International Conference on Science, Engineering & Management Trends

International Journal of Science, Engineering and Technology
ISSN: 2348-4098, P-ISSN: 2395-4752

Spatial Analysis of Cropping Intensity and Agricultural Productivity in South Dinajpur District, West Bengal

Ujjal Chandra Roy[1], Dr. A. Rajshekhar [2]

[1]Research Scholar, Department of Geography, Kalinga University, Raipur, Chhattisgarh, India
[2]Research Supervisor, Department of Geography, Kalinga University, Raipur, Chhattisgarh, India

Abstract- Cropping intensity is widely used in agricultural geography as an indicator of how intensively cultivated land is used across seasons, but it does not automatically explain spatial differences in agricultural productivity. In districts where irrigation access, soil quality, crop structure, and infrastructure vary across space, high aggregate cropping intensity may coexist with uneven output and uneven agrarian opportunity. South Dinajpur district in West Bengal is a useful case for examining this problem. Official district records indicate a net sown area of 188.6 thousand hectares, a gross cropped area of 331.9 thousand hectares, and a cropping intensity of 176 percent. Yet the same profile shows only partial irrigation coverage, strong dependence on shallow tube wells and lift irrigation, and continued rainfed exposure across a substantial share of cultivated land. This paper develops a district-focused geographical analysis of the relationship between cropping intensity and agricultural productivity in South Dinajpur. It uses a review-based approach, combining official district statistics with recent peer-reviewed literature on agrarian transition, irrigation, crop diversification, agricultural sustainability, remote sensing of cropping intensity, and soil fertility in the Barind tract of Dakshin Dinajpur. The paper argues that South Dinajpur should not be treated simply as a high-intensity agricultural district. Rather, it should be understood as an internally differentiated agrarian space in which productivity is mediated by the uneven geography of irrigation, soil fertility, crop structure, and infrastructural support. The paper contributes a spatial analytical framework for future block-level and GIS-based research and shows why district averages are insufficient for understanding agricultural performance in this part of West Bengal. (Department of Agriculture & Farmers Welfare, 2025; Government of India, 2011; Malo & Saha, 2025; Nandi et al., 2025; Paria et al., 2022).

Keywords- Cropping intensity, agricultural productivity, South Dinajpur, West Bengal, spatial analysis, irrigation.

I. INTRODUCTION

Cropping intensity has become a central concept in agricultural geography because it captures the repeated use of the same cultivated land across seasons. In a country such as India, where agricultural land is finite but food and livelihood demands continue to grow, multiple cropping is one of the main

International Journal of Science, Engineering and Technology
ISSN: 2348-4098, P-ISSN: 2395-4752

ways in which the pressure on land is managed. Official national land-use statistics show a cropping intensity of 155.9 percent for India in 2022-23, indicating that repeated cultivation is now a structural feature of the agrarian economy rather than an exceptional practice. That broader national context makes district-level analysis important, because districts do not experience intensification in the same way or with the same outcomes. (Department of Agriculture & Farmers Welfare, 2025).

The key problem is that cropping intensity is often used as if it were equivalent to agricultural productivity. It is not. Cropping intensity tells us how many times land is used, but productivity depends on whether repeated cultivation is supported by reliable irrigation, favorable soils, viable crop combinations, infrastructure, and market access. Recent work on agricultural sustainability in India treats cropping intensity as only one part of a wider agrarian system that also includes irrigation intensity, foodgrain productivity, crop diversification, transport, and institutional support. In the same way, recent district-level work from West Bengal shows that irrigation, fertilizer use, roads, and market and storage facilities strongly shape agrarian transition and crop choice. This means that a high-intensity district may still contain lower-performing localities if the conditions needed to convert intensity into productivity are unevenly distributed. (Jatav & Naik, 2023; Paria et al., 2022).

South Dinajpur district offers a strong case for examining this contradiction. The district agriculture contingency profile records a geographical area of 221.9 thousand hectares, a cultivable area of 204.85 thousand hectares, a net sown area of 188.6 thousand hectares, an area sown more than once of 143.3 thousand hectares, and a gross cropped area of 331.9 thousand hectares. These figures together yield a cropping intensity of 176 percent, which is well above the recent all-India average. On the face of it, South Dinajpur appears to be a strongly intensified agricultural district. Yet the same official profile shows that the district has a net irrigated area of 82.54 thousand hectares, a gross irrigated area of 135.23 thousand hectares, and a rainfed area of 93.08 thousand hectares. Thus, repeated cultivation is widespread, but it is not uniformly secured by irrigation. (Government of India, 2011).

The district's physical geography reinforces the importance of a spatial reading. South Dinajpur lies in the Lower Gangetic Plain and the Old Alluvial Zone, and the official district profile identifies major soil groups including very deep clay loam, deep clay, deep loamy, sandy, and sandy loam soils. It also records a monsoon-dominant rainfall regime, with 1,549.8 mm received during the southwest monsoon and 1,847.8 mm annually. A district with such rainfall concentration, soil heterogeneity, and partial irrigation coverage is unlikely to perform uniformly across space. In geographical terms, this suggests that high cropping intensity in South Dinajpur should be treated as a district-level average masking local differences rather than as proof of uniform productivity. (Government of India, 2011).

Recent research makes this argument even stronger. A 2025 study of the Barind tract of Dakshin Dinajpur investigates spatial variations in soil fertility under rice-based cropping systems and reports that 45.41 percent of the study area falls under low fertility, while the overall soil condition is described as deficient for sustainable rice production. The study argues for site-specific nutrient management, GIS-based mapping, and zonal planning, which is important because it provides district-relevant evidence that the ecological basis of productivity is itself spatially uneven. Intensification, then, cannot be interpreted only as repeated land use. It has to be read together with the quality of the soil resource base. (Malo & Saha, 2025).

The research problem addressed in this paper is therefore straightforward but significant: how should the relationship between cropping intensity and agricultural productivity in South Dinajpur be interpreted when the district's aggregate statistics suggest strong intensification, but recent literature points to uneven water access, crop transition, and soil fertility? The paper addresses this problem by asking three questions. First, what does the district profile reveal about the structure of land use and irrigation in South Dinajpur? Second, what does recent literature suggest about the main drivers that

International Journal of Science, Engineering and Technology
ISSN: 2348-4098, P-ISSN: 2395-4752

mediate the relation between cropping intensity and productivity? Third, why is a spatial rather than purely district-average interpretation necessary for understanding agricultural performance in the district? These questions are addressed through a review-based analytical approach. (Das et al., 2024; Malo & Saha, 2025; Nandi et al., 2025; Paria et al., 2022).

The central argument advanced here is that South Dinajpur should be interpreted as an internally differentiated agrarian space. High cropping intensity is a real and important feature of the district, but productivity is mediated by the uneven geography of irrigation, soil fertility, crop structure, and rural support conditions. The paper's contribution is not to present a new empirical model, but to synthesize current evidence into a district-focused spatial framework that can guide future block-level and GIS-based research. That contribution is relevant both to conference discussion and to future empirical work in regional agricultural geography. (Government of India, 2011; Malo & Saha, 2025; Pazhanivelan et al., 2025).

II. LITERATURE REVIEW

A useful starting point in the literature is the distinction between agricultural intensification and agricultural productivity. Intensification refers to the more frequent use of land, labor, and inputs in order to raise output from a limited land base. Productivity refers to the effectiveness of that process in terms of output relative to land, labor, or broader input combinations. The two are related but not interchangeable. Recent work on agricultural sustainability in India treats cropping intensity as one among several indicators rather than as a sufficient measure of performance. This is analytically important because it stops the researcher from assuming that land used more often is necessarily land used more successfully. (Jatav & Naik, 2023).

A second major debate in the literature concerns irrigation. Das et al. show that agricultural efficiency in an Indian semi-arid region remains positively related to irrigation intensity, though not determined by it alone. Their work suggests that irrigation is an enabling condition rather than a complete explanation of performance. This perspective is reinforced by Paria et al., who show that in West Bengal crop diversification and agrarian transition are shaped by irrigation, fertilizer use, roads, and market and storage facilities, alongside climatic variables. Together, these studies indicate that irrigation has strong explanatory power, but only when placed within a wider geographical and institutional context. For South Dinajpur, this is particularly relevant because the district profile shows high intensity but incomplete irrigation coverage. (Das et al., 2024; Paria et al., 2022).

A third debate concerns crop diversification and spatial scale. Nandi et al. show that crop diversification across the Eastern Indo-Gangetic Plain varies substantially across space and that larger-scale indicators can conceal district, sub-district, and community-level differences. This matters because a district average can appear moderate or strong even when internally it consists of highly contrasting localities. Their argument is methodological as well as substantive. It suggests that the right scale of analysis is itself part of the research problem. When applied to South Dinajpur, this implies that a district-wide cropping intensity of 176 percent may be accurate but still inadequate if the question concerns agricultural productivity across blocks or local agro-ecological settings. (Nandi et al., 2025).

The literature on spatial analysis of cropping patterns strengthens this point. Pazhanivelan et al. argue that the spatial and temporal analysis of cropping patterns and intensity is essential for agricultural planning and that finer spatial resolution becomes increasingly important as the study area becomes smaller and more heterogeneous. This is directly relevant to South Dinajpur. A district-level average is useful for state or national comparison, but it does not identify where multiple cropping is concentrated, where it is fragile, and where local constraints interrupt the translation of intensity into productivity.

International Journal of Science, Engineering and Technology
ISSN: 2348-4098, P-ISSN: 2395-4752

From a spatial-analysis perspective, district totals are descriptive but not fully explanatory. (Pazhanivelan et al., 2025).

The district-specific literature, though more limited, is also instructive. The official contingency profile of Dakshin Dinajpur provides a baseline picture of land use, rainfall, soils, and irrigation sources, all of which point toward environmental heterogeneity. More significantly, the recent Barind tract study by Malo and Saha shows that soil fertility is spatially differentiated and that many areas are not adequately fertile for sustainable rice-based production without targeted nutrient management. This moves the discussion beyond irrigation and crop choice to the ecological metabolism of the district's farming systems. It suggests that even if land is cultivated repeatedly, the quality of that repeated cultivation will differ according to soil conditions. (Government of India, 2011; Malo & Saha, 2025).

The research gap emerges at the intersection of these literatures. We know from official district data that South Dinajpur is a highly intensified agricultural district. We know from recent peer-reviewed work that irrigation, diversification, infrastructure, and climate shape agrarian transition in West Bengal, that agricultural sustainability cannot be reduced to cropping intensity alone, that finer spatial scales matter, and that parts of Dakshin Dinajpur face serious soil-fertility limitations. What remains missing is a concise district-focused analytical paper that brings these strands together to interpret South Dinajpur's cropping intensity and agricultural productivity through a spatial lens. This paper addresses that gap by constructing such a framework. (Government of India, 2011; Jatav & Naik, 2023; Malo & Saha, 2025; Nandi et al., 2025; Paria et al., 2022).

III. METHODOLOGY OR CONCEPTUAL APPROACH

This conference paper adopts a review-based conceptual approach rather than an empirical design. An empirical paper on this topic would require block-level crop-area data, seasonal yield data, irrigation coverage by source and season, soil maps, and ideally GIS layers capable of linking land use, water access, and productivity. Since such a dataset has not been provided, the most credible format is a review paper that remains transparent about its limits while still producing an original geographical argument.

The source base consists of three kinds of material. First, official district and national documents were used to establish the agricultural baseline of South Dinajpur and to place the district within the wider Indian agricultural context. Second, recent peer-reviewed studies were used to represent the key conceptual debates on agrarian transition, irrigation, crop diversification, spatial agricultural analysis, and agricultural sustainability. Third, recent district-relevant soil-fertility research from the Barind tract of Dakshin Dinajpur was used to connect the district's official land-use profile to a concrete biophysical mechanism affecting productivity. (Department of Agriculture & Farmers Welfare, 2025; Government of India, 2011; Malo & Saha, 2025; Nandi et al., 2025; Paria et al., 2022; Pazhanivelan et al., 2025).

The conceptual framework used in the paper is sequential. Land pressure and agrarian dependence encourage multiple cropping. Irrigation access determines whether repeated cultivation can be sustained across seasons. Soil fertility influences whether repeated cultivation actually supports strong yields over time. Crop structure and diversification affect resilience, value realization, and exposure to climatic or market stress. Infrastructure and institutions mediate whether production gains can be stabilized and expanded. The interaction of these factors produces the observed relation between cropping intensity and agricultural productivity. In South Dinajpur, the argument developed here is that these enabling conditions are uneven across space, which is why district averages alone are insufficient. (Das et al., 2024; Jatav & Naik, 2023; Paria et al., 2022).

International Journal of Science, Engineering and Technology
ISSN: 2348-4098, P-ISSN: 2395-4752

IV. RESULTS OR ANALYSIS

The first result of the review is that South Dinajpur is clearly a high-intensity agricultural district at the aggregate level. The official district profile records 188.6 thousand hectares of net sown area, 143.3 thousand hectares sown more than once, and 331.9 thousand hectares of gross cropped area, producing a cropping intensity of 176 percent. Compared with the all-India level of 155.9 percent in 2022-23, South Dinajpur stands out as a district where multiple cropping is already structurally important. This matters because any analysis of agricultural productivity in the district must begin from the fact that land is already under substantial pressure and repeated use. (Department of Agriculture & Farmers Welfare, 2025; Government of India, 2011).

The second result is that this high-intensity profile rests on uneven irrigation conditions. South Dinajpur has a net irrigated area of 82.54 thousand hectares and a rainfed area of 93.08 thousand hectares, which means that a large share of cultivation remains exposed to rainfall dependence or partial water insecurity. The district's irrigation structure is dominated by bore wells or shallow tube wells, which account for 53.3 thousand hectares or 57.8 percent of the irrigated area, followed by lift irrigation at 22.4 thousand hectares and tanks at 10.36 thousand hectares. Canal irrigation is absent from the reported profile. This source structure is important because groundwater-based and lift-based irrigation systems tend to be uneven in distribution and reliability. The district's overall cropping intensity is therefore likely to conceal local differences in the stability of repeated cultivation. (Government of India, 2011).

The third result concerns environmental heterogeneity. The official district profile lists major soil groups that include very deep clay loam, deep clay, deep loamy, sandy, and sandy loam soils, while also recording a monsoon-dominant rainfall regime with 1,549.8 mm in the southwest monsoon and 1,847.8 mm annually. This means that cultivation in South Dinajpur operates across a varied physical environment rather than a uniform agricultural surface. Repeated cultivation under such conditions is unlikely to produce the same outcomes everywhere. Some areas will benefit from better soil moisture retention and more favorable textures, while others will be more vulnerable to nutrient stress, water fluctuation, or weaker input response. (Government of India, 2011).

The fourth result is that productivity in the district is likely to be shaped by selective rather than uniform crop transition. Regional work from West Bengal shows that non-foodgrain transition is influenced by irrigation, fertilizer use, roads, storage, markets, and climatic factors. This means that where supportive conditions exist, farmers are more able to diversify and potentially improve returns; where they do not, repeated cultivation may remain cereal-heavy and less flexible. South Dinajpur's contingency planning sections repeatedly refer to rice-based and rice-linked systems such as rice-mustard, rice-wheat or mustard, rice-potato, rice-vegetable, and jute-rice under different soil and water situations. This suggests that intensification in the district is structured around a relatively narrow but differentiated set of crop sequences rather than a fully diversified agrarian mosaic. Productivity, therefore, is likely to vary according to where those sequences can be sustained and where diversification remains constrained. (Government of India, 2011; Paria et al., 2022).

The fifth result is that soil fertility creates a second major axis of spatial disparity. Malo and Saha's study of the Barind tract of Dakshin Dinajpur reports that 45.41 percent of the study area falls within a low soil-fertility category and that the overall soil fertility condition is deficient for sustainable rice production. The study further argues that location-specific fertility assessment and GIS-based nutrient management are necessary because broad or generalized fertilizer practice is inadequate for the area. This finding has direct implications for the relation between cropping intensity and productivity. It means that repeated cultivation may not translate into proportionate productivity gains where soils are

International Journal of Science, Engineering and Technology
ISSN: 2348-4098, P-ISSN: 2395-4752

already nutrient-stressed or unevenly managed. In such settings, intensity can become a sign of pressure as much as performance. (Malo & Saha, 2025).

The sixth result is methodological but fundamental: district averages are too coarse to explain productivity outcomes. Nandi et al. show that sub-national crop diversification patterns across the Eastern Indo-Gangetic Plain conceal smaller-scale variation, while Pazhanivelan et al. stress the importance of spatial and temporal analysis of cropping intensity for meaningful planning. Applied to South Dinajpur, this means that a district-wide intensity figure of 176 percent is useful for comparison but not sufficient for explanation. It cannot tell us which blocks sustain double or triple cropping more securely, which areas are more soil-constrained, or where irrigation dependence produces vulnerability. A spatial analysis of productivity must therefore move below the district average. (Nandi et al., 2025; Pazhanivelan et al., 2025).

The final analytical result is the construction of a district-specific explanatory framework. In South Dinajpur, agricultural productivity appears to be produced through the interaction of four spatially uneven forces: irrigation access, soil fertility, crop structure, and infrastructural support. Cropping intensity tells us that land is used repeatedly, but these other variables determine how effectively repeated cultivation is converted into output. The district should therefore be understood as a differentiated agricultural space in which some localities are better positioned to translate intensification into productivity than others. This is the central insight that a spatial analysis brings to the topic. (Das et al., 2024; Government of India, 2011; Malo & Saha, 2025; Paria et al., 2022).

V. DISCUSSION

The findings of this paper support a more careful interpretation of South Dinajpur's agricultural profile. High cropping intensity in the district is real and significant, but it should not be mistaken for uniform agricultural productivity. The district's partial irrigation coverage, dependence on groundwater and lift irrigation, soil heterogeneity, and evidence of low fertility in parts of the Barind tract all suggest that repeated cultivation does not occur under equal conditions. This interpretation aligns with wider geographical literature showing that irrigation, diversification, and sustainability need to be read together rather than in isolation. (Das et al., 2024; Jatav & Naik, 2023; Malo & Saha, 2025).

The paper also reinforces the importance of scale in agricultural geography. If productivity is unevenly produced, then a district-level average can only ever be a partial account. South Dinajpur's aggregate intensity is high, but the literature strongly suggests that block-level and sub-block differences are where the real explanatory story lies. Some localities are likely to benefit more from irrigation, better soils, or stronger crop transition, while others remain constrained by rainfall dependence, weaker soil fertility, or limited diversification. A spatial analysis, therefore, is not an optional refinement. It is necessary if the district's agricultural performance is to be understood in a meaningful way. (Nandi et al., 2025; Pazhanivelan et al., 2025).

A further implication is that agricultural planning in South Dinajpur cannot rely only on headline measures such as cropping intensity. If the geography of productivity is uneven, then policy also needs to be spatially differentiated. Areas constrained primarily by irrigation need different interventions from areas constrained by soil fertility or narrow crop structures. The recent Barind tract study already points toward this logic by recommending site-specific nutrient management and GIS-supported zoning. The West Bengal transition literature similarly suggests that roads, storage, and market access influence agrarian change alongside irrigation and fertilizer. This means that productivity enhancement in South Dinajpur requires area-specific rather than district-uniform strategies. (Malo & Saha, 2025; Paria et al., 2022).

International Journal of Science, Engineering and Technology
ISSN: 2348-4098, P-ISSN: 2395-4752

From a disciplinary perspective, the paper contributes to conference discussion by clarifying the analytical difference between land-use frequency and productive performance. In many district profiles, high intensity is read as a sign of agricultural success. The present analysis suggests a more complex reading. Intensification may indeed signal active and effective land use, but in a district such as South Dinajpur it may also reflect pressure on fragile water and soil systems. The geographical task is therefore not simply to measure intensity, but to explain where, why, and under what constraints intensity produces different productivity outcomes. That is the main conceptual contribution of this paper. (Government of India, 2011; Jatav & Naik, 2023; Malo & Saha, 2025).

VI. CONCLUSION AND FUTURE WORK

This paper has argued that the most defensible way to write on "Spatial Analysis of Cropping Intensity and Agricultural Productivity in South Dinajpur District, West Bengal" without a primary dataset is as a review paper with a district-focused conceptual framework. The analysis shows that South Dinajpur is a high-intensity agricultural district by aggregate measures, but that this intensity is supported unevenly because irrigation, soil fertility, crop structure, and enabling infrastructure are not uniformly distributed. The district's official land-use profile and recent peer-reviewed literature therefore point toward a common conclusion: cropping intensity and productivity in South Dinajpur are connected, but they are not identical and should not be treated as such. (Department of Agriculture & Farmers Welfare, 2025; Government of India, 2011; Malo & Saha, 2025; Paria et al., 2022).

The paper's main contribution is to reframe South Dinajpur as an internally differentiated agrarian district rather than a single agricultural average. That reframing matters because it changes both research design and policy thinking. Once the district is understood as spatially uneven, the need for block-level analysis, GIS-supported mapping, and localized agronomic planning becomes clear. A headline intensity figure is not enough. The real geographical question is how repeated cultivation is stabilized or constrained across space. (Nandi et al., 2025; Pazhanivelan et al., 2025).

Future work should therefore move in three directions. First, block-wise empirical analysis is needed to relate cropping intensity directly to crop-yield and value data. Second, GIS-based mapping of irrigation sources, seasonal cropped area, and soil-fertility conditions should be developed so that intra-district variation can be measured rather than inferred. Third, future studies should examine whether localities with more diversified crop structures display more resilient or more remunerative productivity trajectories than those that remain narrowly rice-based. These are the steps needed to move from district description to robust spatial explanation. (Malo & Saha, 2025; Nandi et al., 2025; Pazhanivelan et al., 2025).

REFERENCES

1. Das, S., Sharma, K. K., Majumder, S., Das, D., & Roy Chowdhury, I. (2024). Spatio-temporal variation and relationship between agricultural efficiency and irrigation intensity in a semi-arid region of India. Regional Sustainability, 5(2), 100144.
2. Department of Agriculture & Farmers Welfare. (2025). Annual report 2024-25. Government of India.
3. Government of India, Ministry of Agriculture. (2011). Agriculture contingency plan for district: Dakshin Dinajpur, West Bengal.
4. Jatav, S. S., & Naik, K. (2023). Measuring the agricultural sustainability of India: An application of Pressure-State-Response (PSR) model. Regional Sustainability, 4(3), 218-234.
5. Malo, S. K., & Saha, S. (2025). Assessment of the soil fertility index (SFI) for sustainable nutrient management in rice-based cropping systems of Barind tract of West Bengal, India. Discover Soil, 2, 96.

International Journal of Science, Engineering and Technology
ISSN: 2348-4098, P-ISSN: 2395-4752

6. Nandi, R., Ghosh, A., Karmacharya, S., & Krupnik, T. J. (2025). Spatiotemporal variation of crop diversification across Eastern Indo-Gangetic plains of South Asia. Farming System, 3, 100138.
7. Paria, B., Mishra, P., & Behera, B. (2022). Climate change and transition in cropping patterns: District level evidence from West Bengal, India. Environmental Challenges, 7, 100499.
8. Pazhanivelan, S., Kumaraperumal, R., Vishnu Priya, M., Rengabashyam, K., Shankar, K., Nivas Raj, M., & Yadav, M. K. (2025). Multi-temporal analysis of cropping patterns and intensity using optical and SAR satellite data for sustaining agricultural production in Tamil Nadu, India. Sustainability, 17(4), 1613.