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# Changing agricultural landscape of Jaunpur District, Uttar Pradesh: A geographical assessment of land use pattern

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**Abstract**
Agriculture constitutes the fundamental economic and geographical base of Jaunpur District in eastern Uttar Pradesh. However, the agricultural landscape of the district has undergone significant transformation due to population growth, expansion of settlements, irrigation development, changing cropping practices, infrastructural development, market forces, technological advancement and environmental pressures. The present study examines the changing agricultural landscape of Jaunpur District through a geographical assessment of land use and agricultural land-use patterns. The study is based primarily on secondary data obtained from the Census of India, District Census Handbook, Government of Uttar Pradesh, National Remote Sensing Centre (NRSC), agricultural contingency-plan data and other governmental sources. The analysis covers major land-use categories including forest, agricultural wasteland, current fallow, other fallow, barren and unculturable land, land put to non-agricultural uses, pasture, trees and groves, net sown area and net irrigated area. The study compares land-use conditions during 2001, 2011 and 2021 and examines the direction and magnitude of change. Available data indicate that the net sown area declined from 291,303 ha in 2001 to 278,538 ha in 2011 and further to 274,778 ha in 2021, representing an overall decline of about 5.68% during 2001–2021. In contrast, land under non-agricultural uses increased from 44,217 ha in 2001 to 52,574 ha in 2021. Net irrigated area increased considerably between 2001 and 2011, although a slight decline occurred by 2021. The study demonstrates that Jaunpur is experiencing a gradual transition from an overwhelmingly agriculture-dominated landscape towards a more diversified land-use structure.

**Keywords:** Agricultural landscape, land use, land-use change, Jaunpur, Uttar Pradesh, agriculture, irrigation, cropping intensity, geographical analysis, sustainable agriculture

## Introduction

Land is one of the most important natural resources and constitutes the fundamental spatial base of agriculture, settlements, infrastructure, forests, grazing, industries and other human activities. The pattern in which land is utilized reflects the interaction between physical environment and human society. Agricultural land use is particularly dynamic because it responds continuously to changes in population, market demand, irrigation, technology, agricultural policies, road connectivity, urban expansion and climatic conditions.In India, agricultural land use has undergone considerable transformation since the Green Revolution. Expansion of irrigation, introduction of high-yielding varieties, increased fertilizer use, mechanization, improved transportation and market integration have contributed to agricultural intensification. At the same time, population growth and expansion of settlements, roads, industries and other infrastructure have generated pressure on agricultural land. Thus, agricultural landscape change cannot be understood simply in terms of increase or decrease in cultivated area; it must also be examined through changes in fallow land, non-agricultural uses, irrigation, cropping intensity, crop diversification and the spatial distribution of agricultural resources.Agriculture remains the principal economic activity of the district.The agricultural landscape of Jaunpur, however, is not uniform. Variations in soil, drainage, irrigation, settlement density, accessibility and agricultural technology produce significant spatial differences. Earlier studies have also identified differences in cropping intensity, agricultural productivity and land-use efficiency among the development blocks of the district.

## Study Area

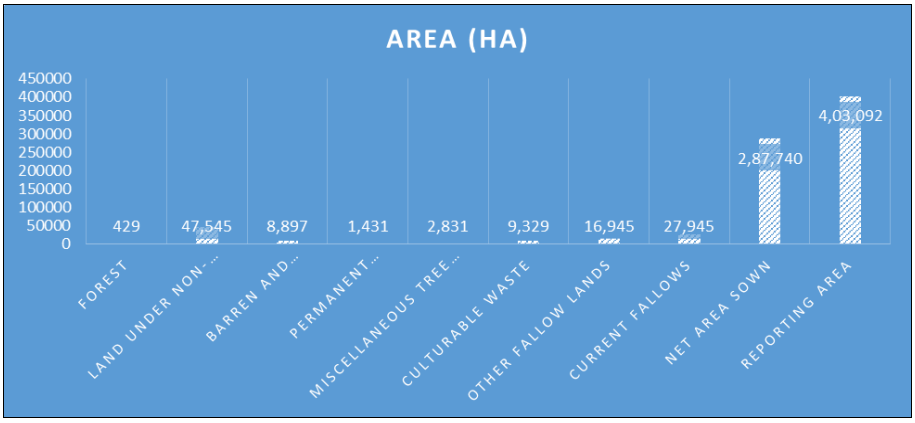
Jaunpur district is situated in the eastern part of Uttar Pradesh and forms part of the Middle Ganga Plain. The district is characterized predominantly by alluvial terrain, fertile agricultural soils and a monsoonal climatic regime. The official district profile records an average normal annual rainfall of approximately 987 mm. The district covers approximately 4,021 sq km and has 21 development blocks and six tehsils.The physical setting of Jaunpur is favourable for agriculture. The relatively level terrain permits extensive cultivation and facilitates irrigation and mechanization. The agricultural landscape is further supported by groundwater resources, canals and private irrigation facilities. Historically, irrigation expansion has been associated with increasing cropping intensity and a shift toward wheat and other high-yielding crops.The district is also influenced by urbanization and expansion of transport and industrial activities. The official district profile notes emerging industrial development along the Varanasi–Jaunpur road and industrial activity in Satharia. Such developments increase the pressure on land resources and contribute to conversion of agricultural land to non-agricultural uses.

**Theoretical Background of Shannon Entropy**

The Shannon Entropy Index (SEI) is a statistical measure originally developed by Claude E. Shannon (1948) within information theory to quantify uncertainty, randomness, and information content in a system. The concept was subsequently adopted in geography, ecology, landscape ecology, urban studies, and land-use/land-cover research to measure the degree of diversification, concentration, and heterogeneity within a spatial system.In geographical analysis, the fundamental principle of entropy is that a system dominated by one category has a low degree of diversity, whereas a system in which several categories have relatively similar proportions has a high degree of diversity. Applied to land-use analysis, Shannon Entropy therefore provides a quantitative measure of how land is distributed among different land-use categories.According to the Uttar Pradesh land-use statistics, Jaunpur had a reporting area of 403,092 hectares in 2022–23. The major land-use categories included forest, land under non-agricultural uses, barren and unculturable land, permanent pastures and other grazing lands, miscellaneous tree crops and groves, culturable waste, other fallow lands, current fallows, and net area sown.

**Table 1:** Land-Use Pattern of Jaunpur District, 2022–23

| S. No. | Land-use category | Area (ha) |
|---|---|---|
| 1 | Forest | 429 |
| 2 | Land under non-agricultural uses | 47,545 |
| 3 | Barren and unculturable land | 8,897 |
| 4 | Permanent pastures and other grazing lands | 1,431 |
| 5 | Miscellaneous tree crops and groves | 2,831 |
| 6 | Culturable waste | 9,329 |
| 7 | Other fallow lands | 16,945 |
| 8 | Current fallows | 27,945 |
| 9 | Net area sown | 287,740 |
| Total | Reporting area | 403,092 |




**Shannon Entropy for 2022–23**

The Shannon Entropy formula:

$H = -\Sigma_{i=1}^{n} P_i \ln(P_i)$

$P_i = A_i / A_t$

$A_t = 405092$ ha

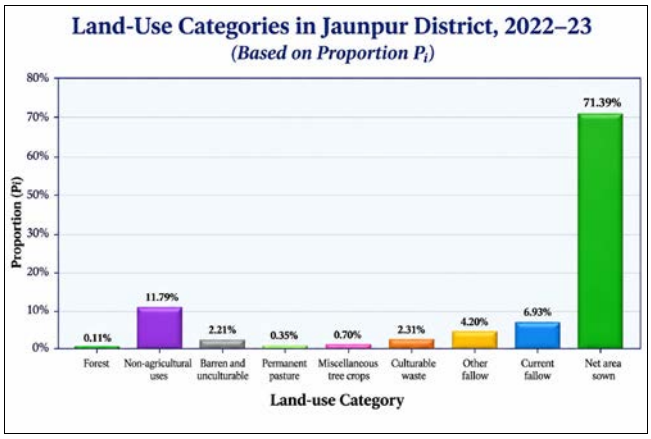
$n = 9$

**Where:**

- H = Shannon Entropy Index
- $P_i$ = Proportion of area under the i-th land-use category
- $A_i$ = Area of the i-th land-use category (ha)
- $A_t$ = Total geographical area (ha)
- n = Number of land-use categories

**Table 2:** Shannon Entropy Calculation for Jaunpur, 2022–23

| S. No. | Land-use category | Area (ha) | (P_i) | (\ln P_i) |
|---|---|---|---|---|
| 1 | Forest | 429 | 0.001064 | −6.846 |
| 2 | Non-agricultural uses | 47,545 | 0.117935 | −2.138 |
| 3 | Barren and unculturable | 8,897 | 0.022076 | −3.813 |
| 4 | Permanent pasture | 1,431 | 0.003548 | −5.642 |
| 5 | Miscellaneous tree crops | 2,831 | 0.007023 | −4.958 |
| 6 | Culturable waste | 9,329 | 0.023142 | −3.766 |
| 7 | Other fallow | 16,945 | 0.042041 | −3.169 |
| 8 | Current fallow | 27,945 | 0.069321 | −2.669 |
| 9 | Net area sown | 287,740 | 0.713850 | −0.337 |




The Shannon Entropy analysis of the land-use structure of Jaunpur District for 2022–23 provides a quantitative measure of the relative distribution, concentration, and diversification of different land-use categories. The analysis considers nine major land-use categories, namely forest, land under non-agricultural uses, barren and unculturable land, permanent pastures, miscellaneous tree crops, culturable waste, other fallow land, current fallow land, and net area sown. The proportion of each category was calculated by dividing the area of the respective land-use category by the total reporting area of 403,092 ha. The natural logarithm of each proportion was then used in the Shannon Entropy calculation.

The forest category covers only 429 ha, representing a very small proportion of the total reporting area, with . Its natural logarithm is −6.846, indicating the extremely small relative contribution of forest land to the overall land-use structure. The very low proportion of forest land is geographically significant because it demonstrates that Jaunpur is not characterized by extensive natural forest cover. Instead, the landscape is predominantly agricultural and rural-settlement based. The limited forest area also contributes only marginally to overall land-use diversification.

Land under non-agricultural uses represents the second-largest land-use category, covering 47,545 ha, equivalent to a proportion of 0.117935, or approximately 11.79% of the reporting area. Its value is −2.138. This relatively high proportion reflects the expansion and spatial importance of settlements, roads, markets, educational and institutional facilities, industrial and commercial activities, and other infrastructure. From a geographical perspective, the substantial share of non-agricultural land indicates increasing human pressure on the rural landscape and suggests that urbanization, infrastructural development, and demographic growth are contributing to land-use transformation in the district.

The barren and unculturable land category accounts for 8,897 ha, with, representing approximately 2.21% of the total reporting area. Its logarithmic value is −3.813. Although this category occupies a relatively small area, its presence indicates land that is unsuitable or difficult to bring under regular cultivation because of physical, soil, drainage, erosion, or other environmental constraints. The relatively low proportion means that barren and unculturable land does not dominate the district's landscape, but it remains an important component of the overall land-use mosaic.

Permanent pastures and other grazing lands account for approximately 1,431 ha, giving a proportion of 0.003548, or only about 0.35% of the reporting area. The corresponding logarithmic value is −5.642. The extremely small share of permanent pasture indicates the limited spatial significance of formally recorded grazing land in Jaunpur. Geographically, this may reflect the conversion or competing use of traditionally open or common lands for cultivation, settlement, infrastructure, and other purposes.

The low proportion also indicates that livestock-related land uses occupy a relatively minor component of the district's formal land-use structure.

The category of miscellaneous tree crops and groves covers 2,831 ha, corresponding to , or approximately 0.70% of the reporting area. Its value is −4.958. This category represents land occupied by orchards, groves, and other tree-based land uses outside the conventional forest category. Although its area is small compared with net sown land, such land uses contribute to landscape heterogeneity and can provide ecological and economic functions, including fruit production, shade, soil protection, and habitat. Nevertheless, the low proportion indicates that tree-based land uses are not a major component of Jaunpur's overall land-use pattern.

Culturable waste land accounts for 9,329 ha, representing, or approximately 2.31% of the reporting area. The corresponding is −3.766. Culturable waste represents land that has potential for cultivation but has remained uncultivated for a considerable period. Its presence indicates an underutilized component of the agricultural resource base. From a geographical and agricultural-development perspective, the extent of culturable waste may be related to soil limitations, inadequate irrigation, economic constraints, fragmented holdings, labour availability, or other local factors. Consequently, this category has potential importance for future agricultural intensification if appropriate technological, economic, and infrastructural interventions are introduced.

The other fallow land category covers 16,945 ha, with , equivalent to approximately 4.20% of the reporting area. Its logarithmic value is −3.169. This relatively larger proportion compared with barren land, pasture, and tree crops indicates that a meaningful part of the district's land resource is temporarily or periodically excluded from active cultivation. Other fallow land can result from soil exhaustion, inadequate moisture, economic considerations, crop rotation, or temporary changes in land management. Its presence is therefore an important indicator of the intensity and sustainability of agricultural land use.

Current fallow land represents 27,945 ha, with , accounting for approximately 6.93% of the total reporting area. Its value is −2.669. The relatively high proportion of current fallow land demonstrates that a considerable amount of land remains temporarily uncultivated during the reference period. Current fallow may be associated with crop rotation, seasonal agricultural practices, water availability, labour constraints, economic decisions, or climatic variability. From the perspective of agricultural geography, the presence of nearly seven percent current fallow indicates that the actual utilization of agricultural land is dynamic rather than completely continuous.

The most important land-use category is net area sown, which covers 287,740 ha. Its proportion is 0.713850, meaning that approximately 71.39% of the reporting area is devoted to cultivated land. Its logarithmic value is −0.337, which is the highest among all nine categories and consequently makes a major contribution to the Shannon Entropy calculation.

**Normalized Shannon Entropy for Jaunpur (2022–23)**

$H_{2022–23} = 1.04447$

The normalized entropy is:

$E = H / ln(9)$

E = 1.044474 / 2.197225

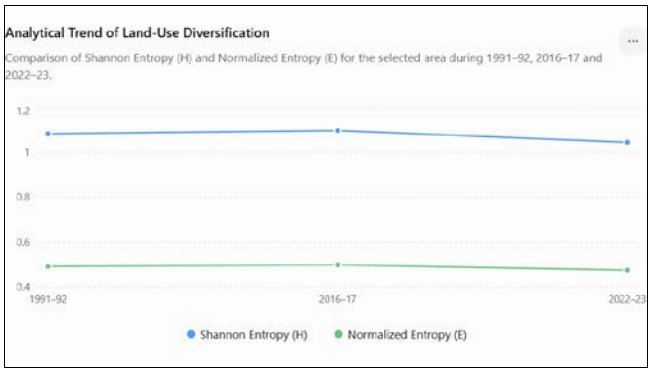
$E_{2022–23} = 0.47536$

**Three-Period Shannon Entropy Analysis**

The Three-Period Shannon Entropy Analysis was used to examine changes in the degree of land-use diversification and concentration in Jaunpur District, Uttar Pradesh, over three benchmark periods: 1991–92, 2016–17, and 2022–23. Shannon Entropy is particularly useful for measuring the distribution of land among different land-use categories. A higher entropy value indicates a more diversified and relatively balanced land-use structure, whereas a lower value indicates greater concentration of land in a few dominant categories.In the present analysis, nine land-use categories were considered for all three periods.

**Table 3:** Temporal Change in Shannon Entropy Of Jaunpur District

| Indicator | 1991–92 | 2016–17 | 2022–23 |
|---|---|---|---|
| Reporting/selected area (ha) | 379,939 | 400,636 | 403,092 |
| Number of categories | 9 | 9 | 9 |
| Maximum entropy | 2.19722 | 2.19722 | 2.19722 |
| Shannon Entropy (H) | 1.08243 | 1.09683 | 1.04447 |
| Normalized Entropy (E) | 0.49263 | 0.49919 | 0.47536 |
| Diversification class | Moderate | Moderate | Moderate |




The analysis of land-use diversification for 1991–92, 2016–17 and 2022–23 provides important insights into the changing structure of the agricultural landscape. The reporting/selected area increased from 379,939 ha in 1991–92 to 400,636 ha in 2016–17, and further to 403,092 ha in 2022–23. This indicates an overall expansion of approximately 23,153 ha (6.09%) in the area considered for land-use analysis during the study period. The number of land-use categories remained constant at nine in all three periods, allowing a consistent comparison of diversification over time. The maximum possible entropy also remained unchanged at 2.19722, since the number of categories did not change.

**Change in Shannon Entropy, 1991–92 to 2022–23**

The overall change is:

$\Delta H = 1.04447 - 1.08243$

$\Delta H = -0.03796$

**Normalized Entropy Change:**

$\Delta E = 0.47536 - 0.49263$

$\Delta E = -0.01727$

**Percentage Change:**

$(0.47536 - 0.49263) / 0.49263 \times 100$

−3.51%

The overall change in Shannon Entropy (H) between 1991–92 and 2022–23 indicates a gradual decline in land-use diversification over the long-term study period. Shannon Entropy decreased from 1.08243 in 1991–92 to 1.04447 in 2022–23. Therefore, the absolute change in Shannon Entropy was −0.03796, calculated as. This decline indicates that the distribution of land among the different land-use categories became somewhat less balanced over the study period.

**Change in Normalized Entropy between 2016–17 and 2022–23**

This is particularly important because it represents the more recent phase of agricultural-landscape transformation.

$\Delta E = 0.47536 - 0.49919$

$\Delta E = -0.02383$

**Percentage Change:**

$(-0.02383 / 0.49919) \times 100$

$-4.77\%$

The change in Normalized Entropy (E) between 2016–17 and 2022–23 provides an important indication of the recent transformation in the agricultural and land-use landscape. The Normalized Entropy declined from 0.49919 in 2016–17 to 0.47536 in 2022–23. Thus, the absolute change in entropy was −0.02383, calculated as. In relative terms, the percentage change was approximately −4.77%, indicating a noticeable decline in land-use diversification during the recent period.

This decline suggests that the distribution of land among different land-use categories became slightly less diversified or more concentrated between 2016–17 and 2022–23. In other words, although the total reporting area increased and the net area sown also expanded, the relative balance among the nine land-use categories weakened. The result may indicate increasing dominance of certain land-use categories, particularly agricultural land, over others. The decline in Normalized Entropy therefore reflects a shift towards greater land-use concentration rather than increasing diversification. Nevertheless, the diversification class remained Moderate, indicating that the change was not sufficiently large to transform the overall land-use structure into a highly specialized category. Overall, the 4.77% decline in Normalized Entropy represents a significant recent trend and highlights the need to examine the specific land-use categories responsible for this reduction in diversification.

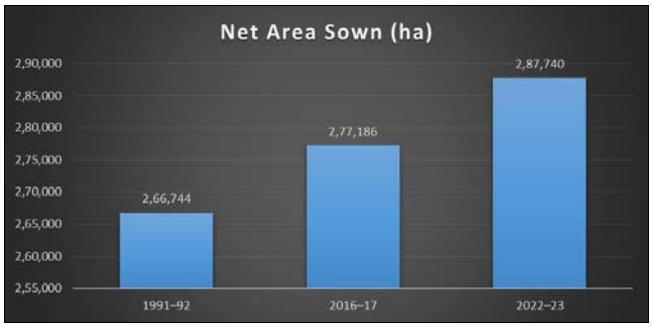
The combined decline in both Shannon Entropy and Normalized Entropy suggests a gradual movement towards greater concentration of land in certain dominant land-use categories. The decline is not extremely large, however, and the land-use diversification remained within the Moderate classification throughout the study period. Thus, the long-term trend does not indicate a complete restructuring of the agricultural landscape, but rather a moderate shift from a relatively diversified land-use pattern towards somewhat greater concentration, which may be associated with the expansion of cultivated land and changes in the relative importance of other land-use categories.

**Net Sown Area**

The Net Sown Area (NSA) represents the total area of land that is cultivated with crops at least once during an agricultural year and is an important indicator of the agricultural structure and land-use intensity of a region. In the study area, the Net Sown Area shows a continuous increasing trend during the period from 1991–92 to 2022–23. It increased from 266,744 ha in 1991–92 to 277,186 ha in 2016–17, and further to 287,740 ha in 2022–23. Thus, the total increase over the entire study period was 20,996 ha, representing approximately 7.87% growth.

**Table 4:** Change in Net Area Sown

| Year | Net Area Sown (ha) |
|---|---|
| 1991–92 | 266,744 |
| 2016–17 | 277,186 |
| 2022–23 | 287,740 |




The trend of Net Area Sown indicates a gradual and continuous expansion of cultivated land in the study area during the period from 1991–92 to 2022–23. In 1991–92, the net area sown was 266,744 ha, which increased to 277,186 ha in 2016–17, representing an increase of 10,442 ha or approximately 3.91% over the first period. By 2022–23, the net area sown further increased to 287,740 ha, adding another 10,554 ha compared with 2016–17. Overall, between 1991–92 and 2022–23, the net area sown increased by 20,996 ha, equivalent to approximately 7.87%. This persistent increase suggests a gradual strengthening of agricultural land utilization, possibly associated with expansion of cultivation, conversion of marginal or other land uses into agricultural land, improved irrigation facilities, and increasing dependence on agriculture. The relatively steady growth also indicates that agricultural land remained an important component of the regional land-use structure throughout the study period. However, the increase should be interpreted alongside changes in other land-use categories to understand whether agricultural expansion occurred at the expense of forests, fallow land, wasteland, or other categories.

**Results and Discussion**

The updated Shannon Entropy analysis demonstrates that the land-use structure of Jaunpur District underwent a non-linear transformation between 1991–92 and 2022–23. The normalized Shannon Entropy increased from 0.49263 in 1991–92 to 0.49919 in 2016–17, indicating a marginal increase in land-use diversification during the first phase. However, the index subsequently declined to 0.47536 in 2022–23, suggesting a gradual return towards greater land-use concentration. The overall decline in normalized entropy between 1991–92 and 2022–23 was 0.01727 points, equivalent to approximately 3.51 percent. The decline was more pronounced during 2016–17 to 2022–23, when normalized entropy decreased by approximately 4.77 percent. Despite these changes, all three observations remained within the moderate diversification category. The changing entropy pattern is closely associated with the

continued dominance of net sown area in the district. Net area sown increased from 266,744 ha in 1991–92 to 277,186 ha in 2016–17 and 287,740 ha in 2022–23. In 2022–23, net sown area represented approximately 71.38 percent of the reporting area, making agriculture the overwhelmingly dominant land-use category. Therefore, the recent decline in entropy suggests that agricultural land-use concentration has strengthened rather than weakened during the latest phase. This finding indicates that Jaunpur's agricultural landscape remains highly dependent upon cultivation, despite the presence and gradual expansion of non-agricultural, fallow, wasteland and other land-use categories.

**Conclusion**

The agricultural landscape of Jaunpur has not followed a linear trajectory of either diversification or de-agriculturalization. Instead, the district experienced a modest increase in land-use diversification between 1991–92 and 2016–17, followed by increasing land-use concentration by 2022–23. The decline in normalized Shannon Entropy from 0.49919 in 2016–17 to 0.47536 in 2022–23 indicates that the recent landscape has become relatively more concentrated. This change is primarily associated with the continued expansion and dominance of net sown area, which reached 287,740 ha in 2022–23. Consequently, Jaunpur can be characterized as a predominantly agricultural landscape undergoing selective diversification rather than a fundamental transition away from agriculture.

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