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REVIEW ARTICLE

APPLICATION OF KERNEL DENSITY ESTIMATION (KDE) FOR IDENTIFYING SPATIAL PATTERN OF ROAD DENSITY AND ITS IMPACT ON LANDSCAPE FRAGMENTATION IN VISAKHAPATNAM CITY, ANDHRA PRADESH, INDIA

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ABSTRACT

Increasing density of population is enforcing tremendous pressure on urban sectors. These urban centers are highly populous and cluster settlement by the centralized regional planning process in India. This work has been emphasis on road network and road density study urban area of Visakhapatnam, Andhra Pradesh. Increase of urban density along with road network is effective important factors which as directly linked to the ecological disruption under roads build-up area.The major objective to the study of identified the road density measuring through the Kernel density formula using. The Kernel Density Estimation (KDE) has applied on road network analysis which is followed by the OSM data in Arc GIS software. This Kernel density measuring for road network density per sq. m in Visakhapatnam city. The estimation the patch density and landscape fragmentation due to urbanization expansion by FRAGMENTED software. The results indicate that areas with higher road densities characterized by greater proportion of urbanized land along with a lower presence of agricultural along with forested areas. This result reflects vice versa condition of these considered components. The result indicates that the road networks have divided the landscape into smaller sections, creating numerous patches. The spearman rank correlation model also demonstrated a positive relationship between road density (measured in meters per square meter) and landscape fragmentation across the entire area of Visakhapatnam city. Within this KDE, the city of Visakhapatnam exhibits a distinct spatial distribution of road density, allowing for accurate prediction of the road's impact on landscape fragmentation.

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INTRODUCTION

The urbanization provides countries opportunities to improve the human lives and enhance the economic development in cities and towns. The coastal areas have a high population density due to the presence of marine environment facilities that support activities like transportation, tourism, and fishing. The urbanization means the increase the pressure on ecosystem and major problem are landscape conflict between natural and manmade resources. The 40% world population lives in coastal area (Burke *et al.*, 2001; IOC/UNESCO, IMO, FAO, UNDP, 2011) and a significant demographic concentration within a limited geographical area. That represent a large number of population obtained goods and service from the marine ecosystems. It's a very challengeable condition and rapidly change the coastal landscape." Visakhapatnam has been transformed into a port city, with its economy centered around port-related activities and industries. The Visakhapatnam port is a significant port with the second-highest capacity on the East Coast". Near to the the port Gangavaram is a privately operated port with dedicated railway sidings and direct access to the National Highway. Both of them have experienced a significant increase in transportation activities over the past few decades. Urban growth significantly contributes to the decrease in global biodiversity due to the fragmentation of urban landscapes. Road network is an important component of human development that comprises transport activities for the country side area. Any urban road network is segregated the urban landscape patches, which are the important social, economic and ecological factor like Visakhapatnam city. Moreover, landscape changes are rapidly found in urban area, because this areahas always the nature of pulling the people and capital towards activities center.

Currently, Visakhapatnam is the capital of Andhra Pradesh. Previously, this city was renowned as a port and industrial hub. However, it has now become the capital city - the state of Andhra Pradesh. So, road density and settlement density are rapidly increasing through the rapid landscape fragmentation since last few decades. Urbanization and landscape modification have a vice -versa relationship for an urban area. The road networks in Visakhapatnam city exhibit diverse forms and distinct characteristics. The city is dispersed from mountains (Eastern Ghats) location and plain land encroached only a cluster location, so the human populations are closelyclustering identified in this city. Visakhapatnam city is situated adjacent to NH-16, which is component of' Golden Quadrilateral' initiative implemented by the GoI. The region was traversed by a portion ofthe Waltair division in the ECR and the Vijayawada Division in the SCR. The primary transportation link between the port and the surrounding inland areas is also significantly contributing to the influx of passengers who are willing to pay for urban activities & tourism. Currently, the availability of airline connections is significantly restricted because of operational limitations in navy facilities along this coastline. Road system of the Visakhapatnam Metropolitan region is comprises of two National High-ways, such as NH-5 & NH-43, connected through Anakapalli-Anandapuram road (State Highway).Important road, NH-5 from Chennai to Kolkata passes through this town. Ankapalli is railway head-quater on the Vijaywada-Waltair section of Chennai-Kharagpur railway line. The river Sarada, which has been flow on the west side of the town, it is spanned over by both road and railway bridges.In 1970, this port area emerged as a central hub for the city's urban expansion, primarily due to its industrial development and shipyard activities. The Visakhapatnam metropolitan urban growth has beenrapid towards Pendurthi, Anakapalli, Narava, Madhurwada, Vizianagaram, Bheemunipatnam and the catchment area of Meghadrigada Reservoir. The expansion of the city has been limited on the northern, western, and eastern sides primarily due to the presence of the Adivivaram hills range on the northern side, the Yeneda hill range on the southern side. On the other hand,extensive Bay of Bengal is occupying the eastern part of this city. Port swamp area is covering about 3000 hectares with in the city which has been confided bydefense areas, airport and hills. The Urban Growth has been taken place on hilly areas, mainly around Simhadri and Yarada hills. Transportation activity has been increased and assigned of development.

The study region possesses a highly advanced inter-city transportation network that encompasses various modes of transportation, including rail, air, road, and sea routes. The designated region for the project is connected to the remaining country through major roads such as NH-26 and NH-16. The VMRDA Area spans approximately 490 kilometers of State Highways, along with other roads including major district roads and other district roads, amounting to a total of roughly 1,700km. The BRTS project was approved for two corridors as part of the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) scheme. Two of these corridors are the Pendhurthi Transit Corridor (PTC) as well as the Simhachalam Transit Corridor (STC). The Visakhapatnam metro rail project has been planned to be implemented in three phases. The suggested routes include a connection between the steel plant and Bhogapuram airport, a link between Thatichetlapalem and ChinnaWaltair, and a route connecting Gurudwara to the old head post office. The existing pathways are going to be upgraded by introducing battery-powered trams along routes such as "Steel Plant to Anakapalle, NAD junction to Pendhurthi, and Old Head Post Office - R.K.Beach-Bheemunipatnam. The Chennai-Howrah main line of the Indian Railways serves the VMRD Aarea". Presently, it is under the purview of both SCR along with ECoR. The VMRDA region encompasses a railway network of approximately 300 km, along with an additional 675 km of extended railway lines. The VMRDA region includes two prominent maritime ports, namely Visakhapatnam Port Trust as well as Gangavaram Port. Thus, the project area encompasses 2 prominent ports, namely a container terminal as well as a fishing harbor. The Visakhapatnam airport serves as an operational airport inside the project area. While it primarily serves domestic flights, it has recently expanded its operations to include international flights. The Visakhapatnam airport is situated approximately 7 kilometers away from the city, in close proximity to NH-16. The study focuses on the evaluation of road density using the KDE procedures including landscape metrics to accurately describe road networks as well as their relationship with landscape fragmentation. KDE aiming calculationofcontinuous and smooth estimation of the probability density for a single or multiple variables. This is achieved by employing "a weighted distance function, typically a Gaussian Kernel, that measures distances in Euclidean space (Rosenblatt 1956, Parzen 1962, Silverman 1986, Bailey and Gatrell 1995). Often, KDE allows for the display of event clusters across the analyzed region. These visualizations demonstrate that peaks represent clusters or 'hot spots' in the distribution of events, while low estimated values indicate events occurring far less frequently in this region. (Xuejiao Cai *et al*. 2013). Historically, KDE function was extensively utilized in various point or pattern analyses, encompassing analysis of populations as well as crime hot-spot analysis (Bailey and Gatrell 1995), as well as the estimate the home range of wildlife(Worton 1987). Considering the recent enhancements in the ArcMap Desktop 9.2 GIS software" (ESRI 2006), it is now feasible to utilize KDE procedure to examine the attributes of networks along with their impacts on the environment. The landscape fragmentation is the challengeable issues in a hilly rocky coastal city. Because roads area located between the hilly region and it is narrow patches. Moreover it's highly convertedthe landscape fragmentation and increasing the small patches forming by the road network. This FRAGSTAT software are measuring the Patch density (PD), Mean Area (MA) and assessment the more landscape science. The objective of this paper are-i) To assess road density which quantified by KDE function, ii) Trends of present land-use and land-cover assessment using Landsat-8 image, iii) Estimation of road density patches using Spearman Rank- Correlation techniques, iv) To identify the Patch density (PD) and AREA_MN ratio of the land use patches using FRAGSTAT software. The result of this article all small road density compress a small geographical area. All small road networks well connected with National Highway 5 and 43. The forest and agricultural landscape area decreases and increases the human landscape within Visakhapatnam city.

MATERIALS AND METHODS

Area consideration: Research under consideration is the city of Greater Visakhapatnam, Andhra Pradesh'scapital. Visakhapatnam, a city of high status, is situated on the eastern coast of India, specifically in the state of Andhra Pradesh, adjacent to the Bay of Bengal. The city's urbanized region spans approximately 76 square kilometers, with its boundaries roughly defined by latitudes 17°42' and 17°46' N, and longitudes 83°16' E and 83°22' E.Visakhapatnam was initially a fishing village before hundred years back. The satellite image reveals that the city is located in a depressed basin bordered by the Kailasa hill range (478 m) to the north and the Yarada hill range (352 m) to the south, which are about 10 km apart from both. Both these hill ranges from a part of the Eastern Ghats. Apart from these E-W trending hill ranges, there are a few small hills with an elevation of less than 50 meters located in the municipality area. The regional landscapes in Greater Visakhapatnam city have transitioned from the transitioning from a conventional agricultural landscape to an established urban landscape. A small wide beach present which width is near about 50 to 75 meter. The depth are so high near the shoreline and water color the light blue. The geographical view it is the rocky coastal region.

Data Potentials: The Open Street Map (OSM) data are generated by usingthe Arc-GIS pro software on Greater Visakhapatnam city in 2022. The OSM data are a necessity for road-length networks in Visakhapatnam city. A land-use map generated through manual interpretation of Landsat- OLI/TIRS satellite image with a resolution of 30 meters in the year 2022. This Landsat image was downloaded from USGS Earth Explorer. In order to streamline the data for analysis, have categorized land-use into 6 distinct types of landscape: settlement, vegetation, water body, industries, agricultural land, and port. The adoption of this simplified land employs categorization scheme aiming the analyzing of the relationship among the OSM road network as well as the corresponding landscaping pattern throughout Visakhapatnam city. The settlement and industries are covering 24.85 % and 17.84 %respectively in the Visakhapatnam city. Another area of a vegetation and water body has covered are 29.53% and 1.89 %respectively in this city.

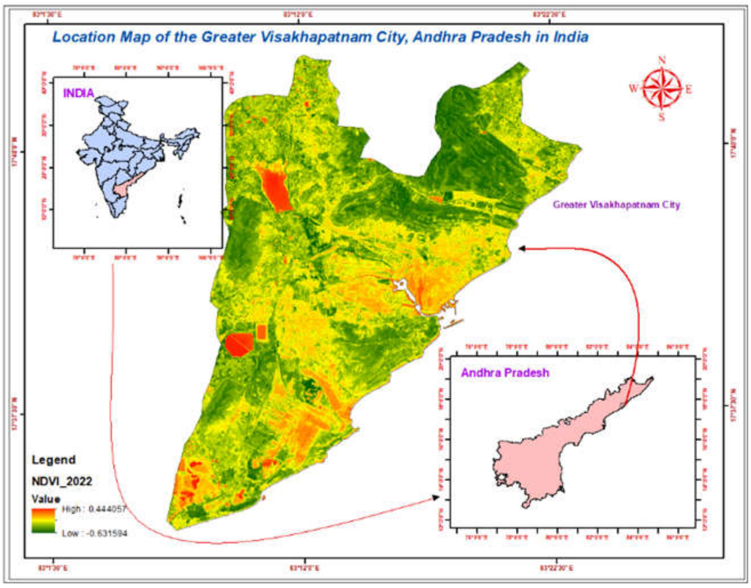

Figure 1. Location map of the study area

Kernel Density Estimation (KDE) using GIS: The KDE uses the line and point features of any area in ARC GIS. Let x1, ..., xn represent a "set of independent and identically distributed samples selected from a population with a density distribution function f. The f value at a specific point x is denoted as f(x)".In general, followed by Rosenblatt–ParzenKDE, estimation has been employed through following " function:

$$fn(x) = \frac{1}{nh}\sum_{i=1}^{n} k\left(\frac{x - x_i}{h}\right)$$

The kernel" function defined by variable k. The bandwidth, denoted by h, is greater than 0. The term (x-xi) represents distance between the estimation point and also the sample xi. Precisely measuring bandwidth in KDE significantly affects resulting outcome. "An h increases; the change of the dot density in the space becomes always smoother, concealment the structure of the density. As h value decreases, the variation in the estimation point becomes increasingly irregular. Here, the variable h is flexible and needs to be tested based on various h values (XuejiaoCai *et al*. 2013).When performing Kernel Density Estimation in ArcGIS, a default bandwidth is automatically generated by dividing the minimum width or length by a consideration of 100 mt".

The specific attribute of Kernel Density Estimation stated below:

- This "estimation utilizes a predetermined searching radius, which represents the bandwidth of the kernel function. It also counts the number of events within a circular area that moves along.
- This function has calculated the precise grid size based on the required level of precision and accuracy for the events being considered.
- The kernel function directly determines the density contribution of each event considered to each grid within the circle.

- The algorithm calculates the density value for each grid by summing the contributions of the density functions from each event within the search circle to the" corresponding grid.

Simpson's Diversity Index

"$D = 1 - (\sum n(n-1)/N(N-1))$"

Where, D = Simpson's Diversity Index,

n = Individuals of a single parameter or sample.
N = Individuals in total population

"Shannon's Diversity Index

$H = -\sum_{i=1}^{s} p_i \, 1np_i$"
where, H= Shanno'n Diversity Index.
p_i = Fraction of the entire considered population made up of sample *i*
S= Number of sample encountered.

Patch Density

$PD = NP/CA$
Units Number per 100 hectares
"Range: PD > 0, without limit.
Description: The PD is calculated by dividing the number of patches of a specific patch type (NP) by the total area of the landscape. The result is then multiplied by 10,000 and 100 to convert it to 100 hectares".

Spearman rank Correlation

$$p = 1 - \frac{6\sum d_i^2}{n(n^2-1)}$$

Where,

p = Spearman's rank correlation coefficient.
di = Difference between the ranks of each observation.
n = Number of observation.

Landscape fragmentation caused by roads network: Landscape fragmentation of Greater Visakhapatnam city has been increased temporarily due to rapid growth of road networks and road density. The increase has been quantified employing PD and mean patch area (AREA_MN; hectares). PD and AREA_MN had been calculated by integrating the original landscape graph with the corresponding road network graph. The degree of fragmentation of landscape resulting from roads can be quantified by the ratio of two metric alterations (XuejiaoCai *et al.* 2013).

The metrics were selected based on their intrinsic capacity to depict the condition of landscape fragmentation in this investigation. Furthermore, previous studies have utilized these metrics, enhancing the comparability of the results (Tinker *et al.* 1998, O'neill *et al.* 1999, Saunders *et al.* 2002, Geneletti 2004, Hawbaker *et al.* 2006). The metric values have been determined by employing the FRAGSTATS software.

Quantitative relationship between road network and landscape fragmentation: Ultimately, the researchers utilized Spearman Rank Correlation analysis to investigate the connection amongst road densities with landscape fragmentation in the Greater Visakhapatnam City. The road density, as measured by the KDE function, exhibited a continuous distribution. It was then categorized into 4 distinct categories, along with the correlation among road density as well as landscape fragmentation.

RESULTS AND DISCUSSION

Spatial Pattern of road density: The Kernel Density distribution of the road system in Greater Visakhapatnam City, estimated with a 100-meter bandwidth for the KDE, clearly reflects the spatial structure of the road network in the core area or CBD zone. The road kernel densities were primarily focused on National Highways (NH), State Highways (SH), Urban local Roads (UR), and Industrial Road (IR) within the central business district (CBD) area of the city.

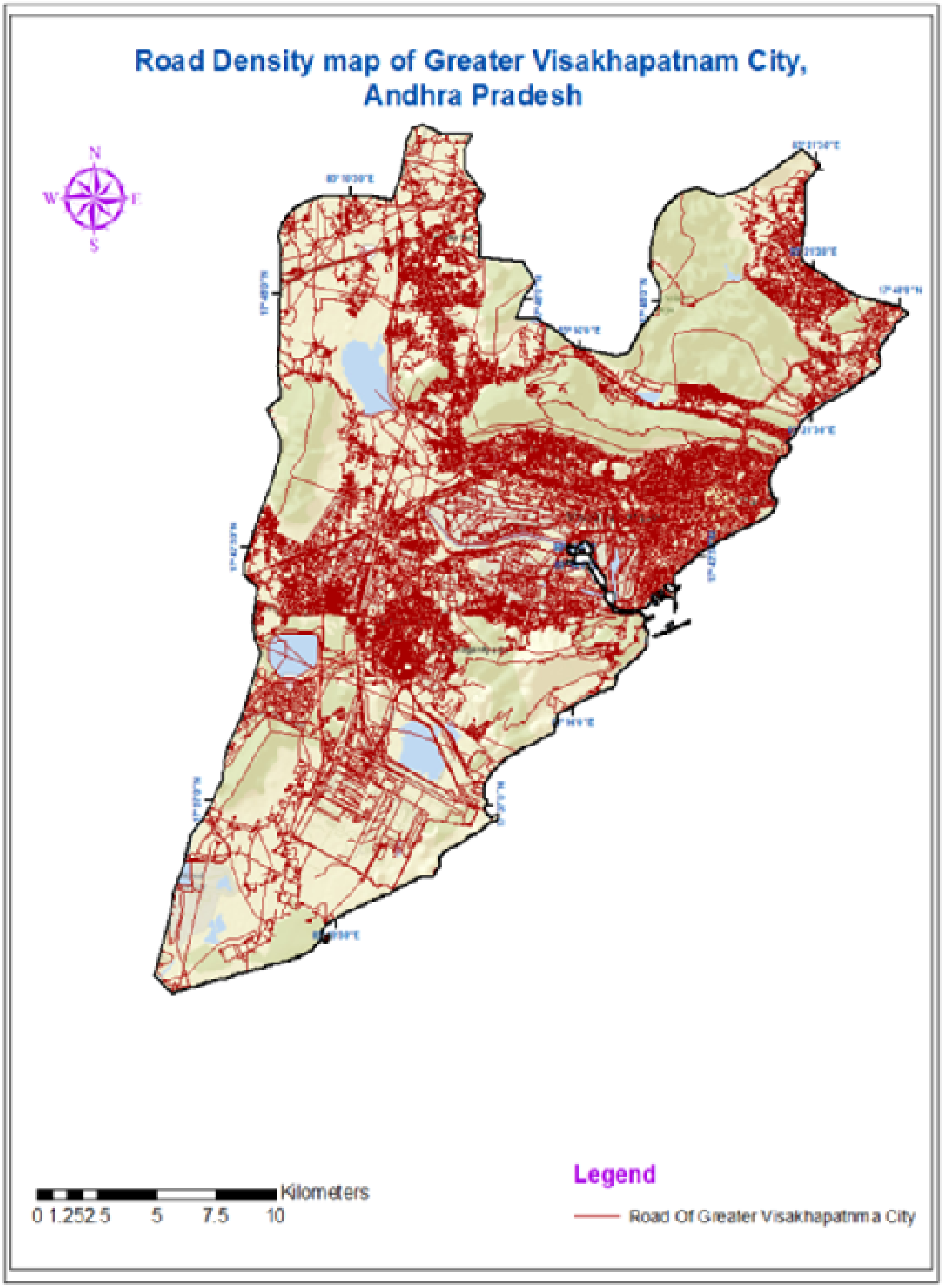

Figure 2. Road Density (RD) map of Greater Visakhapatnam City, Data sources (OSM), by the ARC GIS 10.8 Software

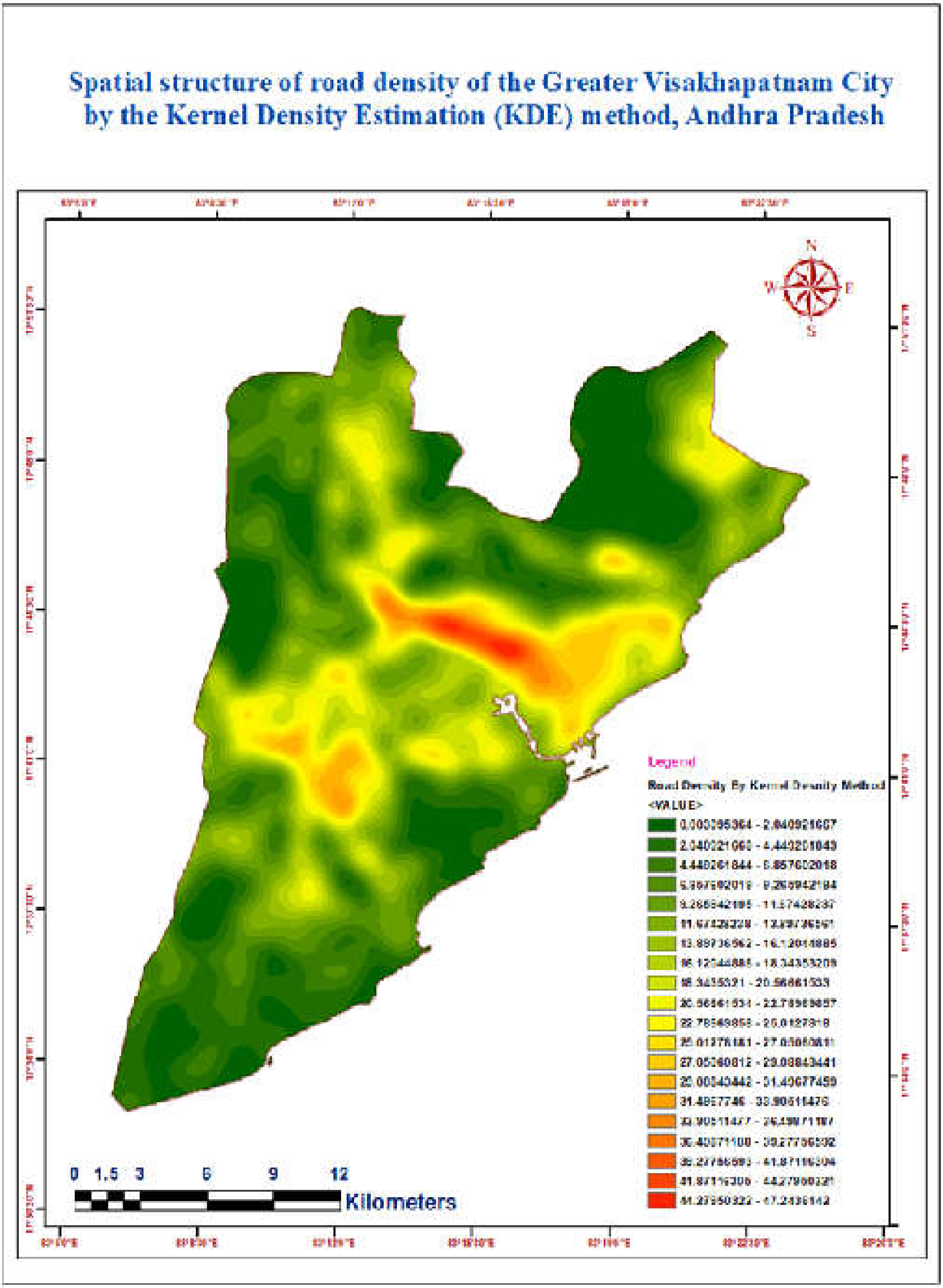

Figure 3. Spatial Structure of Road Density (RD)

The areas with high road density (greater than 1m/m2) were concentrated in the metropolitan area of Greater Visakhapatnam city. This is due to the city's extensive history of land use since gaining independence. This city was previously a port city and after industrial growth, it became the capital city of Andhra Pradesh. The Greater Visakhapatnam City transportation israpidly increasing after industrial growth and tourism purposes. The highest city road density is 44.28 and 47.24 (22.79 $m/m^2 \leq RD <$ 47.24 m/m^2) meters per square meter respectively between the hilly and water channel network area. The periphery zone of the city road density is 0.0031 m/m^2 and 9.26 m/m^2 respectively, where density area isscatters within the city. This scatter road density area has been decreases towards the urban periphery and hilly area.

This has occupied by low population density. The peripheral city is characterized by a scarcity of industrial factories and a low level of economic activity. The density ofroad alters within the city as per landscape fragmentation. The result shows that landscape core area are estimatedfor Settlement area are (24.99 %), Industrial land (17.69 %), Agricultural land (25.84 %), Vegetation (29.43 %), waterbody (1.88 %) and port (0.16 %) respectively (Table-1). In this region 24.08 m/m^2 road density (RD) has been confirmedfor built up area, 6.11 m/m^2 for industrial area and 5.56 m/m^2 for the agricultural and urban peripheral zone (Table-2). The graphical presentation of the land use attainment is also present in Figure -1. After the classification of considered parameters road density is also determined in this paper. The result reveals that, the buildup area is indicating highest value of road density parameter, only hilly area is represents lowest value of road density. The graphical presentation of this result is given in Fig-2. Moreover, the distribution of road networks increases in a built-up area and is sparse in urban peripheral zone within the city.

Table 1. Land uses attainment in percentage of Greater Visakhapatnam City

TYPE	PLAND (Percentage of Landscape)
Class 6 (Agricultural Land)	25.84
Class 5 (Industries)	17.69
Class 1 (Settlement)	24.99
Class 2 (Vegetation)	29.43
Class 3 (Waterbody)	1.88
Class 4 (Port)	0.16

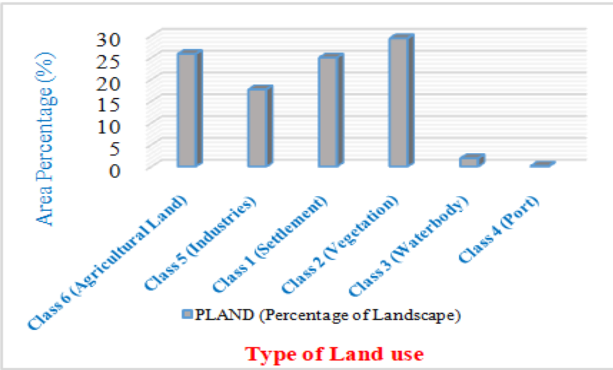

Fig.4. Percentage of Landscape

Table 2. Estimated Road Density (RD) for different land use classes

Road Density value	Class / Categories	Road Density(m/m^2)
RD>22.78	Built up Area	24.08
16.12 < RD ≤22.78	Industrial Area	6.11
11.67 < RD ≤16.12	Agricultural Land &Peripheral Area	5.56
6.85 < RD ≤11.67	Vegetation and Hilly area	4.82

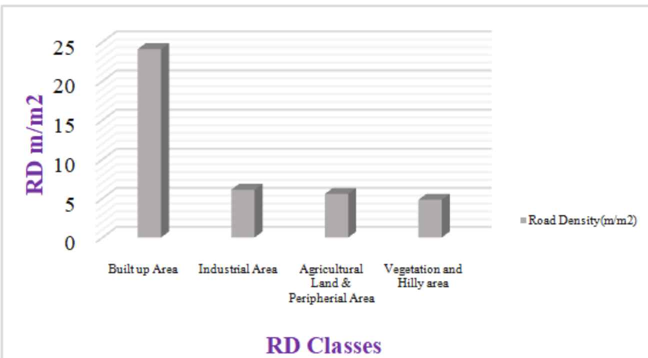

Fig. 5. RD Classes

Landscape fragmentation caused by road networks: Landscape fragmentation refers to reduction in average patch size as patch density (PD) increases. As planned, the PD (patch density) increased while the mean patch area decreased when the road network system was introduced alongside the land-use map. There is a correlation between the density of roads and the increase in population density (PD) in Visakhapatnam city. Specifically, as the road density increases, the PD increases, and as the patch area decreases, the correlation becomes stronger. Moreover, the Spearman rank correlation model demonstrates that there is a positive relationship among Landscape fragmentation as well as road density within city. The density of roads isdenser attainmentwhen the landscapes are more fragmented. The level of landscape fragmentation is directly proportional to the density of the road network. This relationship is relevant for six different landscape types in the study area.

Patch Density (PD) condition: Urban roads autonomously facilitate the transportation of both individuals and goods, serving as a crucial component of modern urban civilization. Roads are indispensable for the contemporary urban existence and way of life. Nevertheless, the construction and maintenance of roads have sparked controversy due to public concerns regarding the long-term effect of roads on landscapes (Forman and Alexander 1998, Spellerberg 1998, Trombulak and Frissell 2000).

Table 3. RD class wise Patch Density (PD)

Road Density Classes (RD)	Land use Type	PD (Patch Density)
11.67 < RD ≤16.12	Agricultural Land	1.966
16.12 < RD ≤22.78	Industries	2.4556
RD>22.78	Settlement	1.5247
6.85 < RD ≤11.67	Vegetation	1.24
<6.85	Waterbody	0.0709
<6.85	Port	0.0256

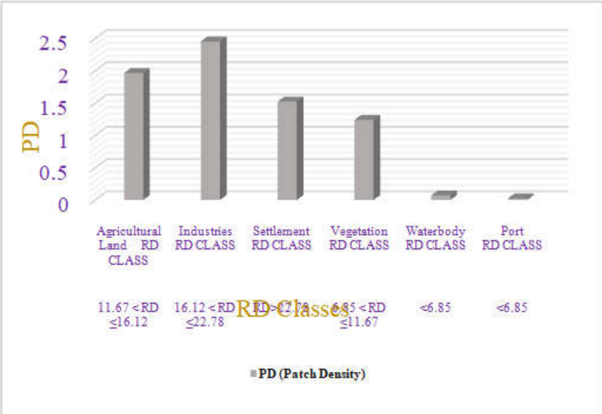

Fig. 6. RD class-wise Patch Density (PD)

Table 4. RD class wise AREA_MN of land use classes

Road Density Classes (RD)	Land use Type	AREA_MN (Mean)
11.67 < RD ≤16.12	Agricultural Land	13.14
16.12 < RD ≤22.78	Industries	7.20
RD>22.78	Settlement	16.39
6.85 < RD ≤11.67	Vegetation	23.71
<6.85	Waterbody	26.55
<6.85	Port	6.30

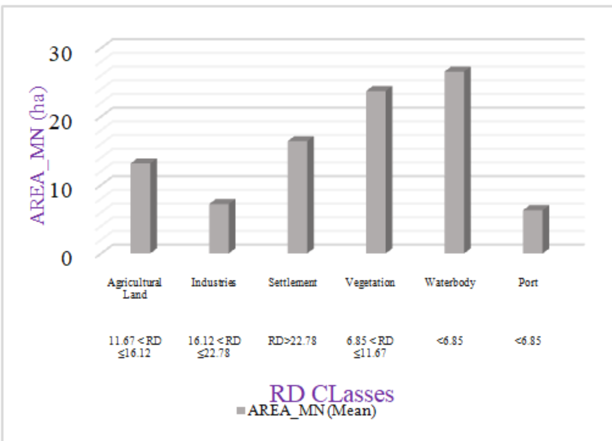

Fig. 7. AREA_MN of RD class

Table 5: Ratio of the PD and AREA_MN on different RD classes

Road Density Classes (RD)	Land use Type	Ratio of changes in PD and AREA_MN	Percentage The ratio of changes in PD and AREA_MN
11.67 < RD ≤16.12	Agricultural Land	0.14958	23.28
16.12 < RD ≤22.78	Industries	0.340842529	53.25
RD>22.78	Settlement	0.0930251	14.53
6.85 < RD ≤11.67	Vegetation	0.052296182	8.15
<6.85	Waterbody	0.00266987	0.41
<6.85	Port	0.004058532	0.63

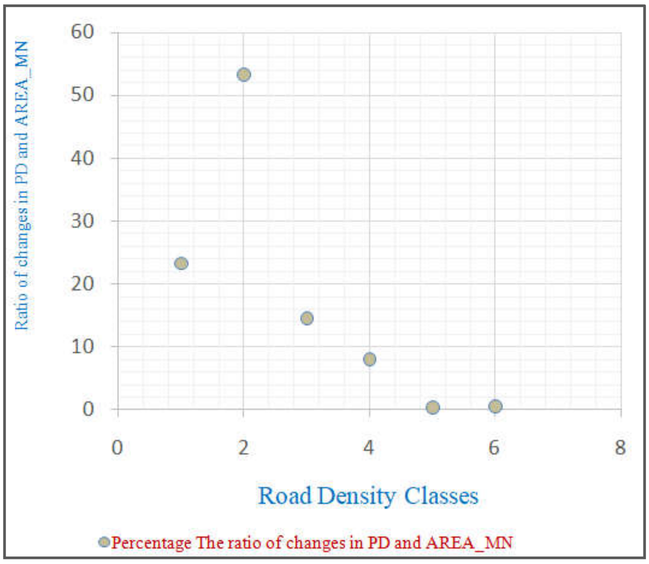

Fig. 8. Ratio of PD and AREA_MN of RD classes

In relation to the land scape denomination along with road density factor, Patch Density (PD) also is calculated through the FRAGSTAT software. The result of this calculation has been given in Table-3. The result reveals that, the Patch Density (PD) is greater where the road density is greater in value. As per the result given in Table-3, Patch Density (PD) are 1.69 for agriculture land, 2.45 for industries, 1.52 for settlement, 1.24n for vegetation, 0.07 for water bodies and 0.02 for port area respectively. A diagrammatic presentation is also presented in Fig-3 accordingly.Consequently, area mean also estimated through this calculation, which is given in Table: 4. In this case water bodies and vegetal covers has indicated highest mean values. These are 26.55 and 23.71 respectively.The results of ratio of changes of PD and area mean have been determined. The result is shown in Table-5. The percentage of ratio of changes in PDand area mean is most for industries (53.25). Agricultural land is lying is second rank (23.28) and settlement exhibits in third rank (14.53) respectively. This result is also present through diagrammed in Fig: 5.

Table 6. Results of Spearman rank correlation tests about the relationship between road density and landscape fragmentation

Spearman rank correlation		PD (Patch Density)	Significance	AREA_MN (Mean)	Significance
Agricultural Land	RD CLASS	1.96	P < 0.01	13.14	P < 0.01
Industries	RD CLASS	2.45	P < 0.01	7.20	P < 0.01
Settlement	RD CLASS	1.52	P < 0.01	16.39	P < 0.01
Vegetation	RD CLASS	1.24	P < 0.01	23.71	P < 0.01
Waterbody	RD CLASS	0.07	P < 0.01	26.55	P < 0.01
Port	RD CLASS	0.02	P < 0.01	6.30	P < 0.01

Table 7. Overall results of Landscape metrics for considered parameters

Landscape Metrics	
Parameter	*Value*
AREA_MN (Mean)	13.72
AREA_AM (Area-Weighted Mean)	2446.94
AREA_SD (Standard Deviation)	182.75
AREA_CV (Coefficient of Variation)	1331.37
SHDI (Shannon's Diversity Index)	1.44
Simpson's Diversity Index (SDI)	0.75
PD (Patch Density)	7.28
LPI (Largest Patch Index)	14.95
TE (Total Edge)	3200900
ED (Edge Density)	63.0558

The Spearman rank correlation test statistics provide a reliable method for assessing the relationship amongst road density as well as landscape fragmentation.

As the road expands, its population density (PD) increases and area of landscapes it covers decreases. This ultimately leads to landscape fragmentation in the city under consideration. The Spearman rank correlation model demonstrates a significant relationship between the degree of landscape fragmentation and the increasing road density in investigation. There is a direct correlation between road density as well as landscape fragmentation (Table-6). Due to its ability to accurately identify clusters in road distributions, KDE application can be estimated how important roads have a significant impact on landscape fragmentation.

The transportation infrastructure is a crucial service sector that serves as the foundation for economic growth across society. The transport network serves to establish connections between the region and the rest of the world, as well as to enhance connectivity within the region by utilizing its own resources. As per consideration of six components, patch density is higher for industrial sectors, having value with 2.45 at p value 0.01 level of significance. On the other hand, mean area for all considered components are statistically significant at 0.01 (p- value), level of significance (Table-6). The patch density for water body and port area are exhibits insignificant at 0.01 (p-value), level of significance. There needs to be a stronger focus on the transportation network and how it is used; this requires a thorough understanding and analysis of the current urban situation. Therefore, the application of correlation calculation and its resulting insights enables the resolution of current issues and the anticipation of future problems.
The landscape metrics has been calculated including area mean, area weighted mean, standard deviation, coefficient of variation,large patch index, along Shannon's diversity index with Simpson's diversity index accordingly. Results have been given in Table-7. These entire indexes indicate high values, that means the incensement of the road density directly attain them positively. Total edge area has been increasing depends upon the increase of road density for the considered study area.

CONCLUSION

The research based on GIS, satellite imagery, FRAGSTAT software, remote sensing, and a novel quantitative methodology known as intensity analysis to evaluate LULC change and urban landscape patches changes. The land transformation rapidly due to urbanization. The Greater Visakhapatnam city number of landscape patches increases when number of road network increases. The patch density increases (PD) with road network expanses and decreases the vegetation cover within the Greater Visakhapatnam city. The road network and landscape fragmentation are correlated subject and both are developed due to urbanization process. This assessment are measuring for which location road density are maximum and which places patch density are maximum. The shortest path maximum found in this research paper and digitizing road networks present in Visakhapatnam. KDE has unveiled the spatial arrangement of road networks. The PD of the considered area is 7.28, Simpson's Diversity Index (SIDI) is 0.75 and Shannon's diversity result value is 1.44. This comparison indicates that, Simpson's result value is high biodiversity of entire land use classes and Shannon's diversity value has expressed moderate level of diversity of land use classes in Greater Visakhapatnam city. The research gap of this study the lack of comparison with other data correction methods. The limited discussion off this type research subject. The future research necessity of traffic control system development for efficient route and bypasses road developed.

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Finally, I would like to thank God, for letting me through all the difficulties. I have experienced your guidance day by day. You are the one who let me finish my degree. I will keep on trusting you for my future.

Author's contribution

Mr. Mintu Jana - The constructing of the hypothesis or idea of research and planning methodology to reach a conclusion. Supervising the research in progress, and taking responsibility for the research completion. The literature study and writing this paper to reach the result and discussion. The using the ARC GIS for assessment the Kernel density estimation (KDE). The preprocessing the landsat images in ARC GIS and landscape structure assessment using the FRAGSTAT software. This FRAGSTAT software using for the Patch Density (PD), AREA_MN (AM) and average assessment the landscape fragmentation.

Dr. Dipak Bisai– Overall concept provide and methodology assessment with the critical review before submission. Another important contribution of research hypothesis build-up and research gap identification on this research paper.

Mrs. Taniya Roy – The author working on the analysis of the interpretation and fixation of the objective of this research paper.

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4. Funding information (Please mention "Funding: None" if you have not received any support for your research)

Conflict of Interest Statement: During this study, there was very few literature found on this topic within the selected area. The financial not to support from our institution. In the preparation of this study collection of the data from Landsat images and cloud percentage is another problem in this research paper.

Data Availability statement

The data collection is a very important part of this research article. This research work is done only depending on secondary data. The secondary data was collected from valuable sources such as satellite images and internet sources. The data availability from many valuable sources are

- **Source data**: The Open Street Map (OSM) data was collected from https://www.openstreetmap.org/. Another Greater Visakhapatnam City (GVC) boundary shape file downloaded from https://apsac.ap.gov.in/gisportal/home/item.html?id=811e402e56944f85ac0d89fc76d235c2 . The Landsat 8 OLI/TIRS image downloaded from USGS EARTH-EXPLORER . The satellite images data sources link is https://earthexplorer.usgs.gov/ . The Asian Highway (AH) 45 and National Highway (NH 16) data are collected from Basic Road Statistics of India, the website link of which is https://morth.nic.in/basic-road-statistics-india. The Greater Visakhapatnam Dity (GVS) data are collected from this website link is https://www.gvmc.gov.in/ .
- Underlying data – The Kernel Density Estimation (KDE) applies to Greater Visakhapatnam City (GVC) for assessing the road density (RD) measures by the use of ARC GIS 10.8 GIS application software. The FRAGSTAT software tools are used for measuring the Patch Density (PD), road density (RD), and AREA_MN (AM) in the selected study area.
- **Extended Data:** Some important literature which are helpful to this research article. These references help to research design and planning for research completed.
- **Reporting Guidelines:** These guidelines relate to the research policy on data availability, which requires all authors to share the underlying data that relates to this article.

We recommended that all data should to an approved online repository together as a single dataset, which can then be cited throughout thi article.

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