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Exploring the importance of accessibility in evolving land use pattern in Aligarh city, India

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Abstract

Urban areas in India as it is elsewhere have become dynamic and witnessing large scale and rapid land transformation. Accessibility and land use are strongly interlinked. India, where roads are the most popular mode of transportation, the development, and growth of several cities stemmed from their location along major roads. Competitions for accessible sites are therefore significantly strong in Indian cities where lan-use patterns are highly dynamic. The present study examines the role of accessibility in land transformation of a rapidly growing urban centre namely Aligarh city. The study is based on remotely sensed data, which were processed in the GIS environment using ILWIS software. The results show that significant expansion and land transformation have taken place in the city mainly due to an increase in population and change in occupational structure, which raised the demand as well as the value of land in and around the city. The results also show that land transformation in the city is more pronounced along the main roads.

Keywords: *Accessibility, Urban land-use, Land transformation, Roads, Buffer.*

Introduction:

The concept of accessibility is a key element in urban, regional and transportation planning, and accessibility is generally considered as one of the important determinants of land–use patterns and land-transformation. On the other hand, land-use has a strong impact on accessibility through the spatial distribution of urban activities. Thus accessibility and land-use are strongly interlinked and are a key element in urban land-use studies Sola et.al 2018). Accessibility, in physical terms linked with activities at one place that can be reached from another place through the transport network. Accordingly, accessibility is dependent on spatial distributions of the destinations (centre of opportunities) relative to a given location, the magnitudes, quality, and character of activities found at the destinations, the efficiency of the transportation system, and the characteristics of the traveler.

Accessibility is a relative quality assigned to a piece of land through its relationships with the transport network and the system of opportunities represented mainly by the urban centers (Inturri et al., 2017). Thus all locations are endowed by a degree of accessibility, but some locations are better and easily accessible than others. Accessibility is related to the principle of minimizing the frictional effects of distance. This principle was originally expressed by Zipf (1949) as the principle of least effort and any industry by Losch (1954) as the law of minimum effort. The underlying reason for these principles is the general tendency for human activities to agglomerate to save operation costs by taking advantage of economies of scale. Thus settlements can be considered as a manifestation of the economies of scale, and the intra-urban concentration of industrial districts and shopping centers are even stronger manifestations of this principle. At a larger spatial scale, more accessible locations appear to be sites for larger agglomerations, which further leads to hierarchical urban structures as described by Christaller (1933) in his central place theory.

Transportation is a web of connected systems meeting particular needs through the interrelated and interdependent activities of its many component units (Rodrigue 2017). Irrespective of size, scope or area of concern, this definition holds the material evidence with which to understand the underlying principle behind any specific land use. Transportation is vital to the development of any settlement; economically transport provides and enhances the space-time quality and utility of goods and services (Morlok, 1980). Today, road transport is one of the most widely used modes. Its development has led to rapid spatial development and growth in various cities and towns of the world. Today in the process of rapid urbanization and industrialization, urban built-up areas have been expanding continuously, leading to the extension of urban socioeconomic activities to suburban and rural areas. This has led to the emergence of distinctive suburban areas surrounding the core areas of many major cities. Because the suburban area is a transitional zone between city and countryside, its development is affected by the interaction of industrial, residential, transport, commercial, and agricultural activities from both urban and rural areas, (Sultana 2019; Gollege, 1960). Consequently, land use in suburban areas often changes rapidly and it always exhibits patterns and dynamics which are quite different from those observed in urban or rural areas. (Wang et al 2011).

The integrated study of transportation development and land transformation and land-use change in the suburban areas can contribute not only to research on land use and urban planning but also to transportation development. Transport infrastructure plays a pivotal role in urban and regional development. By enhancing accessibility and easing the movement of people and goods, improvement in transportation systems accelerates urban land expansion and regional economic growth (Hawbaker et al., 2006). Several studies have found that transport infrastructure development contributes to land use/land cover change, producing urban growth (Handy, 2005; Jha and Kim, 2006), deforestation (Chomitz and Gray, 1996; Cao, 2006), and other ecological effects (Miller et al., 1996; Forman and Alexander, 1998; Trombulak and Frissell, 2000). One of the greatest forces in the spatial development of any area undoubtedly is road development as road expansion and road development promote outward expansion of cities because transport remains the key to the understanding of the land-use changes.

The road is the most popular mode of transport in India because of its reliability, efficiency and above all because it needs less capital than its alternatives. Roads are especially important for transportation over shorter distances. The road network is, therefore, a significant influence on the expansion and transformation of land for different uses in and around cities (Raza and Agarwal, 1986). The transformation of land depends mainly on accessibility, land availability and land value. These factors interact with each other and give rise to specific land uses in and around urban centers (Fazal, 2000). This interaction, which accompanies the development process, leads to redistribution of land in space through the complementary tendencies of concentration and dispersion. As a consequence, some locations experience greater demand from specific land uses than others and hence play a crucial role in the subsequent transformation of the land. These spatial variations require spatial investigation. The buffer zone and gradient analysis provide a powerful spatial analytic technique for detecting the impact of transport infrastructure on land use by investigating spatial distribution and gradient of land use patterns along transport corridors (Zhu et al., 2006).

The Study Area

The present study for Aligarh city which is a class 1 city of the state of Uttar Pradesh situated in its western part between Ganga and Yamuna rivers. The city is spread over an area of about 45 km^2. The city is located in the Lodha block of Koil tehsil and it lies almost in the centre of Aligarh district. Aligarh city situated in the fertile agricultural tract is also characterized by rich agricultural hinterland. Further, the city is the seat of administration and governance. All these locational advantages have contributed to Aligarh city to grow and expand.

Data and Methodology

The study is based on remotely sensed data, which were processed in the GIS environment using ILWIS software and also used ***single land use dynamic degree technique*** (SLUDD) for assessing land-use dynamics in each land-use class. The present study aims at assessing the influence of road proximity and accessibility on land use, its transformations and pace, and the direction of urban expansion in Aligarh city. This analysis was carried out on six main roads coming from different directions and converging on the central part of the city. The six main roads are:

Grand Trunk Road: This is one of the most important roads of not only the country but the Indian sub-continent, built by Mughal ruler Sher Shah Suri. This road has played a vital role in the country's development, stretching through the heartland of the country. Now it connects the two metro cities Delhi (capital of the country) and Kolkata. This road bears heavy traffic inflow because most of the commercial transactions are made through this road. This road enters the study area from the northwest direction.

Agra Road: This is another important road, which connects the city to an important city of the region, the world-famous Agra. This road further joins the city to the state of Madhya Pradesh. Through this road, which enters from the south, the movement of agricultural goods, inputs, and implements occur.

Mathura Road: This road connects the city from Mathura town. This road, also entering from the south, brings agricultural commodities from the nearby regions to Aligarh city and connects to the state of Rajasthan.

Ramghat Road: This road connects the city from Atrauly city to the north-east. This road also brings agricultural commodities and construction materials from the nearby regions.

Anupshahar Road: This is also a very important road that passes through Aligarh University and joins it with the energy generating units of Narora and Qasimpur. It enters from the north and brings agricultural commodities and construction materials from the nearby regions.

Khair Road: This road connects the city from Khair city to the east. This road also brings agricultural commodities and construction materials from the nearby regions.

To study the influence of road proximity on land use and transformation, two buffers were drawn using GIS techniques. The first buffer zone was up to 500 meters from the road (Fig.1) and the second was from 500 to 1000 meters (excluding the first 500 meters) along the roads (Fig.2). Since the roads converge in the central part of the city, the buffer zones are also extended in the central part. Out of the total study area of 15398 hectares, the buffer zone up to 500 meters along main roads extends to 5228 hectares, and the buffer zone of 500-1000 meters along main roads of the city to 3374 hectares.

Discussion

General land use:

The total study area is about 15640 hectares which include not only the city area but also peripheral areas. The total urban area in 1980 was 2259 hectares which increased to 10114.6 hectares in 2015 (Table 1). Much of this increase was in residential class while most of this increase was at the cost of agricultural land that decreased by 7951 hectares during the study period.

Table 1 shows that other than residential and agricultural land another prominent land-use class was vacant land. Vacant land is more like speculative land and agricultural landowners offer their land for urban uses by first converting agricultural land to vacant land and wait for better returns. Among the urban land uses classes, the commercial and industrial class which although do not have large coverage but their transformations were significant. Moreover, these classes also have a specific spatial orientation.

During the period of study (1980 to 2015), Aligarh city has not only expanded from its original size but there was a significant interchange of land among various land use classes. Table.2, and figure 1, show the changes in various urban land use classes in a buffer zone up to 500 meters from the main roads of the city. These changes are because of the development of the city resulting in increased demand for land for residential, commercial, industrial and other purposes. This demand along with site attraction, functional convenience, functional magnetism and the land value of that particular area also have influenced the pace and direction of urban land-use change. However, accessibility appears to have played a dominating role in land transformation.

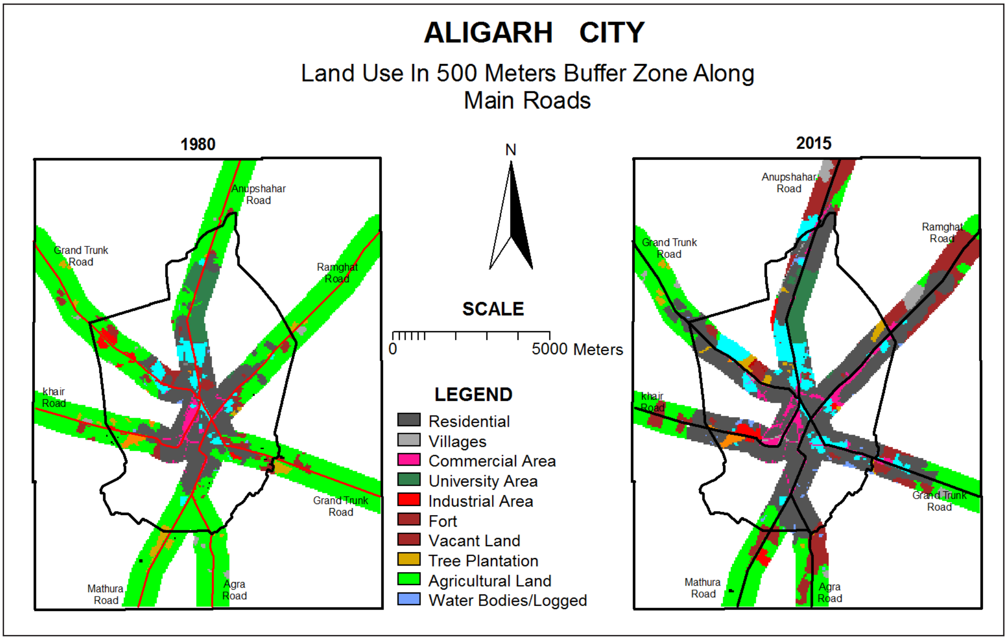

Fig.1: Aligarh City: Land use in 500 meters buffer zone along the main roads

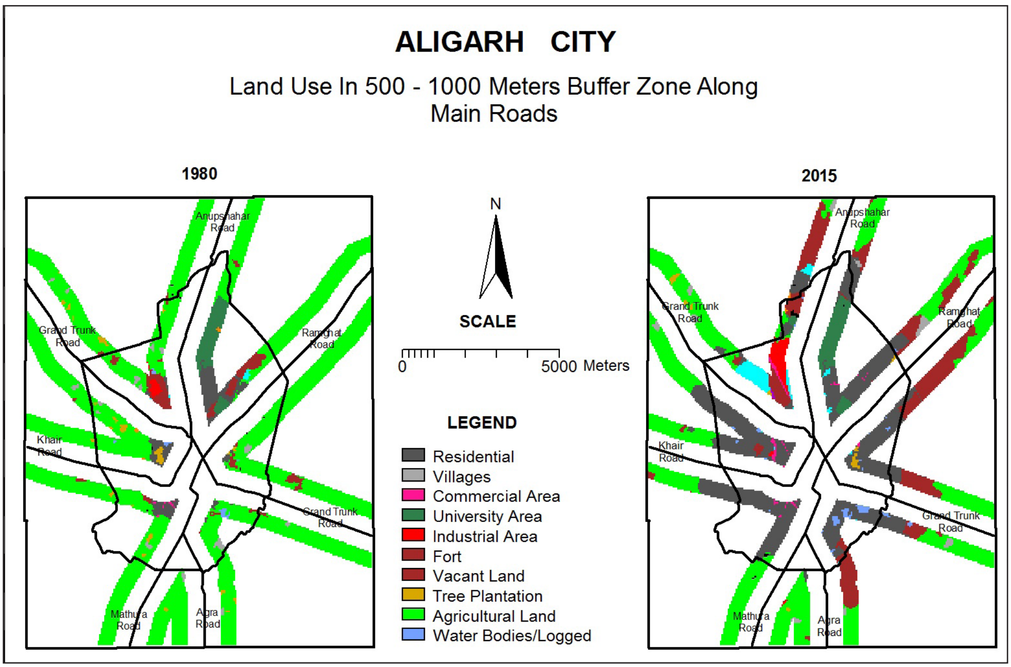

Fig. 2: Aligarh city: Land use in 500-1000 meters buffer zone along the main roads (1980-2015)

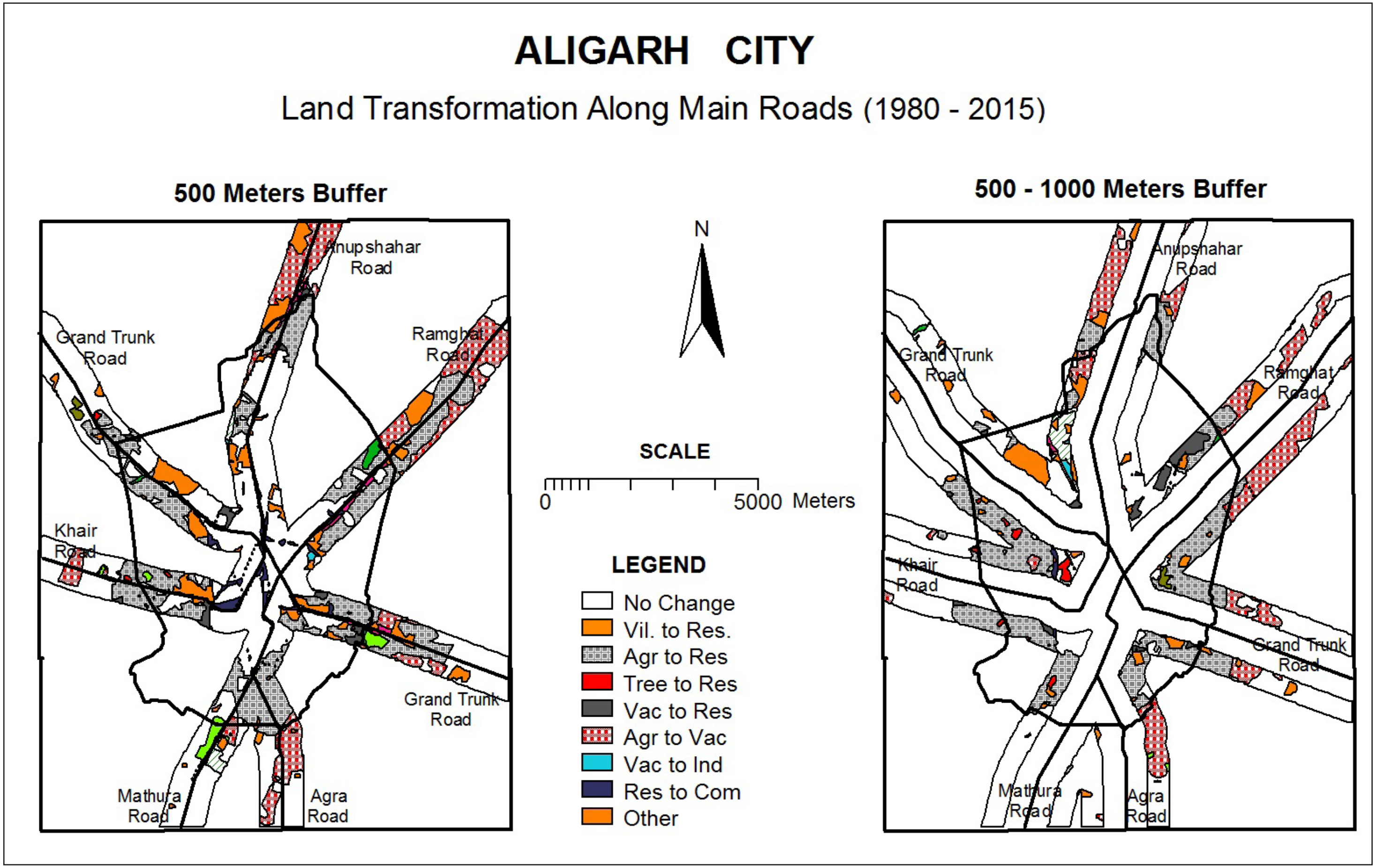

Fig. 3: Aligarh city: Land transformation in 500 meters buffer zone and 500-1000 meters Buffer zone along the main roads

Table 1: Aligarh City: Area under Different Land Use Classes (1980 & 2015)

Land Use/Year	Area (1980)	Area (2015)	Change in Area	% Change
Residential	994.5 (6.35)	4776 (30.53)	3781.5	265.6
Villages	111.5 (0.71)	410.2 (2.62)	298.7	163.9
Commercial	56.5 (0.36)	336.5 (2.15)	280	338.9
Educational Institution & Government Offices	92.5 (0.18)	344.9 (2.20)	257.4	303
University Area	351.5 (2.24)	351.5 (2.24)	-	-
Aligarh Fort	17.5 (0.11)	17.5 (0.11)	-	-
Industrial	64 (0.41)	208.6 (1.33)	144.6	143.7
Vacant Land	441.5 (2.81)	3303.9 (21.12)	2862.4	473.8
Tree plantation	172 (1.09)	267.4 (1.70)	95.4	11
Agricultural land	13209 (84.40)	5258 (33.61)	-7951	-42.3
Others (Recreational, Graveyards, Brick kilns, Water Bodies)	129.5 (0.82)	365.5 (2.33)	236	
Total	15640	15640	-	-
Total urban Area	2259	10114.6	7855.6	24.6
Total non-urban Area	13381	5525.4	-7855.6	-230.4

Note: Area in hectares, Figures in parentheses is the percentage of land to total land

Source: Aligarh City Guide Map, Survey of India, 1980 and IRS ID PAN Satellite Imagery, 2015

Land Use pattern in buffer zone up to 500 meters

The total land which comes under 500 meters from the six main roads of Aligarh city is 5310 hectares. Table 2 and figure 3 show the residential class as the most important dominant land-use class with 2509 hectares followed by agricultural (1621), vacant (334) and commercial (195). Significantly, when we analyze the land transformation especially along with the 500 meters buffer, the residential class has gained the most with an increase of 1526 hectares, whereas agricultural land decreased by 1815 hectares.

Importantly, industrial and commercial use has recorded greater increases. This increase in occupied land close to the roads reflects the importance of accessible location for these land-use classes.

Table 2: Aligarh City: Area under different land use in 500-meter buffer along main roads, (1980-2015)

Land Use/ Year	Area (1980)	Area (2015)	Change in Area	% Change	SLUDD
Residential	947	2509	1562	164	4.85%
Villages	27	6	-21	-77	-2.8%
Commercial	55	195	140	254	7.48%
Government Institution	77	76	-1	-1	-0.038
University	335	335	0	-	-
Social & Recreational	70	73	3	4	0.12%
Industrial	5	119	114	2850	67.05%
Aligarh Fort	0	0	0	-	-
Vacant Land	259	334	75	28	0.85%
Tree Plantation	91	31	-59	-64	-1.90%
Agricultural Land	3436	1621	-1815	-52	-1.55%
Water bodies/ logged	8	11	3	42	1.10%
Total	**5310**	**5310**	**-**	**-**	**-**

Note: Area in hectares.

Source: Based on Aligarh City, Guide Map (survey of India) and IRS 1D Satellite Imagery

Here, a single land use dynamic degree (SLUDD) technique is used to measure the dynamic rate of change in land use during a given time interval in a certain area. The formula for computing SLUDD is as follows:

$$\textbf{SLUDD} = \frac{U_b - U_a}{U_a} \times \frac{1}{T} \times 100\%$$

Where *Ua* is the area of one land-use type at the initial time; ***Ub*** is the area of that land-use type at the later time; T is the length of the time interval. The SLUDD analysis suggests that the industrial area is the most dynamic class in 500 meters buffer along the main roads of Aligarh city. Again all these land use classes require better accessible locations, thus the land transformation dynamics are higher among these classes.

As shown in table 2 and figure 3, agricultural land was the major land-use type in Aligarh city in 1980, covering an area of 3436 ha of the total area, followed by residential area and vacant land of 947 ha and 259 ha respectively. By 2015 the residential area occupied 2509 ha of the total land area, and the agricultural land is the second major land-use class covering 1621 ha land. Vacant land registered a significant increase to 334 ha.

Moreover, in terms of single land use dynamic degree, the rate of expansion of industrial area (67.05%) is the highest greater than the rate of expansion of residential, commercial, vacant land and other important land use classes. Meanwhile, the rate of contraction of villages (2.8%) is the highest, followed by the rate of contraction of tree plantation (-1.90%) and agricultural land (-1.55%). The rate of change in social recreation and government institutions is relatively low, which means the transformation of these types of land use classes is not prominent.

Overall, the area under agricultural land, villages and tree plantation decreased between 1980 and 2015, while the area under residential, industrial, commercial and vacant land has increased. The most obvious characteristic of land-use change is the significant expansion of residential areas and vacant land and the decline in agricultural land and villages. This indicates the augmented requirement of residential space for the increasing population, who are to some extent also inclined towards the urban way of living in a changing socio-economic environment in the city.

Land Use pattern in the buffer zone of 500 – 1000 meters

The 500–1000 meter buffer zone does not have the same level of accessibility as the first zone up to 500 meters from main roads. These areas (buffer of 500- 1000 meters) are served by minor roads and narrow bylanes. Thus the accessibility is comparatively poorer. It is evident from Table 3 and figure 4 that agricultural land covered the largest area in this zone in 2001, followed by residential and vacant land. Negligible presence of commercial and industrial establishments was found in this zone, away from main roads, points towards the importance of accessibility for these land-use classes. Most of the agricultural land in this zone lies beyond the municipal boundary. An increase of 892 hectares in this zone reflects a shift of place of residence from the more expensive inner zone to less expensive land in the less accessible outer zone. Vacant land has also shown a major increase of 132 hectares, which is in anticipation of future residential development. Again most of these increases were on agricultural land, which was reduced by 989 hectares.

The rate of expansion of residential area (41.64%) is the highest, and greater than the rate of expansion of industrial (14.7%), commercial and other important land use classes in terms of single land use dynamic degree (SLUDD). It again highlights the importance of accessibility. The rate of expansion of residential areas away from the roads is more than the other land use classes especially like commercial and industrial which require better accessibility and connectivity.

Table 3: Aligarh City: Area under different land use in 500-1000 meters buffer along main roads, (1980-2015)

Land Use/ Year	Area (1980)	Area (2015)	Change in Area	Percentage Change	SLUDD
Residential	63	955	892	1415	41.64%
Villages	42	14	-28	66	1.96%
Commercial	0	5	-	-	-
Govt Institution	20	20	-	-	-
University	17	17	-	-	-
Social & Recreational	0	0	-	-	-
Industrial	1	6	5	500	14.70%
Aligarh Fort	0	0	-	-	-
Vacant Land	103	235	132	128	3.76%
Tree Plantation	32	11	-21	-65	1.93%
Agricultural Land	3139	2150	-989	-31	0.92%
Water bodies/ logged	10	14	4	40	1.1%
Total	3427	3427			

Note: *Area in hectares*

Source: *Based on Aligarh City, Guide Map (survey of India) and IRS 1D Satellite Imagery*

Land Transformation in the buffer zone up to 500 meters

The complicated interchange of land among various land-use classes, examined with the help of GIS techniques (Table 4 and Fig. 5) show that 3274-hectare land remained unchanged in the buffer zone up to 500 meters. In this zone, the largest transfer was from agricultural to residential (1411 hectares), vacant land (297 hectares), and commercial area (52 hectares). Other transfers were from vacant to residential class (162 hectares). More importantly in this zone, residential use loses 17 hectares of prime land in the heart of the city, which also enjoys maximum land value to commercial land. Commercial land has also captured land from agriculture (52 hectares) and vacant land (49 hectares) but these areas were in the outer part of the city but along the roads. Overall, high-value land uses have captured land from low-value land uses.

Land Transformation in buffer zone of 500 – 1000 meters

The interchange of land among various land-use classes was also investigated in this zone (Table 4 and figure 5) which shows that of the total area of 3274 hectares, 2356 hectares remained unaltered. The largest transfer was from agricultural land to residential (789 hectares) and vacant land (199 hectares). The residential area also captured land from vacant (37 hectares) and villages (26 hectares). The urban sprawl of Aligarh city has swallowed a few villages in this zone.

Table 4:Land Transformations along the main roads in Aligarh city (1980-2015)

Land Transformation	**500 meters buffer**	**500-1000 meters buffer**
No change	3274	2356
Village to Residential	11	26
Agriculture to Residential	1411	789
Tree to Residential	37	11
Vacant to Residential	162	37
Agriculture to Vacant	297	199
Vacant to Industrial	49	9
Residential to Commercial	17	-
Agriculture to Commercial	52	-

Note: *Area in hectares.*

Source: *Based on Aligarh City, Guide Map (survey of India) and IRS 1D Satellite Imagery*

Land transformation in these two buffer zones is caused by the combination of two forces: economic and social. These forces work in opposite directions. Economic forces (present and future land value of the land parcel, demand, location, and so on) are the positive forces for land transformation. They encourage the owner of the land by maximizing returns from the land. On the other hand, social forces (social and religious values, self-prestige, etc) operate in the opposite direction and create resistance to land transformation. The intensity of the social force varies from individual to individual. The degree of land transformation depends on the magnitude of the resultant social-economic force. The increase in population and changes in the economic structure of Aligarh city resulted in increased demand for land for various land-use classes. The increase in land value and pull by economic forces were greater for land transformation along the road in Aligarh city.

Conclusion

The study demonstrates that accessibility overall plays an important role in urban land use development and land transformation, but the precise role varies among different urban land-use categories. The following important features of land use and transformation along the roads constitute the key findings of this research.

The urban expansion was more pronounced along the roads making it radial as new residential areas have come up in areas that are nearer to the city and have better connectivity. Industrial and commercial development were also mostly confined to a zone near the main roads sharing the significance of better accessibility required for these land-use classes.

The dominance of better accessibility is intense for the use of land. It also has a significant bearing on land value. The older part of the city is congested and densely built upon. So land transformation is not viable as a modern-day requirement. Thus the prospect of expansion and transformation lies in the outer part of the city.

That is why in the northern newer part of the city along the roads rapid transformation has been observed. This transformation is also marked by a high degree of a mix, mainly to avoid long distances and compromising with space and high land value. This phenomenon has also resulted in a typical kind of 'pocket development', lacking spatial contiguity among different establishments as well as a high degree of land use class mixing. It is also marked with poor and inefficient urban infrastructure projecting city expansion as unplanned and haphazard development.

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