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SPATIAL-TEMPORAL ANALYSIS OF LAND USE/LAND COVER IN HARYANA

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Abstract

The study of land use and land cover (LULC) changes is essential for understanding the interactions between human activities and the environment. This research aims to conduct a comprehensive spatial-temporal analysis of LULC changes in Haryana, India, over the past few decades. The primary objectives are to identify the patterns and trends of LULC changes, determine the key drivers behind these transformations, and assess the implications for sustainable development and environmental management in the region. The data outlines the trends in various land use categories in India from 1966-67 to 2016-17. Over this period, the net sown area remained relatively stable, starting at 79.46 million hectares in 1966-67 and fluctuating slightly to 80.85 million hectares in 2016-17. Fellow land experienced a significant decrease from 6.01 million hectares in 1966-67 to 4.64 million hectares in 2016-17, indicating a reduction in temporarily uncultivated land. Pasture land also saw a reduction from 1.34 million hectares to 0.69 million hectares, suggesting a decrease in land dedicated to grazing. Barren land varied but showed a notable increase from 11.35 million hectares to 13.03 million hectares, reflecting changes in land degradation or urban expansion. Forest cover saw a significant decline from 2.11 million hectares in 1966-67 to just 0.92 million hectares in 2016-17, highlighting environmental and deforestation concerns.

Keywords: Land Use/Land Cover Dynamics, Temporal Trends. Spatial Analysis, GIS Mapping

Introduction

Temperature, precipitation, and seasonal variations influence vegetation growth, agricultural practices, and the suitability of land for various uses. Elevation, slope, and aspect affect soil characteristics, drainage patterns, and land suitability for different types of land use. Soil fertility, texture, and drainage capacity determine the types of vegetation and crops that can be supported. Proximity to rivers, lakes, and groundwater sources influences agricultural

practices, settlement patterns, and industrial locations (Xu & Gong, 2007). Increasing population demands more residential, agricultural, and commercial land, leading to changes in land use. Industrialization, urbanization, and economic activities drive changes in land use from natural landscapes to build environments. Shifts in agricultural methods, crop types, and irrigation practices impact land cover. Fluctuations in the demand for agricultural products, timber, and other land-based resources influence land use patterns (Tilahun & Teferie, 2015).

Zoning laws, land tenure systems, and government regulations impact land use decisions and patterns. Policies aimed at conserving natural resources and protecting the environment influence land use and cover. Subsidies, grants, and incentives for certain types of land use, such as agriculture or afforestation, affect land cover. Strategic planning for urban growth, infrastructure development, and public services guides land use changes (Chen, et al., 2003). Advances in irrigation, fertilization, and crop management can increase agricultural productivity and change land use. These technologies enhance land use planning and monitoring, enabling better management of land resources. Development of roads, railways, and other transportation networks facilitates access to remote areas, influencing land use (Dwivedi, et al., 2005).

Technological developments in various industries can lead to changes in land use, such as the establishment of industrial zones. Areas with high biodiversity may be prioritized for conservation, affecting land use patterns. Events such as floods, earthquakes, and hurricanes can drastically alter land cover and necessitate changes in land use. Recognition of the value of ecosystem services (e.g., water purification, carbon sequestration) can influence land use decisions towards conservation (Feng & Flewelling,2004). Traditional land use practices and cultural values can shape how land is utilized and managed. Involvement of local communities in land use planning and decision-making can lead to more sustainable and acceptable land use patterns. The distribution and type of land ownership (private, communal, or public) affect land use decisions and changes (Fisher et al., (2005). International demand for agricultural products, minerals, and other resources can drive land use changes. Long-term changes in climate can alter the suitability of land for various uses, necessitating shifts in land cover. Global trends in urbanization and migration influence local land use and cover.

Understanding these determinants is essential for developing effective land management strategies that balance economic development with environmental sustainability (Gomarasca & Gomarasca, 2009).

Objectives

- To analyze the temporal trends in LULC changes and quantify the extent of these changes over six decades.
- To map the spatial distribution of LULC categories in Haryana during 2016-17.
- To identify the socio-economic and environmental drivers influencing LULC changes.
- To evaluate the implications of LULC changes for sustainable development and resource management.

Database & Research Methodology

The present study has been based on the secondary source of data. The data pertaining to the land use/land cover have been collected from Haryana Statistical Abstract, 2018. The temporal analysis involves comparing LULC maps from different years to identify changes and trends. Statistical analyses are conducted to quantify the extent of LULC changes and to correlate these changes with socio-economic and environmental data. The integration of remote sensing, GIS, and socio-economic data provides a holistic understanding of the LULC dynamics in Haryana. The data have been classified into net sown area, fellow land, barren land, pasture and forests. The thematic maps have been prepared with the help of ArcGIS software.

Result and Discussion

Analysing Trend of Land use/land Cover

The analysis of the net sown area in Haryana over the years reveals interesting trends and fluctuations in agricultural land use. From 1966-67 to 1975-76, there was a notable increase in the net sown area, rising from 79.46% to 82.93%. This growth indicates an expansion of agricultural activities during this period. From 1975-76 to 1995-96, the net sown area remained relatively stable around 82%, reflecting consistent land use for agriculture. However, a slight decrease was observed in 2000-01, where the net sown area dropped to

80.56%. This dip was followed by a recovery in 2005-06, reaching 82.37%. Post 2005-06, the net sown area showed a gradual decline with minor fluctuations, settling at 80.85% in 2016-17. The analysis of the fallow land percentage in Haryana over the years shows various fluctuations and trends in land left uncultivated for a period. In 1966-67, the fallow land was relatively high at 6.01%. There was a significant reduction in fallow land by 1970-71 to 3.44% and further to 2.86% in 1975-76, indicating a trend towards more intensive land use. However, by 1980-81, fallow land increased to 4.05%, and then slightly decreased to 3.85% in 1985-86, and remained relatively stable at 3.88% in 1990-91.

In 1995-96, fallow land decreased to 3.57%, but it saw a substantial rise in 2000-01 to 5.30%. This peak suggests a period of less intensive agricultural activity or possibly land left to recover. By 2005-06, fallow land decreased to 4.04%. The lowest percentage of fallow land was recorded in 2014-15 at 2.49%, indicating a period of very intensive land use. Following this, there were slight increases to 2.76% in 2015-16 and a more notable rise to 4.64% in 2016-17. The data provided on the percentage of pasture land in Haryana over a span of five decades reflects a clear trend and notable fluctuations in the use of land for grazing and other pastoral purposes. Initially, in 1966-67, pasture land accounted for 1.34% of the total land use.

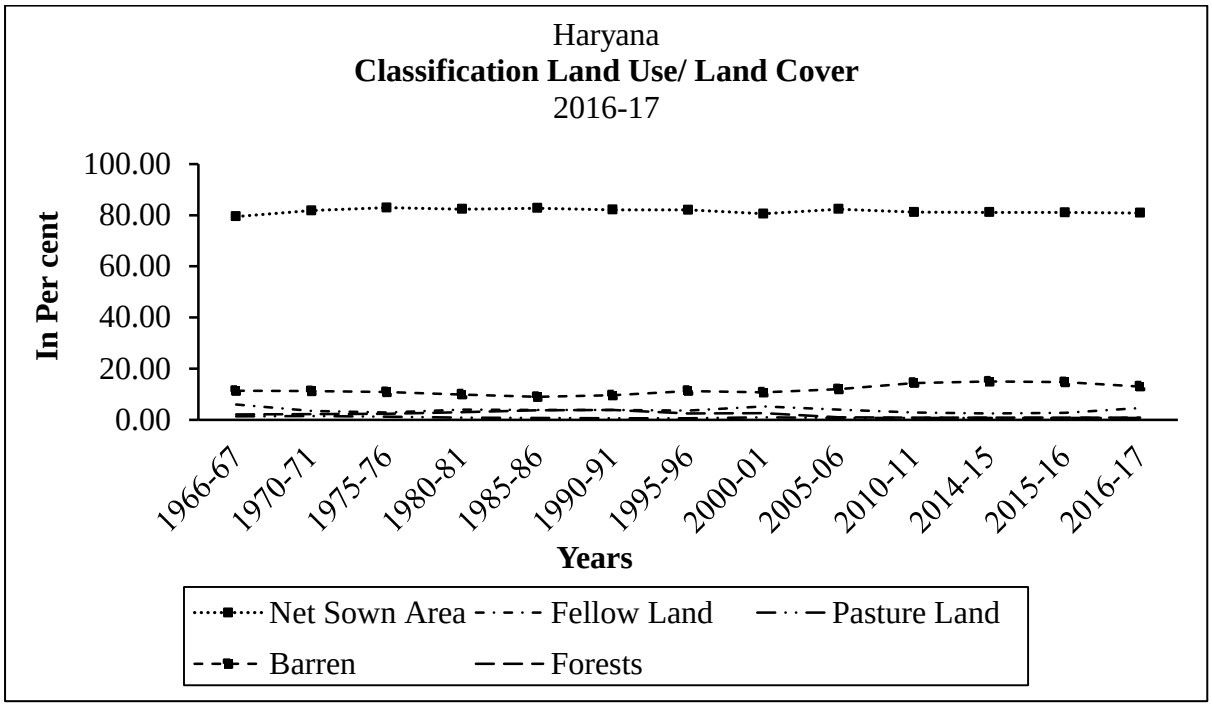
This figure slightly increased to its peak at 1.51% by 1970-71. However, from 1975-76 onward, there was a steady decline, reaching 1.21% in 1975-76 and further dropping to 0.83% by 1980-81. The trend continued downward in the subsequent years, with the percentage of pasture land decreasing to 0.77% by 1985-86 and reaching its lowest point at 0.64% in 1990-91. A slight recovery was seen in 1995-96 to 0.67%, but the notable uptick to 0.96% in 2000-01 suggests variability in land management practices or possibly shifts in agricultural policy or market demands affecting pasture land use. After the peak in 2000-01, the percentage stabilized somewhat but remained lower than earlier decades, hovering around 0.70% in 2005-06, slightly rising to 0.77% in 2010-11, and then marginally adjusting to around 0.71% from 2014 to 2016.

Table 1: Distribution of Land Use/Land Cover in Haryana, 2016-17

Years	Net Sown Area	Fellow Land	Pasture Land	Barren	Forests
1966-67	79.46	6.01	1.34	11.35	2.11
1970-71	81.80	3.44	1.51	11.24	2.27
1975-76	82.93	2.86	1.21	10.82	2.38
1980-81	82.33	4.05	0.83	9.92	3.02
1985-86	82.73	3.85	0.77	8.98	3.80
1990-91	82.13	3.88	0.64	9.58	3.88
1995-96	82.06	3.57	0.67	11.30	2.52
2000-01	80.56	5.30	0.96	10.74	2.63
2005-06	82.37	4.04	0.70	11.99	1.02
2010-11	81.19	2.88	0.77	14.40	0.90
2014-15	81.11	2.49	0.71	14.95	0.88
2015-16	81.06	2.76	0.71	14.72	0.88
2016-17	80.85	4.64	0.69	13.03	0.92

Source: Haryana Statistical Abstract, 2018.

By 2016-17, pasture land slightly decreased again to 0.69%. In 1966-67, barren land constituted 11.35% of the total land area. This percentage showed a slight decline in the early years, decreasing to 11.24% in 1970-71 and further to 10.82% in 1975-76. A more noticeable reduction occurred by 1980-81, where barren land dropped to 9.92%. This downward trend continued until 1985-86, when barren land decreased to 8.98%. However, in 1990-91, there was a reversal, with barren land increasing to 9.58%. The percentage spiked significantly by 1995-96, reaching 11.30%, almost returning to the levels seen in the mid-1960s.



Source: Based on the table 1.

The following ten years saw further swings: in 2000–01, the percentage of uncultivated land fell to 10.74%, but by 2005–06, it had significantly increased to 11.99%. The highest increase was noted in the next years, when the percentage of uncultivated land increased to 14.40% in 2010–11, peaked at 14.95% in 2014–15, and then somewhat decreased to 14.72% in 2015–16. Although it decreased significantly to 13.03% by 2016–17, the percentage of barren land was still greater than in previous decades. Starting from 1966-67, forest cover was at 2.11%. This percentage increased gradually over the next two decades, reaching 2.27% in 1970-71 and 2.38% in 1975-76. By 1980-81, forest cover had risen more substantially to 3.02%, continuing to 3.80% in 1985-86 and peaking at 3.88% in 1990-91. However, after this peak, a significant decline in forest cover is observed. By 1995-96, the forest cover dropped to 2.52%, and by 2000-01, it slightly increased to 2.63%. The most dramatic decrease occurred by 2005-06, with forest cover plummeting to 1.02%. This downward trend continued, with the forest cover reaching its lowest point at 0.88% in 2014-15 and remaining constant in 2015-16. There was a minor recovery to 0.92% in 2016-17.

Spatial Pattern of Land use/Land Cover: 2016-17

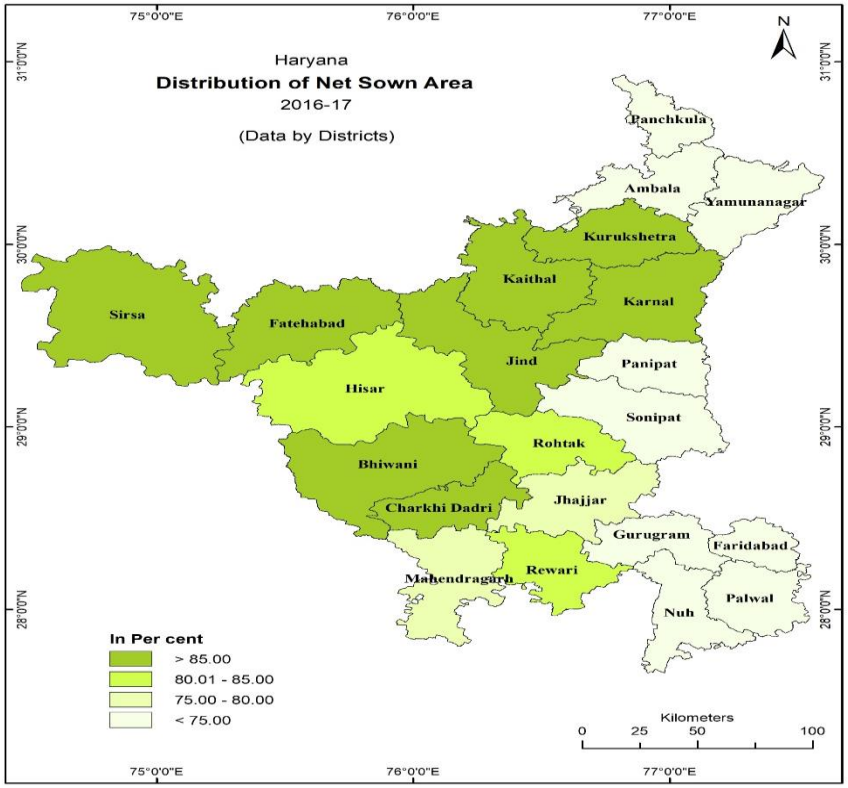
In 2016-17, the percentage of net sown area varied significantly across different districts in Haryana. Sirsa had the highest net sown area at 91.57%, indicating extensive agricultural use. Other districts with high net sown areas include Jind and Fatehabad, both exceeding 89%. Conversely, districts like Faridabad and Panchkula had lower net sown areas, with 44.18% and 46.57% respectively.

Table 2: Distribution of Land Use/Land Cover in Haryana, 2016-17

Sr. No.	Districts	Net Sown Area	Fellow Land	Pasture Land	Barren	Forests
1.	Ambala	70.13	1.95	1.85	25.97	0.65
2.	Bhiwani	86.55	2.60	0.00	10.41	0.43
3.	Charkhi Dadri	86.55	2.60	0.00	10.41	0.43
4.	Faridabad	44.18	1.38	1.34	53.85	0.00
5.	Fatehabad	89.11	0.40	0.00	8.87	1.61
6.	Gurugram	62.18	0.51	1.67	33.16	3.11
7.	Hisar	82.47	6.91	0.00	10.37	0.25
8.	Jhajjar	79.06	8.90	0.00	12.04	0.00
9.	Jind	89.21	0.36	0.40	9.71	0.36
10.	Kaithal	89.04	0.44	0.00	9.21	1.32
11.	Karnal	86.42	5.35	3.81	4.53	0.41
12.	Kurukshetra	86.53	0.14	0.23	12.53	0.60
13.	Mahendragarh	79.27	7.77	0.00	12.95	0.00
14.	Nuh	69.59	22.97	0.97	6.76	0.00
15.	Palwal	74.81	13.33	0.99	8.89	2.22
16.	Panchkula	46.57	12.70	1.09	38.10	2.12
17.	Panipat	72.31	7.69	5.32	15.38	0.77
18.	Rewari	83.80	3.33	0.28	11.31	1.33
19.	Rohtak	82.04	5.39	0.00	12.57	0.00
20.	Sirsa	91.57	4.22	0.00	3.98	0.23
21.	Sonipat	72.04	3.32	1.97	22.75	0.47
22.	Yamunanagar	63.37	1.16	1.83	26.16	8.14
Haryana		**76.67**	**5.16**	**0.99**	**16.36**	**1.11**

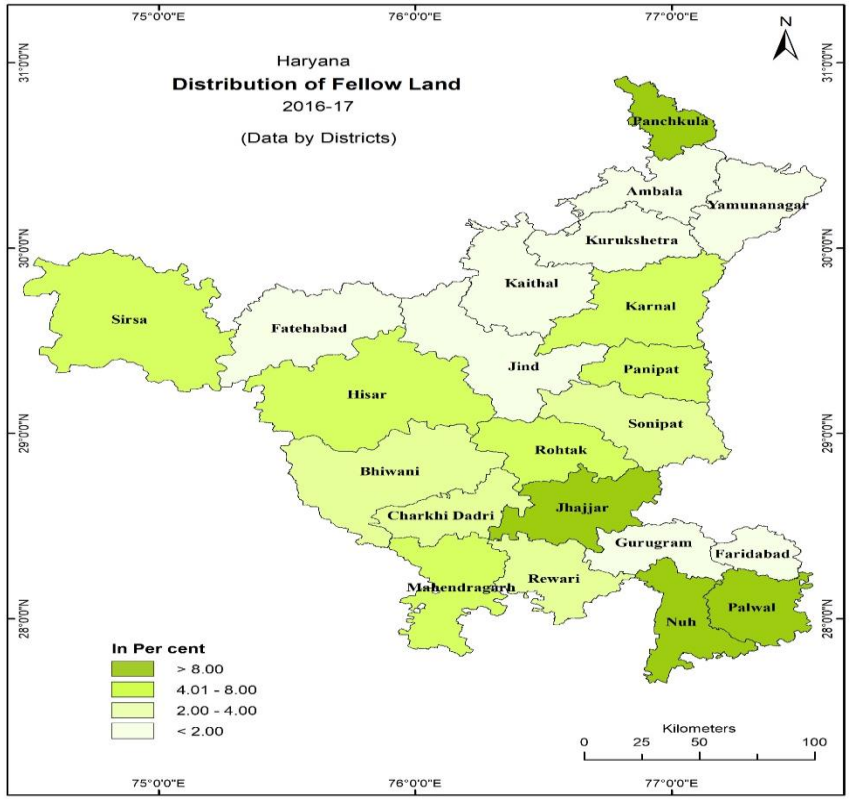
Source: Haryana Statistical Abstract, 2018.

The state average for net sown area was 76.67%, reflecting a broad commitment to agriculture across the region but with notable regional variations (Map 1). In 2016-17, fallow land percentages varied widely across Haryana. Nuh had the highest fallow land at 22.97%, indicating a significant portion of land was left uncultivated. Panchkula and Palwal also had relatively high fallow land percentages at 12.70% and 13.33%, respectively. On the other hand, districts like Kurukshetra and Jind had very low fallow land percentages, at 0.14% and 0.36% respectively, reflecting minimal land left fallow.



Source: Based on the table 2.

Map 1



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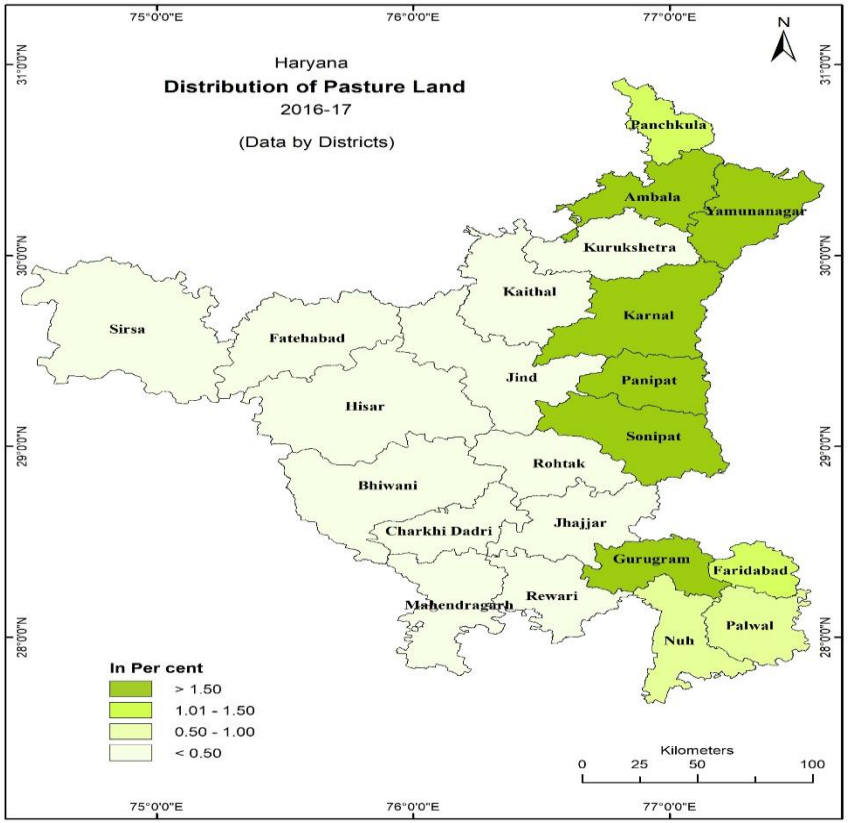
Map 2



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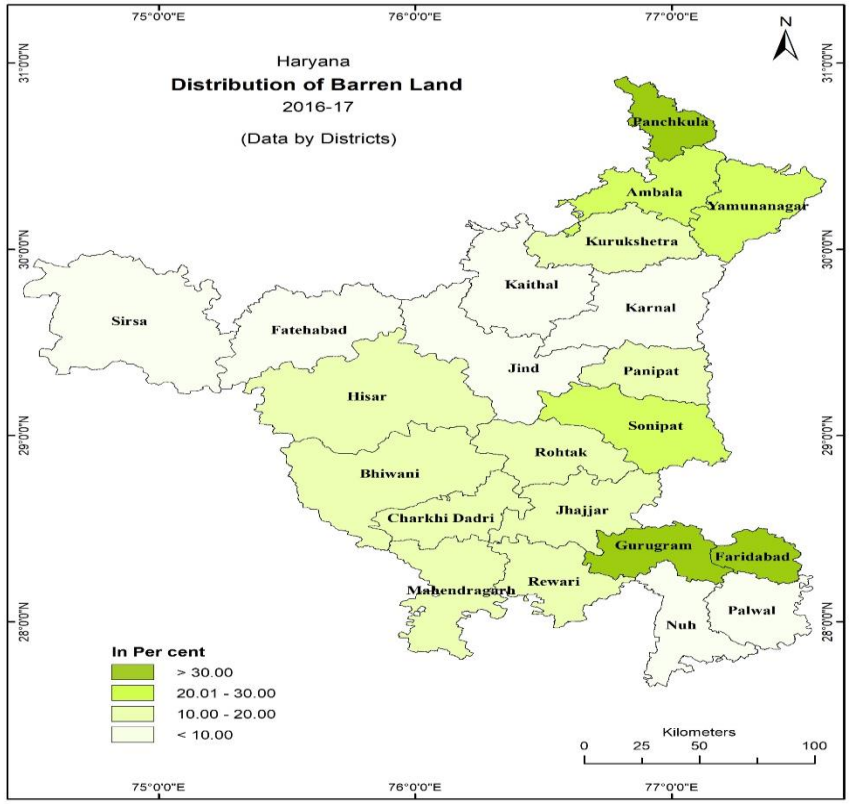
Map 3



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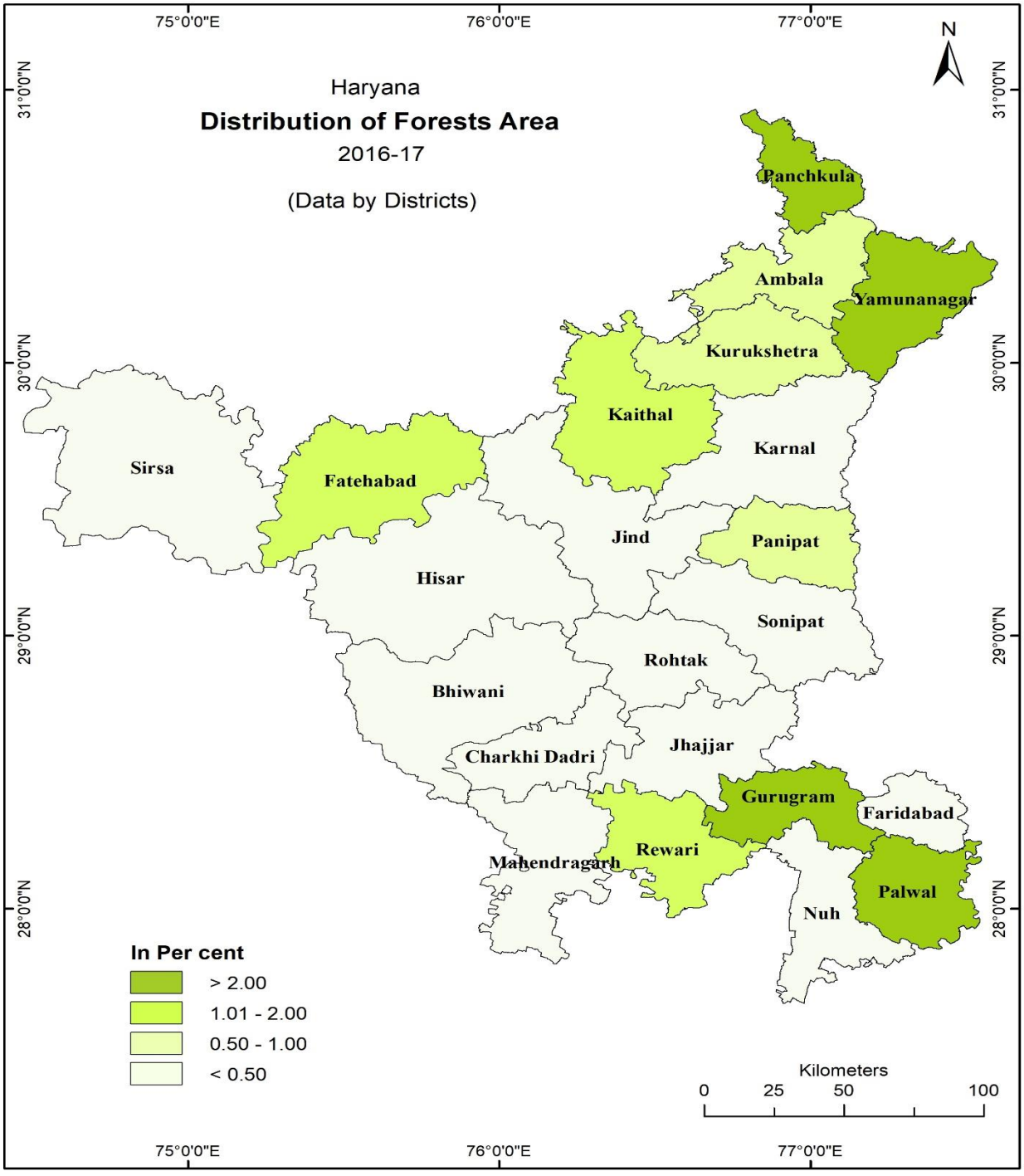
Map 4



Source: Based on the table 2.

Map 5

The state average for fallow land was 5.16%, showcasing the diverse land management practices and agricultural conditions across different districts (Map 2). In 2016-17, pasture land in Haryana was relatively minimal, with significant variation across districts. Panipat had the highest pasture land percentage at 5.32%, indicating a notable allocation for grazing. Karnal also had a relatively higher percentage at 3.81%. Most districts, however, had very low or no recorded pasture land, such as Bhiwani, Charkhi Dadri, Fatehabad, and Hisar, where it was reported as 0%. The state average for pasture land was 0.99%, reflecting a general trend towards limited allocation of land for grazing purposes in Haryana (Map 3).

In 2016-17, the percentage of barren land in Haryana varied significantly across districts. Faridabad had the highest percentage of barren land at 53.85%, indicating a substantial amount of land that is not used for productive purposes. Other districts with high barren land include Gurugram at 33.16% and Panchkula at 38.10%. Conversely, Sirsa and Karnal had the lowest percentages, with barren land at 3.98% and 4.53% respectively. The state average for barren land was 16.36%, highlighting the widespread issue of land underutilization or degradation across the region. In 2016-17, forest cover in Haryana showed considerable variation across districts. Yamunanagar had the highest forest cover at 8.14%, indicating a relatively substantial area of forested land. Other districts with notable forest cover include Gurugram at 3.11% and Palwal at 2.22%. Most districts, however, had low forest cover, with several districts like Faridabad, Jhajjar, and Mahendragarh reporting none. The state average for forest cover was 1.11%, reflecting a generally low level of forested area across Haryana (Map 5).

Conclusion

This spatial-temporal analysis of LULC changes in Haryana offers valuable insights into the region's evolving landscape. The findings underscore the necessity for integrated land use planning and environmental conservation strategies to mitigate adverse impacts and promote sustainable development. The study provides a foundation for informed policymaking and strategic land management practices to balance developmental needs with ecological preservation in Haryana. Overall, the net sown area in Haryana has generally hovered around 80-

82%, indicating relatively stable agricultural land use over the decades, with some variations likely influenced by changes in agricultural policies, economic factors, and land reforms. This stability suggests a consistent commitment to agriculture, but the slight downward trend in recent years highlights the need for sustainable land use practices and careful planning to ensure continued agricultural productivity.

Over the decades, forest cover has steadily declined from 2.11% in 1966-67 to 0.92% in 2016-17, reflecting a significant loss in forested areas. In contrast, net sown areas have remained relatively stable, indicating consistent agricultural use. Fallow land has decreased, suggesting more effective land management or increased agricultural intensity. Pasture land has also seen a slight decline, while barren land has increased, signaling a growing proportion of land that is underutilized or degraded. These changes highlight ongoing environmental and land use challenges that could impact sustainability and land productivity. In 2016-17, Haryana displayed considerable variation in land use across its districts.

Sirsa and Fatehabad had the highest net sown areas, indicating extensive agricultural activities, while Faridabad and Panchkula had notably lower agricultural use. Fallow land was most prevalent in Nuh, with a significant portion of land left uncultivated, whereas Kurukshetra reported minimal fallow land. Pasture land was minimal across most districts, with Panipat having the highest percentage. Barren land was a major issue in Faridabad, contrasting with the relatively low percentages in Sirsa. Forest cover was highest in Yamunanagar, though many districts had negligible forest areas. Overall, the state average figures reveal a diverse land use scenario, with substantial areas dedicated to agriculture, notable issues with barren land, and limited forest cover.

This long-term reduction in pasture land percentage could be indicative of several trends, including the intensification of agricultural practices, urbanization, or shifts towards crop production that offers higher economic returns. The consistent decrease, particularly from the early 1980s, highlights a shift in land use priorities, possibly reflecting broader economic transformations within Haryana. This trend underscores the need for sustainable land

management strategies that balance agricultural productivity with ecological conservation to maintain pasture lands which are vital for biodiversity and ecological balance. The analysis reveals significant shifts in land use patterns, predominantly driven by urbanization, agricultural intensification, and industrial development. Urban areas have expanded at the expense of agricultural and forest lands, while industrial zones have increased, particularly around major urban centers. Concurrently, there has been a decline in water bodies and green spaces, raising concerns about ecological sustainability.

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