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Agricultural Geography of Haryana: Crop Pattern, Irrigation and Impact of Climate Change

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Abstract

Agriculture forms the backbone of Haryana's economy and landscape, engaging a large share of its workforce and shaping the state's distinctive rice-wheat cropping system. This paper presents a geographical analysis of the crop pattern, irrigation base, and emerging climate change impacts across the state. Haryana, often described as the 'wheat basket and rice bowl' of India, contributes substantially to the national foodgrain pool, with wheat and paddy together occupying about two-thirds of its gross cropped area. The study examines the spatial arrangement of major kharif and rabi crops in relation to soil, rainfall, and irrigation availability, and documents the central role of canal and tube-well irrigation, which together cover roughly three-fourths of the net sown area. The paper further reviews scientific evidence on rising temperatures, shifting rainfall patterns, and increasingly frequent heat waves and their measurable effect on wheat and rice yields, with studies indicating yield reductions of the order of 10 to 35 per cent under recent heat-wave conditions and further declines projected by mid-century. The paper concludes by underlining the need for crop diversification, heat- and water-stress-resilient varieties, and climate-smart agronomic practices to sustain Haryana's agricultural productivity in a changing climate.

Keywords: Haryana, agricultural geography, crop pattern, irrigation, climate change, wheat, rice, crop diversification

1. Introduction

Haryana is one of India's most agriculturally advanced states, and agriculture continues to be the principal source of livelihood for a large proportion of its population, with allied activities engaging a majority of the rural workforce directly or indirectly. Located in the Indo-Gangetic plain, the state benefits from fertile alluvial soils, an extensive canal network fed by the Yamuna and Bhakra systems, and a dense grid of tube wells, all of which together have made intensive, high-input agriculture possible even in its semi-arid western tracts.

The agricultural landscape of Haryana was transformed by the Green Revolution of the late 1960s, which introduced high-yielding varieties of wheat and rice, chemical fertilisers, and assured irrigation. Chaudhary Charan Singh Haryana Agricultural University at Hisar, one of Asia's largest agricultural universities, played a central role in this transformation. Consequently, the state today ranks among the leading contributors to the country's central foodgrain pool, with a large share of its cropped area devoted to the wheat-paddy rotation.

However, this very success has created new geographical challenges. The rice-wheat system is water- and energy-intensive, and its continuation under conditions of a changing climate —

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marked by rising mean and maximum temperatures, erratic rainfall, and more frequent heat waves — now threatens the long-term stability of yields. This paper examines (i) the spatial pattern of crop distribution in Haryana, (ii) the structure and coverage of irrigation, and (iii) the documented and projected impacts of climate change on the state's major crops, drawing on government statistics and published research to assess the geographical dimensions of these interlinked themes.

2. Cropping Pattern of Haryana

Cropping in Haryana is organised around two principal seasons. The kharif season (sown in June-July, harvested by October-November) is dominated by paddy, bajra (pearl millet), maize, cotton, sugarcane, and groundnut, while the rabi season (sown in October-November, harvested in March-April) is dominated by wheat, gram, mustard, and barley. Wheat and paddy together account for close to two-thirds of the state's gross cropped area, a concentration that reflects both the profitability of these crops under the minimum support price regime and the reliability of irrigation in the northern and central districts.

There is, however, a clear regional differentiation in cropping choices. The north-eastern and central plains, with higher rainfall and assured canal irrigation, are best suited to the rice-wheat rotation and are also known for high-quality Basmati rice cultivation. The south-western semi-arid tract, by contrast, is more suited to bajra, mustard, gram, and cluster bean, along with arid horticulture, owing to lower and more erratic rainfall and deeper groundwater. Cotton is concentrated in the southern and western districts, while sugarcane is more prominent in the northern districts bordering Uttar Pradesh and Uttarakhand.

Table 1: Major Crops of Haryana by Season and Region

Season	Major Crops	Predominant Region	Sowing–Harvesting Period
Kharif	Paddy (including Basmati), bajra, maize, cotton, sugarcane, groundnut	North-eastern & central plains (paddy); south-western tract (bajra, cotton)	June–July to October–November
Rabi	Wheat, gram, mustard (rapeseed), barley	State-wide (wheat); south-west and rain-fed tracts (mustard, gram)	October–November to March–April
Cash / Horticultural	Sugarcane, vegetables (potato, onion, tomato,	Northern districts (sugarcane); peri-urban	Year-round, crop-specific

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	cauliflower), kinnow, guava	belts (vegetables); south-west (kinnow, guava)	

Source: Compiled by author from SLBC Haryana Agriculture Profile, Ministry of Food Processing Industries State Profile-Haryana (2025), and Directorate of Economics and Statistics, Government of Haryana.

3. Irrigation Base of Haryana Agriculture

Irrigation is the foundation of Haryana's intensive cropping system. About three-fourths of the net sown area of the state is irrigated, through a combination of canal water and tube wells, making Haryana one of the most irrigation-intensive states in India. Roughly two-thirds of the state enjoys assured irrigation, which is best suited to the rice-wheat system, while the remaining rain-fed tracts, concentrated in the south and south-west, are more suited to pearl millet, mustard, and cluster bean, along with agro-forestry and arid horticulture.

Over recent decades, the share of groundwater in total irrigation has risen steadily relative to canal water, driven by subsidised agricultural electricity and the relative unreliability of canal supply at the tail end of commands. This shift has had two important geographical consequences: waterlogging and salinity in over-irrigated canal-command districts of the north and east, and rapid groundwater depletion in the tube-well-dependent districts of the south and south-west, a pattern that has direct implications for the long-term sustainability of the wheat-paddy system in those areas.

Table 2: Irrigation Sources and Coverage in Haryana

Irrigation Source	Approximate Share / Coverage	Associated Geographical Pattern
Canal irrigation (Western Yamuna Canal, Bhakra system, lift canals)	Historically the larger source; declining share of total irrigated area over recent decades	Concentrated in north-eastern and central plains; risk of waterlogging and salinity in over-irrigated tracts
Tube-well / groundwater irrigation	Now the dominant source, exceeding canal-irrigated area	Widespread across the state; heaviest reliance in southern and south-western districts
Rain-fed / unirrigated cultivation	About one-fifth to one-fourth of net sown area	Concentrated in Mahendragarh, Bhiwani, Charkhi Dadri and adjoining semi-arid tracts; suited to bajra, mustard, gram

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Source: Compiled by author from SLBC Haryana Agriculture Profile and Haryana Water Resources Authority reports.

4. Impact of Climate Change on Agriculture

A growing body of research documents a discernible warming trend in Haryana, particularly in maximum temperatures during the post-rainy and rabi seasons, along with increasingly erratic rainfall. These changes bear most heavily on wheat, which is highly sensitive to heat during its grain-filling stage, and on rice, which is sensitive to both temperature extremes and water availability during the kharif season. Key documented and projected impacts include:

- Short exposure of wheat crops to temperatures of 28°C to 32°C during critical growth stages has been found to reduce yields by 20 per cent or more, according to studies referenced by the Haryana State Action Plan on Climate Change.
- Recent heat waves, such as the one in March 2022 that coincided with the wheat grain-filling stage, have been associated with an estimated 10 to 35 per cent reduction in wheat yields across Punjab, Haryana, and Uttar Pradesh.
- Long-term projections suggest major crop yields in Haryana could decline by 4.5 to 9 per cent over the period 2010–2039 due to climate change, with mean maximum temperature projected to rise by about 1.3°C and minimum temperature by about 2.1°C by 2050.
- Farmer perception surveys corroborate these findings, reporting delayed crop maturity, increased irrigation requirements, and a rise in pest and disease incidence linked to terminal heat, erratic rainfall, and wind and hailstorm events.
- Indirect impacts operate through reduced water availability for irrigation, as rising temperatures increase crop water demand even as groundwater resources in several districts are already over-exploited.
- While a rise in minimum temperature has in some cases had a mildly favourable effect on certain crop yields, this has not been sufficient to offset the damage caused by rising maximum temperatures and heat extremes.

Table 3: Documented and Projected Climate Change Impacts on Haryana's Major Crops

Climate Stress	Crop(s) Most Affected	Observed / Projected Impact
Terminal heat / heat waves during grain filling (Feb–March)	Wheat	Yield reduction of roughly 10–35% in recent heat-wave years (e.g., March 2022); up to 20%+ under short exposure to 28–32°C

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Rising mean and maximum temperature (long-term trend)	Wheat, rice, other rabi crops	Projected 4.5–9% decline in major crop yields over 2010–2039; further mean-temperature rise of 1.3–2.1°C anticipated by 2050
High temperature during flowering stage	Cotton	Reduced boll formation and output under heat stress during the flowering period
Erratic rainfall, windstorms, hailstorms, fog	Wheat, mustard, vegetables	Delayed maturity, lodging damage, and yield losses linked to severe weather events near harvest
Reduced irrigation water availability (indirect effect)	Rice, wheat (irrigation-dependent tracts)	Compounding effect of groundwater depletion with rising crop water demand in over-exploited districts

Source: Compiled by author from Haryana State Action Plan on Climate Change (HSAPCC, 2011), Mongabay-India (2022), and peer-reviewed studies on climate change and wheat/rice productivity in Haryana.

5. Adaptation Strategies and the Way Forward

In response to these mounting pressures, agricultural planners and researchers have proposed several adaptation measures for Haryana. These include diversification away from the water- and energy-intensive paddy-wheat rotation towards less water-demanding crops such as maize, pulses, and oilseeds, particularly in groundwater-stressed districts; wider adoption of heat- and drought-tolerant crop varieties developed by institutions such as Chaudhary Charan Singh Haryana Agricultural University; adjustment of sowing windows to help crops avoid the most damaging periods of terminal heat; and expansion of micro-irrigation (drip and sprinkler systems) to improve water-use efficiency under both current and future climatic conditions.

State-level schemes such as 'Mera Pani, Meri Virasat', which incentivises farmers to shift away from paddy cultivation, and ongoing efforts to improve canal efficiency and groundwater recharge through the Atal Bhujal Yojana, represent important steps in this direction. Geographically informed planning — one that matches crop choice and irrigation investment to the specific agro-climatic conditions of each region rather than applying uniform state-wide policies — will be essential if Haryana's agriculture is to remain both productive and resilient in the face of a changing climate.

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Map 1: Location of the Study Area

Study Area

The present study is based on Haryana, one of the agriculturally advanced states of north-western India. Haryana is located in the Indo-Gangetic plain and is known for its fertile alluvial soils, intensive agriculture, and well-developed irrigation system. Agriculture forms the backbone of the state's economy and provides livelihood support to a large share of the rural population. Due to its high agricultural productivity, Haryana is often described as the "wheat basket and rice bowl" of India. Wheat and paddy together occupy a major share of the gross cropped area and play an important role in the national foodgrain supply. The agricultural landscape of Haryana has been shaped by the Green Revolution, which introduced high-yielding varieties of wheat and rice, chemical fertilisers, mechanised farming and assured irrigation. The state has an extensive irrigation network supported by the Yamuna and Bhakra

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canal systems, along with a dense network of tube wells. This irrigation base has made intensive crop cultivation possible even in semi-arid western and south-western parts of the state. About three-fourths of the net sown area is irrigated through canals and groundwater sources, making Haryana one of the most irrigation-intensive states of India.

Physiographically and agriculturally, Haryana shows clear regional variation. The north-eastern and central plains have comparatively better rainfall and assured canal irrigation, making them suitable for the rice-wheat cropping system and Basmati rice cultivation. Districts such as Karnal, Kurukshetra, Panipat, Ambala and Yamunanagar are important for paddy and wheat production. The south-western semi-arid tract, including Bhiwani, Mahendragarh, Charkhi Dadri and adjoining areas, receives lower and more irregular rainfall; therefore, crops such as bajra, mustard, gram and cluster bean are more suitable in this region. Cotton is mainly concentrated in the southern and western districts, while sugarcane is more prominent in the northern districts.

Haryana is also an important study area because its agriculture is facing new environmental and climatic challenges. Rising temperatures, erratic rainfall, frequent heat waves and increasing groundwater stress are affecting the productivity of major crops, especially wheat and rice. The rice-wheat system, though highly productive, is water- and energy-intensive and has increased pressure on groundwater resources. Therefore, the study area provides a suitable geographical setting for examining crop pattern, irrigation structure and the impact of climate change on agricultural sustainability. Thus, Haryana has been selected as the study area because it represents a highly productive but environmentally vulnerable agricultural region. Its diverse cropping pattern, regional variation in irrigation availability, dependence on wheat-paddy rotation and growing climate-related risks make it an important area for the geographical study of agriculture, irrigation and climate change.

6. Conclusion

Haryana's agricultural geography reflects a finely tuned but increasingly strained balance between soil, water, and climate. The dominance of the wheat-paddy system, sustained by extensive canal and tube-well irrigation, has enabled the state to become one of India's leading foodgrain producers, but the same system has heightened vulnerability to rising temperatures, heat waves, and water stress. Evidence reviewed in this paper shows that climate change is already measurably affecting wheat and rice yields in the state, and that these impacts are projected to intensify in the coming decades.

A geographical perspective — one attentive to the spatial variation in soils, rainfall, irrigation access, and groundwater stress across Haryana's districts — is essential for designing region-specific strategies of crop diversification, water-use efficiency, and climate adaptation. Sustained investment in climate-resilient varieties, efficient irrigation technology, and diversification incentives, combined with continued monitoring of climatic trends, will be critical to safeguarding the productivity and sustainability of agriculture in Haryana.

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