table 4) it can be seen that nearly 5.46% of the forest cover during 2010 was converted mostly from agricultural lands of 2000 and some portion of it was converted from other three types of LULC classes. In the next decade, this percentage of conversion seemed to be triple the time of the previous decade which was 17.07% of the total forest area of 2020. This percentage was mostly converted from agricultural lands and open/scrub/pasturelands. But looking at the table (Table 6) it can be understood that a total of 7.17% of forest was transformed mostly from agricultural lands, open/scrub/pasturelands and waterbodies. This indicates that certain percentage of agricultural lands which were converted from forest cover again grew back to its actual coverage.

Unlike built-up landuse, the transformation was observed to be maximum in case of open/scrub/pasturelands between 2000 and 2010. Nearly 70.11% of such lands in 2010 were transformed from all other types of lands. It can be seen that majority of such types of lands were converted from agricultural lands of 2000 followed by which some extent of forest cover and surface waterbodies also converted by 2010. During the second decade also this rate of conversion was 63.34% of the total area under such type of land cover. Even though this percentage is high but the area of converted lands was less compared to the previous decade. During this decade, only 52.92 km² from agricultural lands, 18.55 km² from forest cover and 0.86 km² of extent from surface waterbodies of 2010 was converted to open/scrub/pasturelands by 2020 which was 128.84 km², 57.20 km² and 16.08 km² during the previous decade respectively. Thus, the total transformation of such types of lands over a period of two decades was 70.60% which was converted from only 34.60 km² of agricultural lands, 43.32 km² of forest and 4 km² of waterbodies of 2000 LULC.

There was a noticeable transformation occurred in case of waterbodies in the district too. Nearly 12.13% of the land extent covered by surface waterbodies in 2010 was transformed from 8.37 km² of agricultural lands and some extent of other type of lands while this percentage of transformation dramatically increased during the second decade. Around 58.58% of the waterbodies of 2020 was converted from 80.24 km² of agricultural lands and 12.75 km² of open/scrub/pasturelands of 2010. This conversion was remarkable indeed. Overall, 20.03% of the total waterbodies during 2020 was converted from 27.10 km² of agricultural lands, 3.02 km² of open/scrub/pasturelands and 2.52 km² of forest cover of 2000. This indicates that the area under the coverage of surface waterbodies of 2000 which were converted to other type of LULC, almost reconverted to waterbodies again during 2020. This scenario can be better understood on analysing the percentage of fragmentation of each type of LULC occurred during each decade.

From the table (Table 7) it can be seen that maximum land fragmentation occurred in case of waterbodies during the first decade while agricultural lands fragmented the least. Around 10.31% of the agricultural lands of 2000 fragmented into four other types of lands by 2010. Out of which, majority of the area converted to scrub/open/pasture lands which was 128.84 km² while 27.39 km² of lands converted to built-up types. Even 8.37 km² of agricultural lands of 2000 converted to waterbodies by 2010. From 2010 to 2020, almost same

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percentage of agricultural lands further fragmented which was 10.71% of the area during 2010. During this decade, the conversion of net spatial extent was apparently less compared to the previous decade but 80.24 km² of such lands converted to waterbodies which was only 8.37 km² in the previous decade. Around 52.92 km² of agricultural lands converted to scrub/open/pasture lands while 42.91 km² into forest cover and 21.67 km² into built-up lands. Assessing the bi-decadal rate of fragmentation, it was seen that net 7.47% of agricultural lands from 2000 fragmented to other types of LULC out of which maximum area converted to built-up, then open/scrub/pasturelands and then waterbodies. Small patches of agricultural lands accounting to 18.69 km² converted to forest cover by the end of 2020.

As discussed earlier, the area of built-up landuse increases over time, hence there is no question of fragmentation for such type of landuse rather it is transformed from other type of LULC classes. As per the observation, 24.58% of the net forest area of 2000 fragmented mostly into agricultural lands covering 86.96 km² and 57.20 km² of open/scrub/pasturelands by 2010. Very less extent of forest cover fragmented to waterbodies and built-up types. Between 2010 and 2020 only 14.76% of the forest cover fragmented when most of the parts converted to agricultural lands accounting to 47.84 km² of lands and 18.55 km² to open/scrub/pasturelands. Only 2.49 km² of forest cover converted to waterbodies while only 0.85 km² to built-up lands. Analysing the rate of fragmentation between 2000 and 2020 it was seen that (Table 9) nearly 23.88% of the actual forest cover from 2000 converted to other type of lands by 2020. In this case, maximum extent of the fragmented forest cover converted to agricultural lands and open/scrub/pasturelands over a period of two decades.

Unlike other LULC classes, there was 52.42% of open/scrub/pasturelands of 2000 converted to mostly agricultural lands and forest cover by 2010 which was measured to be 84.0 km² and 7.34 km² respectively. Only 3.04 km² and 0.55 km² of such lands converted to forest cover and waterbodies respectively. This conversion further intensified by the end of 2020 where 84.84% of such lands in 2010 converted to mostly agricultural lands, forest cover and waterbodies accounting to 187.38 km², 39.58 km² and 12.75 km² by 2020 respectively. Between past 20 years, 81.16% of such lands fragmented to agricultural lands (123.77 km²), forest cover (13.98 km²) and 6.20 km² of forest cover. Only 3.02 km² of these land types converted to waterbodies from 2000 to 2020.

As observed, 63.94% of the actual extent of surface waterbodies converted to 108.88 km² of agricultural lands, 16.08 km² of open/scrub/pasturelands by 2010. Very less extent of area converted to forest cover and built-up lands during this first decade. In the second decade, probably the converted area regained its natural space and only 18.19% of fragmentation was observed of which maximum extent converted to agricultural lands. From 2000 to 2020, nearly 35.18% of the waterbodies mostly fragmented to agricultural lands covering an extent of 63.56 km² and only 7.20 km² to other types of LULC. It can be seen that the percentage of transformation and fragmentation for any particular LULC class was never same for any particular period of time. In the next session the actual vulnerable type of LULC class is discussed in details.

VI. Conclusion

Finally, it is concluded that the forest lands are the most vulnerable land-types in the district which has a difference of 16.71% of decrease over the past two decades as it has undergone only 7.17% of transformation but fragmented up to 23.88%. The surface waterbodies are the second most vulnerable land cover types in the district during the same period with the difference of 15.16% of loss in its extent as the resource has to undergo 20.03% transformation but 35.18% fragmentation which indeed a matter of concern for the cultivators who mostly depend on the surface water for soil moisture and irrigation. The rangelands which included the open pasturelands, wetlands, scrublands and woody shrubs also lost the actual extent of at least 10.56% of its original extent during the same period with a trade-off of 70.60% net transformation against 81.16% fragmentation. Loss in the rangelands seriously affects the ecosystem biology as well as stock farming and often it may lead to abnormal local weather condition too. At the same time the actual expansion of farmlands and built-up lands were 7.34% and 60.68% which was exchanged with the decrease of the other three land cover types. So, it was concluded that the natural land cover are the most vulnerable land-types in the districts while this decrease is trading-off with the cultured land covers. And if it is not managed today, then it can pose sever threats on the livelihoods of the locales in future. This research paper may further suggest to annually monitor the LULCC from the LT and LF point of view to properly assess the rate of increasing vulnerability of the land resources for perspective land management practices and public awareness which would help optimising the land resources.

Appendix

LT: Land Transformation

LF: Land Fragmentation

LULC: Land cover – Land use

LULCC: Land cover and Landuse Change

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Table 4 LULC in 2010 Transformed from LULC of 2000

LULC	Agricultural Lands	Built-up Lands	Forest Cover	Rangelands	Waterbodies	Total (2010)	% of LT
Agricultural Lands	**1566.47**	0.00	86.96	84.00	108.88	**1846.31**	**15.16**
Built-up Lands	27.39	**38.48**	0.33	3.04	0.59	**69.83**	**44.89**
Forest Cover	15.40	0.00	**446.73**	7.34	3.03	**472.51**	**5.46**
Rangelands	128.84	0.00	57.20	**86.15**	16.08	**288.27**	**70.11**
Waterbodies	8.37	0.00	1.09	0.55	**72.52**	**82.53**	**12.13**
Total (2000)	**1746.48**	**38.48**	**592.30**	**181.08**	**201.11**	**2759.45**	**0.00**

Table 5 LULC in 2020 Transformed from LULC of 2010

LULC	Agricultural Lands	Built-up Lands	Forest Cover	Rangelands	Waterbodies	Total (2020)	% of LT
Agricultural Lands	**1648.56**	0.00	47.84	187.38	13.10	**1896.88**	**13.09**
Built-up Lands	21.67	**69.83**	0.85	5.37	0.15	**97.88**	**28.65**
Forest Cover	42.91	0.00	**402.78**	39.08	0.90	**485.68**	**17.07**
Rangelands	52.92	0.00	18.55	**43.69**	0.86	**116.02**	**62.34**
Waterbodies	80.24	0.00	2.49	12.75	**67.51**	**162.99**	**58.58**
Total (2010)	**1846.31**	**69.83**	**472.51**	**288.27**	**82.53**	**2759.45**	**0.00**

Table 6 LULC in 2020 Transformed from LULC of 2000

LULC	Agricultural Lands	Built-up Lands	Forest Cover	Rangelands	Waterbodies	Total (2020)	% of LT
Agricultural Lands	**1615.96**	0.00	93.59	123.77	63.56	**1896.88**	**14.81**
Built-up Lands	50.13	**38.48**	2.00	6.20	1.06	**97.88**	**60.68**
Forest Cover	18.69	0.00	**450.87**	13.98	2.14	**485.68**	**7.17**
Rangelands	34.60	0.00	43.32	**34.11**	4.00	**116.02**	**70.60**
Waterbodies	27.10	0.00	2.52	3.02	**130.35**	**162.99**	**20.03**
Total (2000)	**1746.48**	**38.48**	**592.30**	**181.08**	**201.11**	**974.49**	**0.00**

Table 7 LULC of 2000 Fragmented to LULC in 2010

LULC	Agricultural Lands	Built-up Lands	Forest Cover	Rangelands	Waterbodies	Total (2000)	% of LF
Agricultural Lands	**1566.47**	27.39	15.40	128.84	8.37	**1746.48**	**10.31**
Built-up Lands	0.00	**38.48**	0.00	0.00	0.00	**38.48**	**0.00**
Forest Cover	86.96	0.33	**446.73**	57.20	1.09	**592.30**	**24.58**
Rangelands	84.00	3.04	7.34	**86.15**	0.55	**181.08**	**52.42**
Waterbodies	108.88	0.59	3.03	16.08	**72.52**	**201.11**	**63.94**
Total (2010)	**1846.31**	**69.83**	**472.51**	**288.27**	**82.53**	**2759.45**	**0.00**

Table 8 LULC of 2010 Fragmented to LULC in 2020

LULC	Agricultural Lands	Built-up Lands	Forest Cover	Rangelands	Waterbodies	Total (2000)	% of LF
Agricultural Lands	**1648.56**	21.67	42.91	52.92	80.24	**1846.31**	**10.71**
Built-up Lands	0.00	**69.83**	0.00	0.00	0.00	**69.83**	**0.00**
Forest Cover	47.84	0.85	**402.78**	18.55	2.49	**472.51**	**14.76**
Rangelands	187.38	5.37	39.08	**43.69**	12.75	**288.27**	**84.84**
Waterbodies	13.10	0.15	0.90	0.86	**67.51**	**82.53**	**18.19**
Total (2010)	**1896.88**	**97.88**	**485.68**	**116.02**	**162.99**	**2759.45**	**0.00**

Table 9 LULC of 2000 Fragmented to LULC in 2020

LULC	Agricultural Lands	Built-up Lands	Forest Cover	Rangelands	Waterbodies	Total (2000)	% of LF
Agricultural Lands	**1615.96**	50.13	18.69	34.60	27.10	**1746.48**	**7.47**
Built-up Lands	0.00	**38.48**	0.00	0.00	0.00	**38.48**	**0.00**
Forest Cover	93.59	2.00	**450.87**	43.32	2.52	**592.30**	**23.88**
Rangelands	123.77	6.20	13.98	**34.11**	3.02	**181.08**	**81.16**
Waterbodies	63.56	1.06	2.14	4.00	**130.35**	**201.11**	**35.18**
Total (2010)	**1896.88**	**97.88**	**485.68**	**116.02**	**162.99**	**2759.45**	**0.00**

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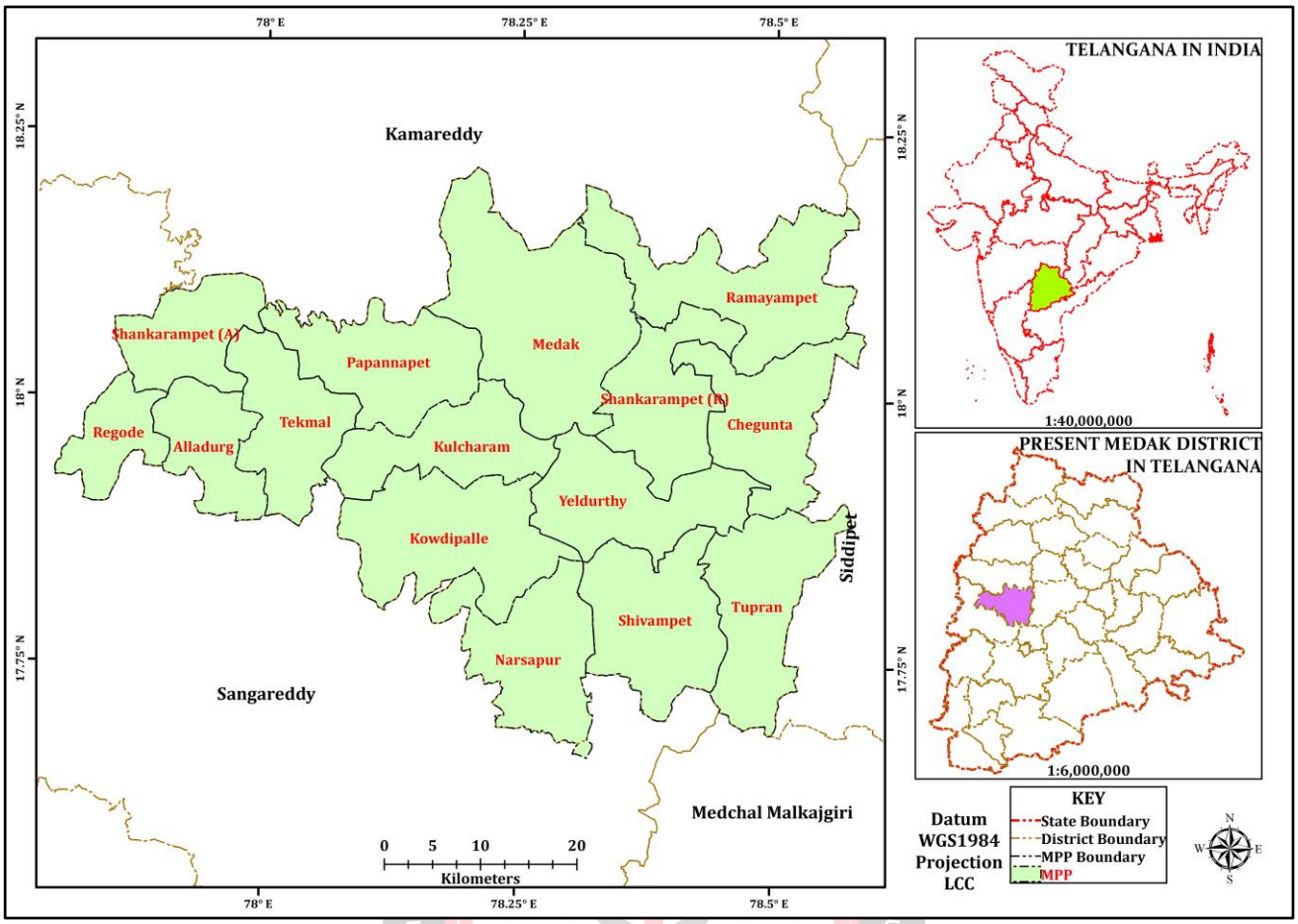
Source: LULC – extracted from Image Classification (Area in km²)

NB: Cells highlighted with green colour represent the unchanged portion of the LULC class.

Figure 1. Location of present Medak district in Telangana State



Source: Telangana Open Data Portal (https://data.telangana.gov.in/)

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