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Spatial Analysis of Cropping Intensity in Uttar Pradesh: A District-Level Assessment

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Abstract: **Cropping intensity is an important indicator of agricultural land-use intensity and reflects the extent to which cultivated land is utilized for multiple cropping. This study examines the spatial distribution of cropping intensity across the districts of Uttar Pradesh during 2020-21 using district-level data and Geographic Information System (GIS) techniques. Cropping intensity was calculated as the ratio of gross cropped area to net sown area and subsequently classified into five categories ranging from very low to very high. The findings reveal substantial spatial disparities, with cropping intensity varying from 115% to 204% across the 75 districts. About 54.67% of the districts fall within the high and very-high categories, whereas 29.33% belong to the low and very-low categories. Barabanki records the highest cropping intensity (204%), while Chitrakoot records the lowest (115%). The spatial pattern indicates relatively intensive agricultural land use in several districts of the western and eastern plains, while comparatively lower intensity is observed particularly in parts of Bundelkhand and central Uttar Pradesh. These variations reflect differences in irrigation availability, agro-ecological conditions, agricultural infrastructure, and farming practices. The study highlights the importance of region-specific agricultural planning, particularly improved irrigation and efficient water management in low-intensity areas, while promoting sustainable resource use in highly intensified regions. The findings provide useful spatial insights for agricultural planning and sustainable land-use management in Uttar Pradesh.**

Keywords: **Cropping intensity; Agricultural land use; Spatial variation; GIS; District-level analysis; Uttar Pradesh; Agricultural intensification.**

1. INTRODUCTION

Agriculture continues to play a pivotal role in India's economy by ensuring food security, generating employment, and sustaining the livelihoods of a large proportion of the rural population. Although the relative contribution of agriculture to the national Gross Domestic Product (GDP) has declined over the past few decades, the sector remains indispensable for inclusive economic development and rural prosperity (Government of India, 2024; Gulati, & Juneja, 2022). Increasing population pressure, shrinking landholdings, and rapid urbanization have intensified the demand for efficient utilization of agricultural land (Hinz et al., 2020; Li et al., 2024). Under such circumstances, enhancing agricultural productivity through intensive land use has become one of the principal objectives of agricultural planning and policy (Husain, 2008).

Cropping intensity is one of the most widely accepted indicators for assessing the degree of agricultural land-use intensity and the efficiency with which cultivable land is utilized. It is defined as the ratio of gross cropped area to net sown area, expressed as a percentage. A higher cropping intensity indicates multiple cultivation of the same land during an agricultural year and reflects greater agricultural intensification, whereas lower cropping intensity generally signifies underutilization of land resources (Singh, 2015; Deshmukh and Shinde, 2018; Choudhary et al., 2024). Besides measuring land-use efficiency, cropping intensity also provides valuable insights into agricultural development, resource utilization, and the sustainability of farming systems (Jain et al., 2021).

The spatial variation in cropping intensity is influenced by a complex interaction of physical, technological, and socio-economic factors. Irrigation availability, soil fertility, climatic conditions, rainfall distribution, farm mechanization, adoption of improved seed varieties, fertilizer consumption, access to credit, and market infrastructure significantly determine the extent to which agricultural land is cultivated more than once in a year (Karunakaran and Palanisami, 1998; Patel et al., 2024). Although irrigation has traditionally been regarded as one of the major determinants of multiple cropping, several studies have demonstrated that cropping intensity is also influenced by technological advancement, institutional support, cropping pattern, and regional socio-economic conditions (Lambin et al., 2000; Deshmukh and Shinde, 2018; Ghosh and Ghosh, 2022; Nidhishree & Deka, 2022).

After the Green Revolution, Indian agriculture experienced remarkable improvements in agricultural productivity through the expansion of irrigation facilities, mechanization, high-yielding varieties (HYVs), and modern agricultural inputs. These developments substantially increased cropping intensity in many parts of the country, particularly within the Indo-Gangetic Plains (Pingali, 2012; Sannigrahi et al., 2020. Nevertheless, considerable regional disparities continue to exist because of differences in natural resource endowments, infrastructure development, groundwater availability, and climatic conditions (Husain, 2008; Government of India, 2024).

Among the Indian states, Uttar Pradesh occupies a prominent position in agricultural production due to its extensive alluvial plains, fertile soils, and well-developed irrigation network. The state contributes substantially to the national production of wheat, rice, sugarcane, pulses, and several other food crops (Government of Uttar Pradesh, 2022; Ministry of Agriculture & Farmer's Welfare, 2023). Agriculture remains the primary livelihood for a majority of the rural population, making efficient utilization of agricultural land essential for ensuring food security and improving farmers' income. Despite its agricultural importance, the state exhibits considerable spatial heterogeneity in cropping intensity owing to variations in irrigation facilities, groundwater resources, rainfall, soil characteristics, and levels of agricultural development across districts (Government of India, 2021; GoI, 2024).

The western districts of Uttar Pradesh generally exhibit higher cropping intensity because of assured irrigation, fertile alluvial soils, mechanized farming, and better market accessibility, whereas relatively lower cropping intensity is observed in several districts of Bundelkhand and parts of central Uttar Pradesh due to recurrent droughts, limited irrigation facilities, and adverse agro-climatic conditions. Understanding these spatial disparities is important for identifying regions requiring targeted interventions for improving agricultural productivity and promoting sustainable land management. The spatial structure of agricultural holdings may also shape the intensity of land use, particularly in regions characterized by fragmented holdings. Previous research has shown that land fragmentation can constrain mechanization and irrigation management and adversely affect agricultural efficiency (Aslam & Fazal, 2025), suggesting that the structural characteristics of farmland may also be relevant to understanding spatial variations in cropping intensity.

Recent advances in Geographic Information Systems (GIS) have considerably enhanced the capability to analyse and visualize spatial patterns of agricultural indicators at finer geographical scales. GIS-based spatial analysis enables the identification of regional disparities, agricultural hotspots, and areas requiring policy attention, thereby providing a scientific basis for regional agricultural planning (Longley et al., 2015; Singh, 2015). However, although several studies have examined cropping intensity at the national and state levels, comprehensive district-level spatial assessments of cropping intensity in Uttar Pradesh remain relatively limited.

Against this backdrop, the present study examines the spatial distribution of district-wise cropping intensity in Uttar Pradesh for the agricultural year 2020-21 using GIS techniques. The study aims to identify regional disparities in cropping intensity and discuss the geographical factors responsible for these variations. The findings are expected to contribute to a better understanding of agricultural land-use intensity and provide useful insights for planners and policymakers in formulating region-specific strategies for sustainable agricultural development.

2. STUDY AREA

Uttar Pradesh, the most populous state of India, is situated in the northern part of the country between 23°52′N to 31°28′N latitudes and 77°03′E to 84°39′E longitudes (Figure 1). The state covers an area of approximately 243,290 km², accounting for about 7.3% of India's geographical area. It is bounded by Uttarakhand and Himachal Pradesh in the north, Haryana, Delhi and Rajasthan in the west, Madhya Pradesh in the south, Chhattisgarh and Jharkhand in the southeast, Bihar in the east, and Nepal along its northern international boundary. According to the Census of India (2011), Uttar Pradesh had a population of 199.81 million, of which nearly 77.7% resided in rural areas, making agriculture the principal source of livelihood for a majority of the population.

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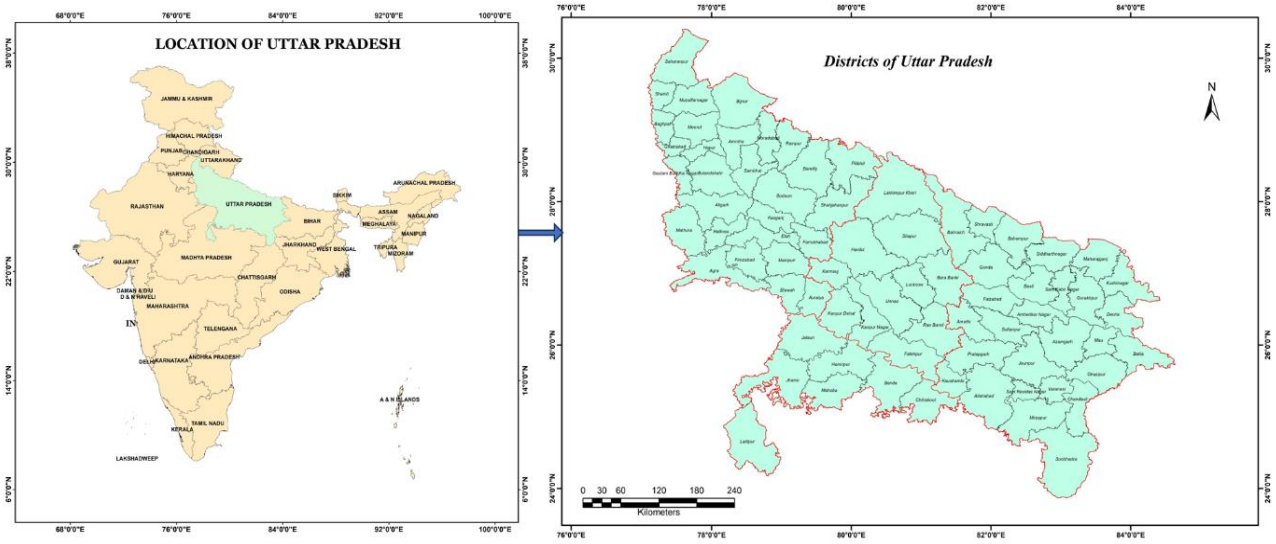

Figure 1: Location of the Study Area.

Physiographically, the state is dominated by the fertile Indo-Gangetic Plain, while the southern part comprises the rugged plateau of Bundelkhand and the Vindhyan Highlands. The state experiences a subtropical monsoon climate characterized by hot summers, cool winters, and rainfall primarily during the southwest monsoon season (June–September). Annual rainfall generally decreases from the eastern districts towards the western and south-western parts, creating considerable agro-climatic diversity.

Agriculture is the dominant economic activity in Uttar Pradesh, supported by fertile alluvial soils, an extensive canal network, and widespread groundwater irrigation. The state is one of India's leading producers of wheat, rice, sugarcane, potato, and pulses. However, substantial regional disparities exist in agricultural development because of differences in irrigation availability, soil characteristics, rainfall, cropping systems, and technological adoption. These variations significantly influence cropping intensity across districts, making Uttar Pradesh an appropriate case for examining the spatial pattern of agricultural land-use intensification.

3. DATA SOURCES AND METHODOLOGY

The present study is based entirely on secondary data. District-wise data on gross cropped area (GCA) and net sown area (NSA) for the agricultural year 2020-21 were obtained from the Sankhyikiya Patrika, Directorate of Economics and statistics, Uttar Pradesh (UPDES). Administrative boundary data (district shapefile) were used to prepare thematic maps in a Geographic Information System (GIS) environment. Cropping intensity was computed using the standard formula:

$$\textit{Cropping Intensity (CI)} = \frac{\textit{Gross Cropped Area (GCA)}}{\textit{Net Sown Area (NSA)}} \times 100$$

where Gross Cropped Area (GCA) refers to the total cropped area, including land cultivated more than once during an agricultural year, while Net Sown Area (NSA) represents the actual area cultivated at least once during the reference year (Singh, 2015; Government of India, 2021).

The calculated district-wise cropping intensity values were integrated with the district boundary layer using ArcGIS 10.5 to generate a choropleth map depicting the spatial distribution of cropping intensity across Uttar Pradesh. The districts were classified into five categories using the Natural Breaks (Jenks) classification method, namely: Very Low (115-138%), Low (139-154%), Moderate (155-165%), High (166-178%), and Very High (179-204%). This classification facilitates the identification of regional disparities in agricultural land-use intensity and enables comparison of cropping intensity among different districts of the state. The spatial distribution of cropping intensity was subsequently interpreted in relation to regional differences in irrigation development, physiographic conditions, and agricultural practices to understand the geographical factors influencing agricultural intensification in Uttar Pradesh.

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4. RESULTS AND DISCUSSION

Cropping intensity is an important indicator of agricultural land-use efficiency, reflecting the extent to which cultivated land is utilized more than once during an agricultural year. The spatial distribution of cropping intensity across the districts of Uttar Pradesh reveals considerable regional disparities, with values ranging from 115 percent to 204 percent (Figure 2). Such variation indicates substantial differences in agricultural intensification resulting from the combined influence of irrigation facilities, soil fertility, climatic conditions, agricultural infrastructure, and farmer's adoption of modern agricultural technologies.

Figure 2 illustrates that the highest cropping intensity is predominantly concentrated in the western and eastern parts of Uttar Pradesh. Districts such as Moradabad, Badaun, Bulandshahr, Maharajganj, Jaunpur, Chandauli, Barabanki, and Aligarh exhibit cropping intensity exceeding 179%, indicating extensive practice of multiple cropping. These districts are characterized by fertile alluvial soils, well-developed canal and groundwater irrigation systems, higher adoption of high-yielding crop varieties, improved access to agricultural inputs, and better market connectivity. The availability of assured irrigation enables farmers to cultivate two or even three crops annually, thereby maximizing the utilization of available agricultural land (Singh, 2015; Government of India, 2021).

Table 1. Spatial Classification of Districts by Cropping Intensity in Uttar Pradesh, 2020-21

Cropping Intensity Class	Districts	No. of Districts
Very High (179-204)	Gautam Buddha Nagar; Bulandshahr; Moradabad; Rampur; Sambhal; Budaun; Aligarh; Barabanki; Maharajganj; Sant Kabir Nagar; Jaunpur; Varanasi; Chandauli	13
High (163-178)	Saharanpur; Ghaziabad; Bareilly; Pilibhit; Shahjahanpur; Kasganj; Etah; Hathras; Agra; Firozabad; Mainpuri; Etawah; Auraiya; Kannauj; Bahraich; Shravasti; Balrampur; Siddharth Nagar; Basti; Gorakhpur; Deoria; Ambedkar Nagar; Rae Bareli; Azamgarh; Mau; Ballia; Kaushambi; Allahabad; Lalitpur	29
Moderate (155-162)	Shamli; Meerut; Hapur; Amroha; Hardoi; Gonda; Kushinagar; Faizabad; Unnao; Jhansi; Ghazipur	11
Low (139-154)	Baghpat; Lakhimpur Kheri; Mathura; Sitapur; Lucknow; Kanpur Dehat; Amethi; Sultanpur; Pratapgarh; Fatehpur; Sant Ravidas Nagar; Mirzapur; Sonbhadra; Jalaun	14
Very Low (115-138)	Muzaffarnagar; Bijnor; Farrukhabad; Hamirpur; Mahoba; Banda; Chitrakoot; Kanpur Nagar	8

Districts with high cropping intensity (166-178%) are distributed across much of the western, central, and eastern regions of the state. This category includes districts such as Rampur, Sambhal, Kasganj, Pilibhit, Hardoi, Kannauj, Gonda, Siddharth Nagar, Gorakhpur, Azamgarh, Ghazipur, Ballia, and Lalitpur. Although these districts possess favourable agricultural conditions, spatial variations in irrigation development, groundwater availability, and cropping systems contribute to moderate differences in land-use intensity. Cropping intensity has become increasingly important in regions where cultivable land is shrinking because it reflects the extent to which existing agricultural land is utilized through multiple cropping. In Uttar Pradesh, recent evidence indicates that although the net sown area has declined over time, the area sown more than once has increased considerably, suggesting that farmers are intensifying land use to sustain agricultural production (Aslam & Fazal, 2025).

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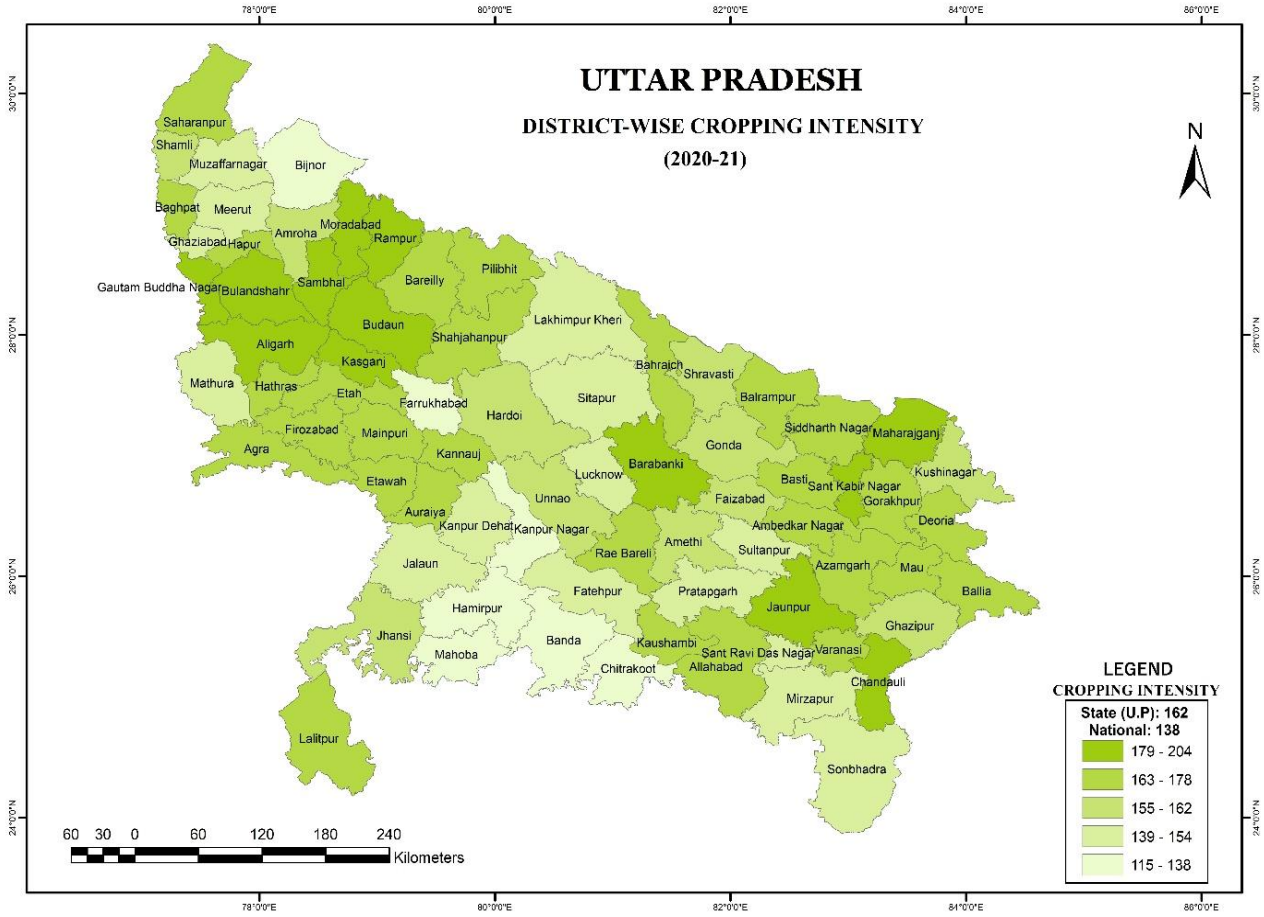

Figure 2: Spatial Distribution of Cropping Intensity in the Districts of Uttar Pradesh

A large number of districts fall within the moderate cropping intensity category (155-165%), representing the dominant agricultural condition in Uttar Pradesh. These districts generally possess moderate irrigation coverage and depend on both canal irrigation and seasonal rainfall. Farmers in these regions predominantly practice double cropping; however, the adoption of intensive cropping systems remains constrained by limited water availability, fragmented landholdings, and variations in agricultural infrastructure.

Conversely, low (139-154%) and very low (115-138%) cropping intensity is mainly observed in the Bundelkhand region and a few districts of central Uttar Pradesh, including Banda, Chitrakoot, Hamirpur, Mahoba, Kanpur Dehat, Sitapur, Bareilly, Mathura, and Sonbhadra. These districts are characterized by relatively poor irrigation facilities, recurrent droughts, undulating terrain, shallow soils, groundwater depletion, and greater dependence on monsoon rainfall. Such agro-ecological constraints limit the possibility of cultivating more than one crop annually, resulting in comparatively lower agricultural land-use intensity (Karunakaran & Palanisami, 1998; Government of India, 2024).

The observed spatial pattern broadly corresponds with the agricultural development gradient of Uttar Pradesh. The highly productive Indo-Gangetic alluvial plains in the western and eastern regions exhibit greater cropping intensity because of favourable natural resource endowments and better irrigation infrastructure, whereas the drought-prone Bundelkhand Plateau continues to record comparatively lower levels of agricultural intensification. Similar regional disparities in agricultural land use have also been reported by Aslam and Fazal (2025), who demonstrated that differences in land resources, irrigation development, and agricultural transformation have produced significant spatial inequalities across the districts of Uttar Pradesh. These findings suggest that cropping intensity is not merely an outcome of physical environmental conditions but also reflects variations in technological adoption, agricultural investment, and policy interventions aimed at enhancing land productivity.

5. CONCLUSION

Cropping intensity provides an important measure of the extent to which available agricultural land is utilized for multiple cropping and, consequently, serves as a useful indicator of agricultural land-use intensity. The present study examined the district-wise spatial distribution of cropping intensity in Uttar Pradesh during 2020-21 using GIS-based analysis. The findings demonstrate considerable spatial heterogeneity across the state, with district-level cropping intensity ranging from 115% to 204%.

The analysis reveals that a substantial proportion of districts exhibit relatively intensive agricultural land use. Of the 75 districts, 13 districts (17.33%) fall within the very-high category, while 28 districts (37.33%) belong to the high category. Collectively, therefore, 41 districts (54.67%) record high to very-high cropping intensity. In contrast, 15 districts (20.00%) fall within the low category and 7 districts (9.33%) within the very-low category, while the remaining 12 districts (16.00%) exhibit moderate cropping intensity. Barabanki records the highest cropping intensity (204%), whereas Chitrakoot records the lowest (115%), highlighting the pronounced spatial contrast in agricultural land-use intensity across Uttar Pradesh.

The spatial pattern indicates that areas characterized by more favourable agricultural conditions and relatively greater access to irrigation and agricultural infrastructure tend to support more intensive land utilization, whereas several districts of Bundelkhand and parts of central Uttar Pradesh exhibit comparatively lower intensity. These variations reflect the combined influence of physical conditions, water availability, agricultural technology, and the socio-economic characteristics of farming systems.

Comparison with the benchmark averages further highlights the intensity of agricultural land use in Uttar Pradesh. The state average cropping intensity is 162%, while the corresponding national average is 138%. Of the 75 districts, 41 (54.67%) record cropping intensity above the state average, four districts (5.33%) are equal to the state average, and 30 districts (40.00%) remain below it. At the national level, 68 districts (90.67%) exhibit cropping intensity above the national average, while one district (1.33%) records a value equal to the national average and six districts (8.00%) remain below it. The substantially larger proportion of districts exceeding the national benchmark indicates the relatively intensive utilization of agricultural land in Uttar Pradesh, although considerable intra-state variation persists. The contrast between the state and national benchmarks is particularly noteworthy: although Uttar Pradesh as a whole exhibits a high level of cropping intensity, nearly two-fifths of its districts remain below the state average, indicating considerable scope for spatially targeted agricultural interventions.

The study has important implications for agricultural planning. Policies aimed at increasing cropping intensity should not adopt a uniform state-wide approach; rather, interventions should be spatially differentiated according to local agricultural conditions. In relatively low-intensity districts, improving irrigation access, promoting efficient water-management practices, strengthening agricultural extension services, and facilitating access to modern inputs may support greater multiple cropping. At the same time, intensification in already high-intensity regions should be pursued cautiously, with emphasis on sustainable groundwater management, soil health, and resource-use efficiency to avoid environmental degradation.

Overall, the district-level assessment demonstrates that cropping intensity in Uttar Pradesh is characterized by substantial spatial disparities. Identifying these disparities through GIS provides a useful basis for region-specific agricultural planning and sustainable land-use management. Future research incorporating district-level irrigation intensity, rainfall, farm-size structure, input use, and land fragmentation could provide further insight into the determinants of these spatial variations and help establish the relative contribution of different factors to cropping intensity across Uttar Pradesh.

6. LIMITATIONS OF THE STUDY

The present study has several limitations that should be acknowledged. First, the analysis is based on district-level cropping intensity data for a single agricultural year (2020–21); therefore, it does not capture temporal variations or long-term trends in cropping intensity. Second, the study primarily focuses on the spatial distribution of cropping intensity and does not statistically examine the relative contribution of factors such as irrigation, rainfall, farm size, agricultural inputs, and land fragmentation. Third, district-level aggregation may mask intra-district variations in cropping practices and resource availability. Finally, cropping intensity alone does not fully represent agricultural productivity or sustainability, as higher

intensity may also be associated with greater pressure on soil and water resources. Future studies using multi-year, finer spatial resolution and multiple explanatory variables could overcome these limitations and provide a more comprehensive assessment of agricultural intensification in Uttar Pradesh.

7. DIRECTIONS FOR FUTURE RESEARCH

The present study has several limitations that should be acknowledged. First, the analysis is based on district-level cropping intensity data for a single agricultural year (2020–21); therefore, it does not capture temporal variations or long-term trends in cropping intensity. Second, the study primarily focuses on the spatial distribution of cropping intensity and does not statistically examine the relative contribution of factors such as irrigation, rainfall, farm size, agricultural inputs, and land fragmentation. Third, district-level aggregation may mask intra-district variations in cropping practices and resource availability. Finally, cropping intensity alone does not fully represent agricultural productivity or sustainability, as higher intensity may also be associated with greater pressure on soil and water resources. Future studies using multi-year, finer spatial resolution and multiple explanatory variables could overcome these limitations and provide a more comprehensive assessment of agricultural intensification in Uttar Pradesh.

REFERENCES

[1] Aslam, M., & Fazal, S. (2025). Exploring the impact of land fragmentation on the performance of agriculture: A systematic review. Discover Agriculture, 3, 55. https://doi.org/10.1007/s44279-025-00207-6

[2] Aslam, M., & Fazal, S. (2025). Transforming India—An Appraisal of Agricultural Land Use in Uttar Pradesh: A Regional Analysis. Journal of Land and Rural Studies, 13(1), 46-66. https://doi.org/10.1177/23210249241297757

[3] Choudhary, A. K., Saxena, K. B., & Shubha, K. (2024). Accelerating cropping intensity to feed ever-growing population in India. Current Science, 126(7), 756–758.

[4] Deshmukh, M. S., & Shinde, V. T. (2018). Cropping Intensity Index and Irrigation Intensity Index in India.

[5] Food and Agriculture Organization (FAO). (2023). The State of Food and Agriculture 2023. Rome: FAO.

[6] Ghosh, S., & Ghosh, S. (2022). Irrigation-based agricultural intensification and future groundwater potentiality: Experience of Indian states. SN Applied Sciences, 4, 65. https://doi.org/10.1007/s42452-021-04417-7

[7] Government of India. (2021). Agricultural Statistics at a Glance.

[8] Government of India. (2024). Land Use Statistics at a Glance 2023-24.

[9] Hinz, R., Sulser, T. B., Hüfner, R., Mason-D'Croz, D., Dunston, S., Nautiyal, S., Ringler, C., Schuengel, J., Tikhile, P., Wimmer, F., & Schaldach, R. (2020). Agricultural development and land use change in India: A scenario analysis of trade-offs between UN Sustainable Development Goals (SDGs). Earth's Future, 8(2), e2019EF001287. https://doi.org/10.1029/2019EF001287

[10] Husain, M. (2008). Systematic Agricultural Geography.

[11] Jain, M., Fishman, R., Mondal, P., Galford, G. L., Bhattarai, N., Naeem, S., Lall, U., Balwinder-Singh, & DeFries, R. S. (2021). Groundwater depletion will reduce cropping intensity in India. Science Advances, 7(9), eabd2849. https://doi.org/10.1126/sciadv.abd2849

[12] Karunakaran, K. R., & Palanisami, K. (1998). An Analysis of Impact of Irrigation on Cropping Intensity in Tamil Nadu.

[13] Lambin, E. F., Rounsevell, M. D. A., & Geist, H. J. (2000). Are agricultural land-use models able to predict changes in land-use intensity? Agriculture, Ecosystems & Environment, 82(1–3), 321–331. https://doi.org/10.1016/S0167-8809(00)00235-8

[14] Li, M., Li, J., Haq, S. U., & Nadeem, M. (2024). Agriculture land use transformation: A threat to sustainable food production systems, rural food security, and farmer well-being? PLOS ONE, 19(1), e0296332. https://doi.org/10.1371/journal.pone.0296332

[15] Longley, P. A., Goodchild, M. F., Maguire, D. J., & Rhind, D. W. (2015). Geographic information science and systems (4th ed.). John Wiley & Sons.

[16] Nidhishree, R., & Deka, N. (2022). Performance of different districts of Assam: In the perspective of cropping intensity and irrigation intensity. Agricultural Economics Research Review, 35(Conference), 175.

[17] Patel, U. B., Leua, A., Garde, Y. A., Patel, H. M., & Saravadiya, S. (2024). Trends and impact of different irrigation sources on cropping intensity in Gujarat. International Journal of Agriculture Extension and Social Development, 7(10), 534–544. https://doi.org/10.33545/26180723.2024.v7.i10h.1271

[18] Pingali, P. L. (2012). Green Revolution: Impacts, limits, and the path ahead. Proceedings of the National Academy of Sciences of the United States of America, 109(31), 12302–12308. https://doi.org/10.1073/pnas.0912953109

[19] Sannigrahi, S., Pilla, F., Zhang, Q., Chakraborti, S., Wang, Y., Basu, B., Basu, A. S., Joshi, P. K., Keesstra, S., Roy, P. S., Sutton, P. C., Bhatt, S., Rahmat, S., Jha, S., & Singh, L. K. (2021). Examining the effects of Green Revolution-led agricultural expansion on net ecosystem service values in India using multiple valuation approaches. Journal of Environmental Management, 277, 111381. https://doi.org/10.1016/j.jenvman.2020.111381

[20] Singh, R. (2015). Analysis of Spatial-emporal Changes in Cropping Pattern and Cropping Intensity in Haryana.