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Evaluating Cropping Intensity and Agricultural Productivity Trends in Shamli District: A Spatial-Temporal Perspective

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Abstract

Agricultural development significantly influences land use dynamics and productivity outcomes in rural economies. This research critically evaluates the impact of agricultural development on cropping intensity and productivity in Shamli district over the past ten years. Cropping intensity, a key indicator of land use efficiency, increased from 149% in 2010 to 160% in 2020, reflecting intensified cultivation practices. Block-wise analysis reveals substantial spatial disparities: Shamli and Kandhla blocks consistently recorded higher cropping intensities due to superior irrigation infrastructure and proximity to urban centres, whereas Uun lagged, indicating infrastructural limitations. Agricultural productivity was assessed using Kendall's Ranking Coefficient Method across eight major crops—rice, wheat, barley, maize, pulses, oilseeds, sugarcane, and vegetables. Wheat and sugarcane emerged as the most productive crops, with Kairana and Uun blocks demonstrating the highest yields. In contrast, pulses and oilseeds exhibited lower and more variable productivity, underscoring the need for targeted agronomic interventions. The findings offer valuable insights for spatially informed agricultural planning and emphasise the imperative of equitable and sustainable rural development.

Keywords

Cropping Intensity, Agricultural Productivity, Kendall's Ranking Coefficient Method, Spatial Variation, Sustainable Agriculture

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1. Introduction

Uttar Pradesh holds a pivotal position in India's agricultural sector as one of the country's most densely populated states. The region's fertile alluvial flatlands, conducive weather patterns, and well-developed irrigation systems make it a key contributor to India's cereal production. Each district within this broader agricultural context makes its own distinct contribution to the state's farming ecosystem. Within this landscape, Shamli District in western Uttar Pradesh emerges as a notable agricultural zone, with sugarcane, wheat, paddy, and various horticultural crops forming the backbone of Shamli's agricultural economy and the principal economic pursuit. Recent years have witnessed notable transformations in Shamli's cropping patterns and land use intensity. Enhanced irrigation capabilities, the growth of sugarcane-centred agricultural systems, and greater utilization of contemporary farming inputs have progressively affected the frequency of land cultivation. These developments have influenced aggregate agricultural output and reshaped the district's overall farming characteristics.

Cropping intensity, referring to the number of crops cultivated on the same land within a year, has risen considerably in Shamli. The increased availability of canal irrigation and tubewells, coupled with the dominance of sugarcane-based cropping systems, has encouraged farmers to cultivate multiple crops annually.

Bhattarai, Sakthivadivel, and Hussain (2002) demonstrate that variations in cropping intensity between irrigated and rainfed regions have significant implications for rural employment and poverty. Siebert, Portmann, and Doll (2010) show that regions with dependable water availability demonstrate much higher intensity levels. Shamli benefits from both canal networks and bore-well irrigation, enabling farmers to adopt intensive and multi-cropping practices. Valipour (2015) argues for efficient, well-planned irrigation management, emphasising that sustainable cropping intensity requires reducing dependence on commercial motives and adopting systematic irrigation practices. Sharma (2015) observed that the expansion of irrigated land in India significantly increased the total cropped area, raising national cropping intensity from 128.9% in the early 1990s to 138% by 2011–12 and Kaini, Gardner, and Sharma (2020) also indicate that the move from subsistence to commercial farming in irrigated areas typically results in higher cropping intensity which apply to Shamli.

2. Study Area

Shamli district became a distinct administrative entity on September 28, 2011, carved out from the larger Muzaffarnagar District. The geographical boundaries of Shamli district are well-defined by its neighbouring regions and natural features.

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To the north, it is bordered by the Saharanpur district. On its south lies the Bagpat district, while to the west, Shamli shares a boundary with the state of Haryana. A significant natural feature, the Yamuna River, carves the district's western edge, enhancing the region's scenic beauty and plays a vital role in its ecological and agricultural systems.

Shamli district is mapped within the Survey of India Toposheet No. 53G. Its coordinates range from latitudes 29°45'49.33" N to 29°42'33.33" N and longitudes 77°23'10.06" E to 78°08'13.18" E, placing it firmly within the fertile plains of northern India. The district has been organised into three tehsils and five developmental blocks to streamline governance and development efforts, ensuring that administrative functions are efficiently distributed across its expanse.

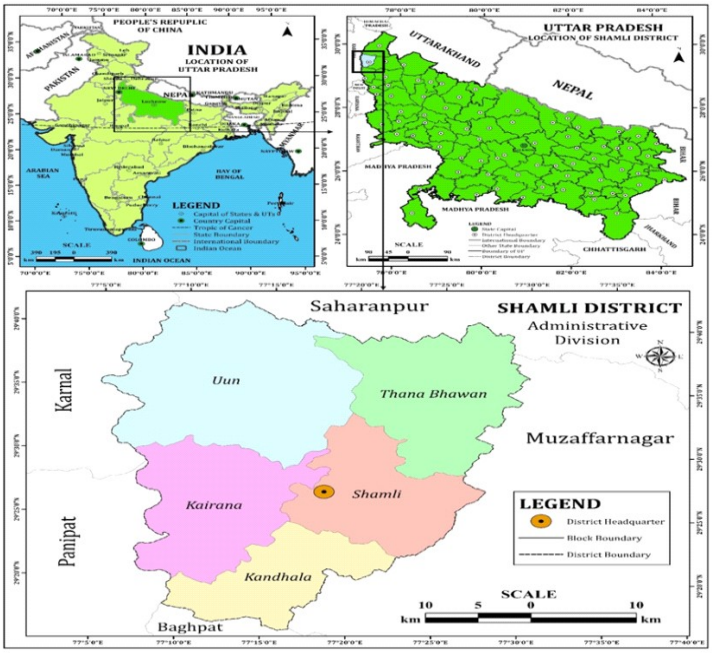

Figure 2.1: Location Map of Study Area

3. Research Objectives

- To analyse the changing pattern of cropping intensity in Shamli from 2010-11 to 2020-21.
- To evaluate agricultural productivity in Shamli district from 2010-11 to 2020-21.

4. Research Methodology

Cropping intensity refers to the number of crops grown on the same field each year. In Shamli district, the cropping intensity is relatively high due to fertile alluvial

soil, assured irrigation from canals and tube wells, and favourable climatic conditions.

Formula for Cropping Intensity:

$$\text{Cropping Intensity (\%)} = \left(\frac{\text{Gross Sown Area}}{\text{Net } Sown\ Area}\right) \times 100$$

- **Gross Sown Area** = Total area sown once and all areas sown more than once a year.
- **Net Sown Area** = Area sown with crops, counting each area only once a year.

Kendall's Agricultural Productivity Analysis Method involves calculating a Productivity Index (PI) to compare the productivity of different crops across regions or blocks. The following sections provide a detailed explanation of this formula and its application in the study context.

$$PI = \frac{Yi}{Ai}$$

Where:

PI is the **Productivity Index** for a particular region or development block.

Yi is the **total production of crops** in the region.

Ai is the **total land area** under cultivation in the region.

Kendall divided this process into three steps:

- Productivity for each unit is ranked by **yield per hectare** for the selected crops.
- The **ranks obtained** for the selected crops by each unit are **summed**.
- The **sum of ranks** for each unit is then **divided by the number of crops**, yielding the **ranking coefficient**.

Kendall used the following formula to determine agricultural productivity.

$$Ranking\ Coefficient\ Index = \frac{R1 + R2 + R3 + \ldots\ldots\ldots RN}{n}$$

Where,

R = Ranking of the productivity of each crop

n = number of crops

5. Results and Discussion

Over the past few decades, Shamli has witnessed considerable transformations in its cropping patterns, cropping intensity, and overall agricultural productivity influenced by a combination of physical factors such as soil fertility, rainfall variability, and irrigation availability, as well as farm size, access to technology, and government policies promoting high-yielding varieties and modern agricultural practices. Cropping intensity, defined as the ratio of total cropped area to net sown area, is an important indicator of land-use efficiency and agricultural intensification. In Shamli district, variations in cropping intensity across blocks and villages highlight

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the spatial heterogeneity of agricultural development, while temporal changes reveal the dynamics of land-use adjustments.

5.1.1 Cropping Intensity

Cropping intensity represents the annual frequency of cultivation on the same land. Shamli district demonstrates high cropping intensity due to fertile alluvial soils, dependable canal and tubewell irrigation, and favourable climate. Farmers typically practice double-cropping with wheat and sugarcane in the rabi season, and with rice or fodder in the kharif season. Some areas cultivate a third crop, particularly vegetables or pulses, near urban centres. While this intensity improves land efficiency, increases production, enhances farmer incomes, but also presents challenges, including soil nutrient depletion, reduced fertility, and groundwater overexploitation.

Cropping Intensity: 2010

During 2010-2011, Shamli district recorded a cropping intensity of 149%. This relatively higher intensity reflects the district's favourable agricultural conditions. Block-wise analysis reveals substantial spatial variations. Shamli block demonstrated the highest cropping intensity at 160%, followed by Thana Bhawan (155%), Kairana (153%), and Kandhla (153%). These elevated values suggest greater access to agricultural inputs, well-developed irrigation systems, and better farmer awareness of intensive cultivation practices. Conversely, Uun block exhibited comparatively lower cropping intensity at 121%, potentially attributable to inadequate irrigation facilities, limited input availability, and insufficient agricultural extension services.

Urban areas of Shamli displayed an exceptionally high cropping intensity of 303%, despite relatively modest absolute values for net sown area (4,080 hectares) and gross sown area (12,380 hectares). This reflects intensive peri-urban farming characterised by small, highly productive plots cultivated multiple times annually.

Table 5.4: Cropping Intensity of Shamli District: 2010

(Source: District Statistical Book, 2010-11)

Block	2010-2011		
	Gross Sown Area	Net Sown Area	Cropping Intensity
Uun	44975	37231	**121**
Thana Bhawan	28142	18101	**155**
Shamli	23449	14668	**160**
Kairana	31435	20579	**153**
Kandhla	15865	10370	**153**
Total Rural	143866	100949	**143**
Total Urban	12380	4080	**303**
Total District	312492	210058	**149**

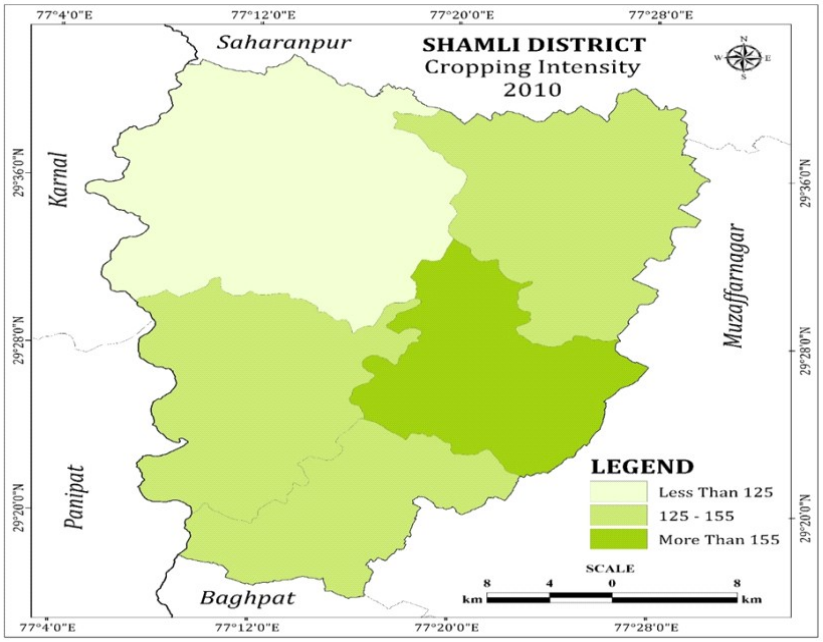

Figure 5.3: Cropping Intensity, 2010

Cropping intensity: 2020

Shamli district recorded a gross sown area of 169,764 hectares against a net sown area of 106,106 hectares, yielding an overall cropping intensity of 160%. Figure 5.3 shows a moderate level of agricultural intensification, indicating significant multiple cropping throughout the region.

Examination of rural blocks reveals interesting contrasts in agricultural practices. Uun block, with the largest net sown area of 36,610 hectares, had a modest cropping intensity of 125%, suggesting constraints in implementing multiple cropping systems. Kandhla block, with cultivated area of 8,589 hectares, achieved the highest cropping intensity of 175% due to superior irrigation infrastructure and the adoption of high-yielding crop varieties. Thana Bhawan, Shamli, and Kairana blocks maintained elevated cropping intensities of 170%, 159%, and 168% respectively, demonstrating efficient agricultural land management and enhanced productivity.

Rural areas collectively recorded a gross sown area of 154,781 hectares and a net sown area of 101,823 hectares, achieving a cropping intensity of 65%. This indicates substantial adoption of double or multiple-cropping strategies. Urban zones, despite contributing 4,283 hectares of net sown area, demonstrated a high cropping intensity of 350%.

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Table 5.4: Cropping Intensity of Shamli District: 2010

Block	2020-2021		
	Gross Sown Area	Net Sown Area	Cropping Intensity
Uun	45871	36610	**125**
Thana Bhawan	30673	18010	**170**
Shamli	29082	18244	**159**
Kairana	34152	20370	**168**
Kandhla	15003	8589	**175**
Total Rural	154781	101823	**152**
Total Urban	14983	4283	**350**
Total District	169764	106106	**160**

(Source: District Statistical Book,) https://updes.up.nic.in/spideradmin/ Hpage1.jsp

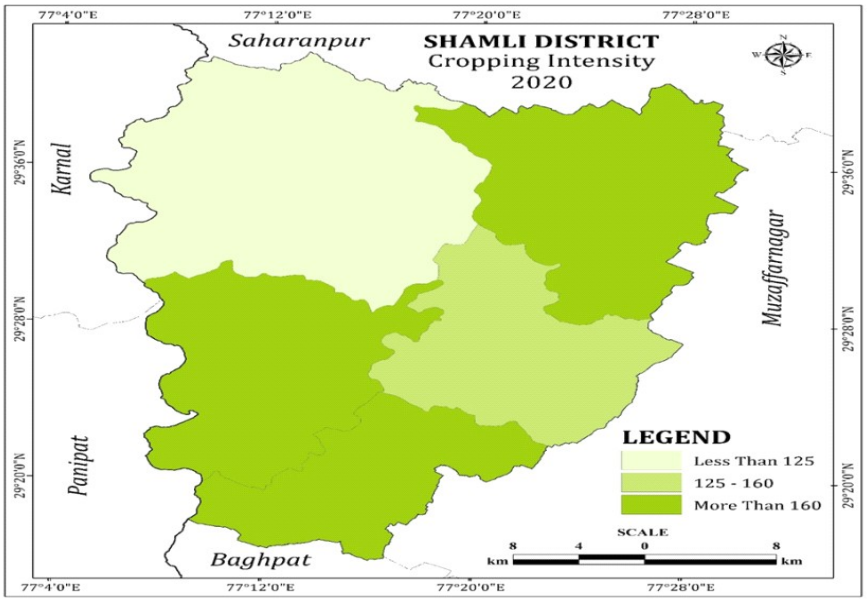

Figure 5.3: Cropping Intensity, 2010

5.1.2 Agricultural Productivity

Agricultural productivity is a tool for assessing production efficiency and resource utilisation in farming systems. Common measurements include yield per hectare, Total Factor Productivity (TFP), which evaluates the ratio of total output to combined inputs, and the Crop Yield Index for temporal and spatial comparisons. The evolution of productivity measurement methodologies reflects increasing

analytical sophistication. Kendall (1939) pioneered the Ranking Coefficient Method, subsequently adapted by Shafi (1960) for Indian conditions.

Agricultural Productivity: 2010

The primary crops grown in Shamli are rice, wheat, barley, maize, pulses, oilseeds, sugarcane, and vegetables. Block-level productivity analysis revealed significant spatial variations and agronomic importance of these crops across the district. Wheat demonstrated the highest cereal productivity, with yields varying from 33.81 quintals per hectare in Kandhla to 36.23 q/ha in Kairana. The district's average wheat yield of 34.41 q/ha reflected intensive farming practices and favourable agro-climatic conditions.

Rice, showed highest productivity of 28.49 q/ha in the Shamli block, whereas Kandhla recorded the lowest at 24.03 q/ha. Barley showed moderate variability with a district mean of 22.85 q/ha, peaking at 25.21 q/ha in the Unn block. Maize, though less prominent, showed considerable spatial variation, ranging from 7.62 q/ha in Kandhla to 13.95 q/ha in Kairana, suggesting differences in input application and soil suitability. Pulse crops performed well in Shamli and Thana Bhawan blocks, achieving yields above 7 q/ha. Oilseed productivity remained moderate with Unn and Thana Bhawan registering superior yields of 13.21 and 14.04 q/ha, respectively, reflecting enhanced agronomic practices and favourable soil conditions. Sugarcane, a valuable commercial crop, exhibited exceptionally high productivity across the district, ranging from 690.97 q/ha in Shamli to 722.41 q/ha in Kairana. Vegetable production maintained consistently high yields across blocks, with Unn achieving 253.86 q/ha, demonstrating the region's shift toward diversification. Shamli's agricultural profile in 2010 was diversified and productive, integrating subsistence and commercial farming to support livelihoods and enhance regional food security.

Table 5.6: Productivity of Major Crops (Quintal/Hectare): 2010

Block	Rice	Wheat	Barley	Maise	Pulses	Oilseeds	Sugarcane	Vegetables
Uun	25.07	35.51	25.21	12.07	6.02	13.21	710.37	253.86
Thana Bhawan	26.1	33.91	23.27	8.37	7.09	14.04	712.58	251.65
Shamli	28.49	35.32	20.11	11.73	7.11	12.17	690.97	251.63
Kairana	25.16	36.23	21.24	13.95	5.97	9.05	722.41	249.98
Kandhla	24.03	33.81	23.18	7.62	4.08	9.27	698.56	238.22
Total Rural	**25.77**	**34.96**	**22.60**	**10.75**	**6.05**	**11.55**	**706.98**	**249.07**
Total Urban	**27.63**	**31.13**	**24.35**	**9.08**	**3.29**	**8.17**	**674.38**	**241.02**
Total District	**26.04**	**34.41**	**22.85**	**10.51**	**5.66**	**11.07**	**702.32**	**247.92**

(Source: Computed by Authors)

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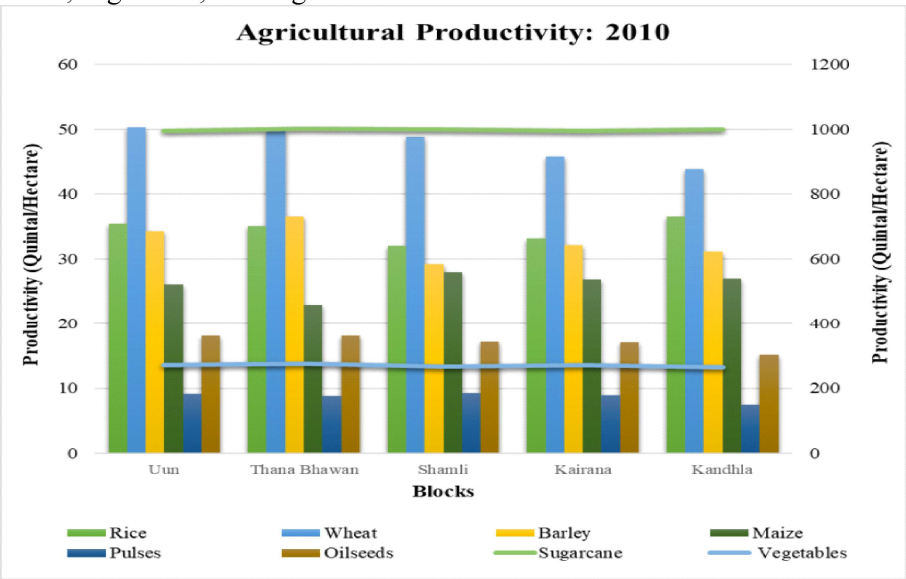
Figure 5.5: Agricultural Productivity: 2010

Agricultural Productivity: 2020

The agricultural productivity pattern of major crops in Shamli district for 2020 reveals notable inter-block disparities that reflect varying agro-ecological conditions, land-use intensity, and the utilisation of agrarian inputs. The analysis considers key food and cash crops, including rice, wheat, barley, maize, pulses, oilseeds, sugarcane, and vegetables.



Rice productivity in Shamli district averaged 26.04 quintals/hectare, with the highest yield reported from the Shamli block (28.49 q/ha), indicative of favourable irrigation infrastructure and improved seed usage. Other blocks, such as Thana Bhawan (26.10 q/ha) and Uun (25.07 q/ha), also demonstrated above-average yields. Wheat, the most prominent rabi crop, yielded an average of 34.41 q/ha, with Kairana (36.23 q/ha) leading in productivity, followed by Uun (35.51 q/ha) and Shamli (35.32 q/ha). In the case of barley, productivity was highest in Uun (25.21 q/ha), and lowest in Shamli (20.11 q/ha), with the district averaging 22.85 q/ha. Maise yields demonstrated considerable variation, with Kairana recording the highest (13.95 q/ha), suggesting better soil fertility and hybrid seed adoption, while Kandhla lagged (7.62 q/ha). The district average stood at 10.51 q/ha.

Pulse crops reported modest yields. Thana Bhawan and Shamli emerged as relatively productive zones with yields exceeding 7 q/ha, while Kandhla remained the least productive at 4.08 q/ha, contributing to a district average of 5.66 q/ha. In

the oilseeds category, productivity was highest in Thana Bhawan (14.04 q/ha), followed by Uun (13.21 q/ha), whereas Kairana and Kandhla recorded lower yields, resulting in a district average of 11.07 q/ha.

Sugarcane, showed high productivity across all blocks. Kairana registered the highest at 722.41 q/ha, while the district average was 702.32 q/ha, indicating intensive cultivation and favourable agronomic conditions. Vegetable crops, recorded substantial yields, with Uun (253.86 q/ha) and Thana Bhawan (251.65 q/ha) leading, resulting in a district average of 247.92 q/ha. While crops like wheat and sugarcane show high and stable productivity across most blocks, pulses, maize, and oilseeds exhibit significant variability.

Table 5.7: Productivity of Major Crops (Quintal/Hectare): 2020

Block	Rice	Wheat	Barley	Maise	Pulses	Oilseeds	Sugarcane	Vegetables
Uun	25.07	35.51	25.21	12.07	6.02	13.21	710.37	253.86
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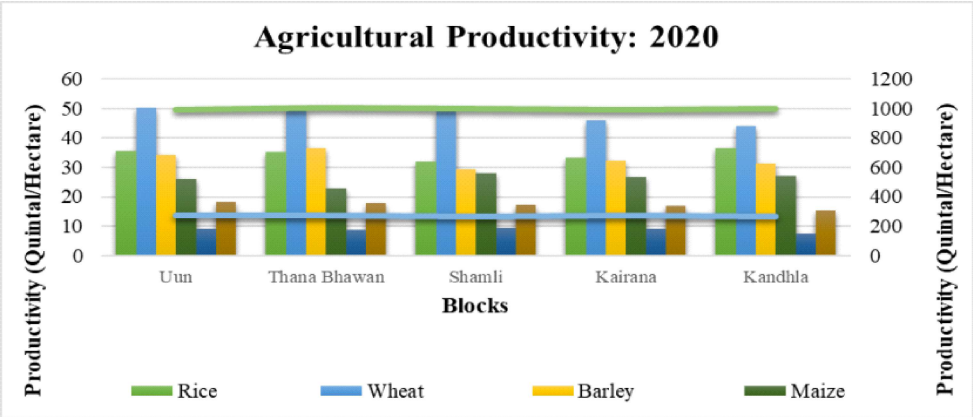
(Source: Computed by Authors)

Figure 5.6: Agricultural Productivity: 2020



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The agricultural transformation of Shamli district between 2010 and 2020 illustrates a multifaceted evolution shaped by environmental endowments, technological progress, policy support, and market dynamics. Sugarcane dominates Shamli's agricultural landscape, commanding the largest cultivated area. This prominence stems from fertile alluvial soils, reliable irrigation via canals and tubewells, proximity to sugar-processing facilities, and robust market demand. Sugarcane cultivation has stimulated agro-industrial growth, particularly sugar mills and jaggery production, generating substantial employment and income opportunities.

Concurrently, food grain production, especially wheat and rice, expanded significantly in both cultivation area and productivity. Wheat yields increased dramatically from 34.41 quintals per hectare in 2010 to 47.59 q/ha in 2020, while rice productivity rose from 26.04 to 34.14 q/ha. These improvements resulted from enhanced irrigation infrastructure, agricultural mechanisation, and widespread adoption of high-yielding varieties. The growth in vegetable and horticultural production reflects strengthened market integration and rising consumer demand, particularly from proximate urban centres like Delhi.

Cropping intensity, a critical indicator of land-use efficiency, increased substantially from 149% in 2010 to 160% in 2020, reflecting the widespread adoption of multiple cropping systems facilitated by dependable irrigation and enhanced farmer awareness.

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