The Influence of Landforms and Slope on Agricultural Cropping Patterns in Chhatrapati Sambhajinagar District

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DOI: https://doi.org/10.51244/IJRSI.2025.120800266

Received: 22 Sep 2025; Accepted: 28 Sep 2025; Published: 04 October 2025

ABSTRACT

This study investigates the significant impact of landforms and slope on agricultural cropping patterns in Chhatrapati Sambhajinagar District, Maharashtra. Employing a mixed-methods approach, combining geospatial analysis and field observations, the research reveals a strong correlation between the district's diverse topography and its agricultural productivity. The fertile, flat plains of the Godavari basin, supported by robust irrigation systems, are predominantly utilized for water-intensive crops such as sugarcane and cotton. In contrast, the hilly and undulating terrains in the northern and western regions, characterized by steeper slopes and thinner soils, are better suited for drought-resistant crops like bajra and various pulses. The findings underscore the critical role of geomorphological factors in shaping agricultural practices and highlight the need for tailored, sustainable strategies that align with the local landscape. By integrating these insights, the study advocates for enhanced agricultural planning to ensure long-term food security and environmental sustainability in the region.

Keywords: Landforms; Slope; Cropping Patterns; Geospatial Analysis; Agricultural Practices; Sustainable Agriculture; Deccan Plateau

INTRODUCTION

Agriculture in India has always been deeply influenced by the physical environment, with landforms and slope acting as decisive factors in shaping cropping patterns. Chhatrapati Sambhajinagar district, situated on the Deccan Plateau of Maharashtra, provides an ideal setting to study this relationship due to its marked geomorphological diversity. The district encompasses fertile river basins formed by the Godavari and its tributaries, alongside the rugged and elevated terrain of the Satmala and Ajanta ranges. Such contrasts in topography create distinct agricultural zones, where the choice of crops and farming practices are closely aligned with land characteristics.

Landforms and slope are not merely background features; they significantly determine soil depth, erosion susceptibility, water retention, and the scope for irrigation and mechanisation. For instance, the flat plains facilitate intensive cultivation of high-water-demand crops such as sugarcane and cotton, supported by canal and well irrigation. In contrast, the hilly and undulating northern and western parts, with shallower soils and steeper gradients, are more suited for hardy, drought-resistant crops like bajra and pulses.

Despite the district's substantial agricultural output, limited scholarly attention has been directed towards systematically analysing how geomorphological conditions influence crop distribution. Understanding these relationships is crucial in the context of sustainable agriculture, as it helps optimise land use while preserving ecological balance. This paper seeks to bridge this gap by employing geospatial analysis and field-based observations to examine how landforms and slope govern agricultural patterns across Chhatrapati Sambhajinagar district, with implications for long-term food security and resource management.

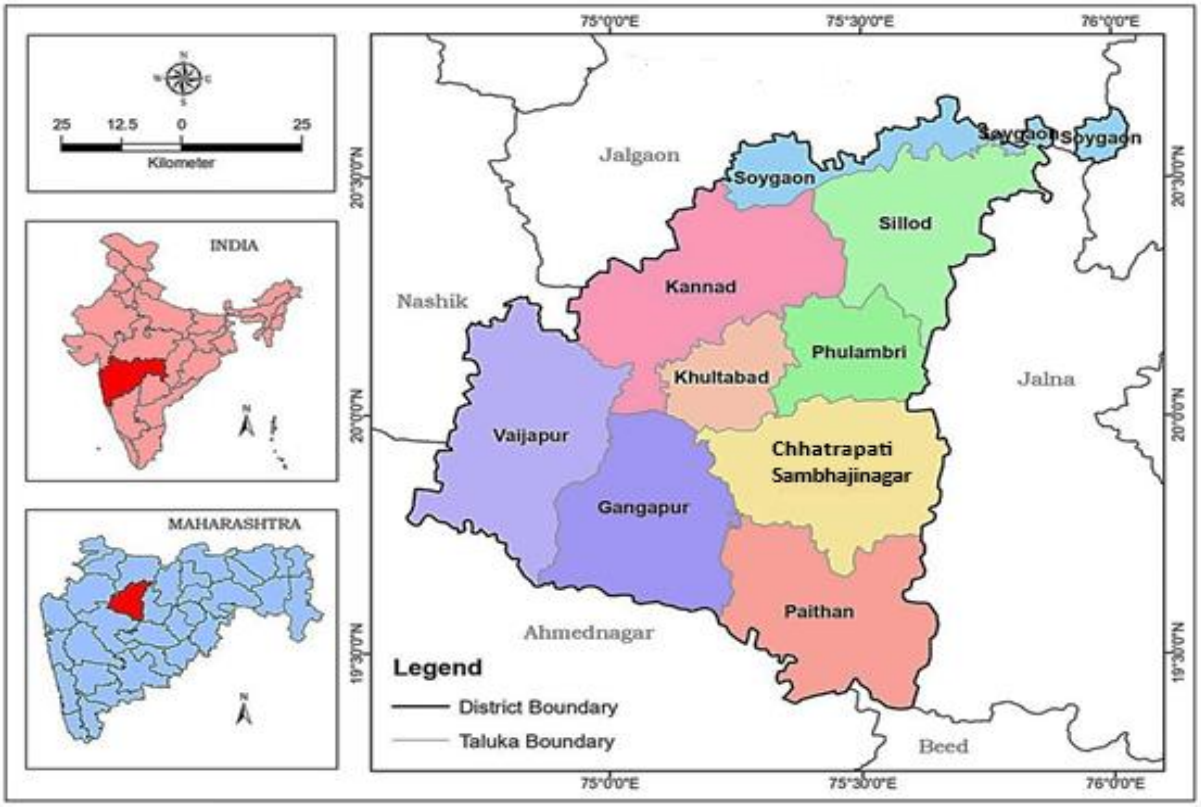
ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IX September 2025

Study Area

Chhatrapati Sambhajinagar district, located in the central part of the state, is an elevated land that has been incised by the Godavari River and its tributaries in the southern part. Except for a little part in the north and north-west, it belongs to the Tapi drainage. The entire district is in the Godavari basin. The Sambhajinagar district measures between $19^0$53' north to $20^0$40' north latitude and $74^0$39' east to $76^0$40' east longitudes. It is bounded by the Jalna district to the east. Nashik district to the west, Ahmednagar district to the southwest, and Jalgaon district to the north. It also has small boundaries with the Buldhana district in the north-east and the Beed district in the south.

Chh. Sambhajinagar district covers an area of 10,100 km2, out of which 37.55% is urban and 62.45% is rural, and it accounts for 3.28 percent. As per the recommendations of the Sukhtnor committee of the district, Chhatrapati Sambhajinagar, Gangapur, Kannad, Paithan, Khultabad, and Vaijapur are included in the drought zone.

The study area consists of nine tahsils, viz. Chhatrapati Sambhajinagar, Khultabad Kannad, Soygaon, Sillod, Paithan, Gangapur, Vaijapur, and Phulambri.



Location Map of Chhatrapati Sambhajinagar District:

METHODOLOGY

This research uses a combined-methods technique. Geospatial evaluation was used to overlay a virtual elevation model (DEM) of Sambhajinagar district with land use and cropping sample maps. This allowed for the spatial correlation of topographical capabilities with specific agricultural activities. Field surveys and farmer interviews had been performed in selected villages representing special landform regions (e.g., flat plains close to Paithan and hilly areas near Kannad) to accumulate qualitative information on farming practices and crop alternatives.

Physiography

The district is in the eastern part of Maharashtra. The district may be broadly grouped into two physical

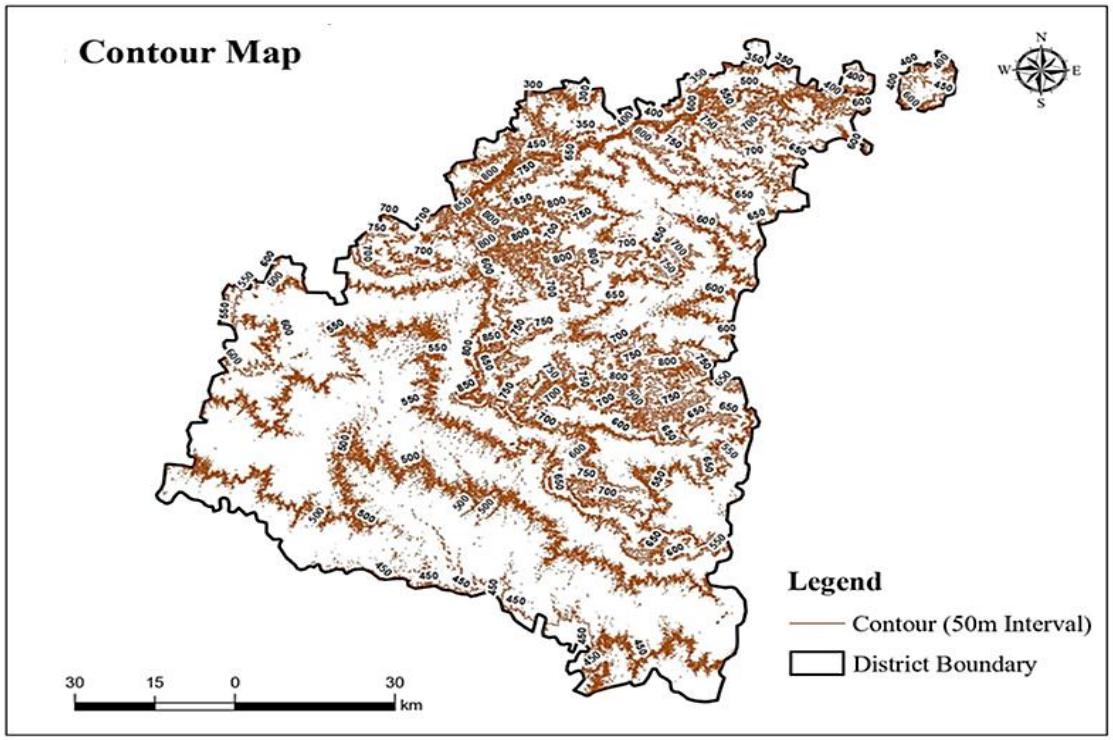
ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IX September 2025

regions 1. One of the Godavari basin and 2. The Ajanta plateaus and Ajantha plateaus are divided as I) Ajanta range, II) Sillod plateau, III) Ellora Hills, and IV) Chh. Sambhajinagar plateau.

Chh. Sambhajinagar district has diversity in the prospective southern part of the district, normally reaching 520 to 575 meters high from sea level, and 580 to 680 meters high in the northern part of the district. The Northern border of the district goes to the Sahyadri branches.

Sahyadri mountain from Maharashtra goes into Satmala and Ajintha ranges, and a subpart of it ranges are known as the hills of Chowka, Satmala Mountain Hills, the mountains of Daulatabad, the hills of Verul (Ellora), and some mountain has peaks with their height from sea level Mhaismal 913 m, Sirsala 840 m, Antar 820 m, Satoda 552, Abbasgad 671 m., and Ajintha 575m, and the famous hill station of Sambhajinagardistrict are Khultabad and Mhaismal. Geographically, Sambhajinagardistrict is divided into the plateau region, the ground, the hills region, and the rivers. All mountains are on average at a height of 600 to 950 m above sea level, and the plateau region is formed by igneous rocks of 460 to 600 m. high above sea level. It has a slope from west to east.

Contour Map:



A contour map uses lines to represent points of equal elevation above sea level. This specific map shows the elevation of the district in 50-meter intervals. The closer the lines are to each other, the steeper the slope, while lines that are far apart indicate a flatter terrain.

High-Elevation Areas: The map shows a high density of contour lines in the northern and western parts of the district. This indicates a mountainous or hilly terrain with steep slopes. The contour lines in these areas reach high elevation numbers, often above 800 meters, which aligns with the location of the Satmala and Ajanta hill ranges.

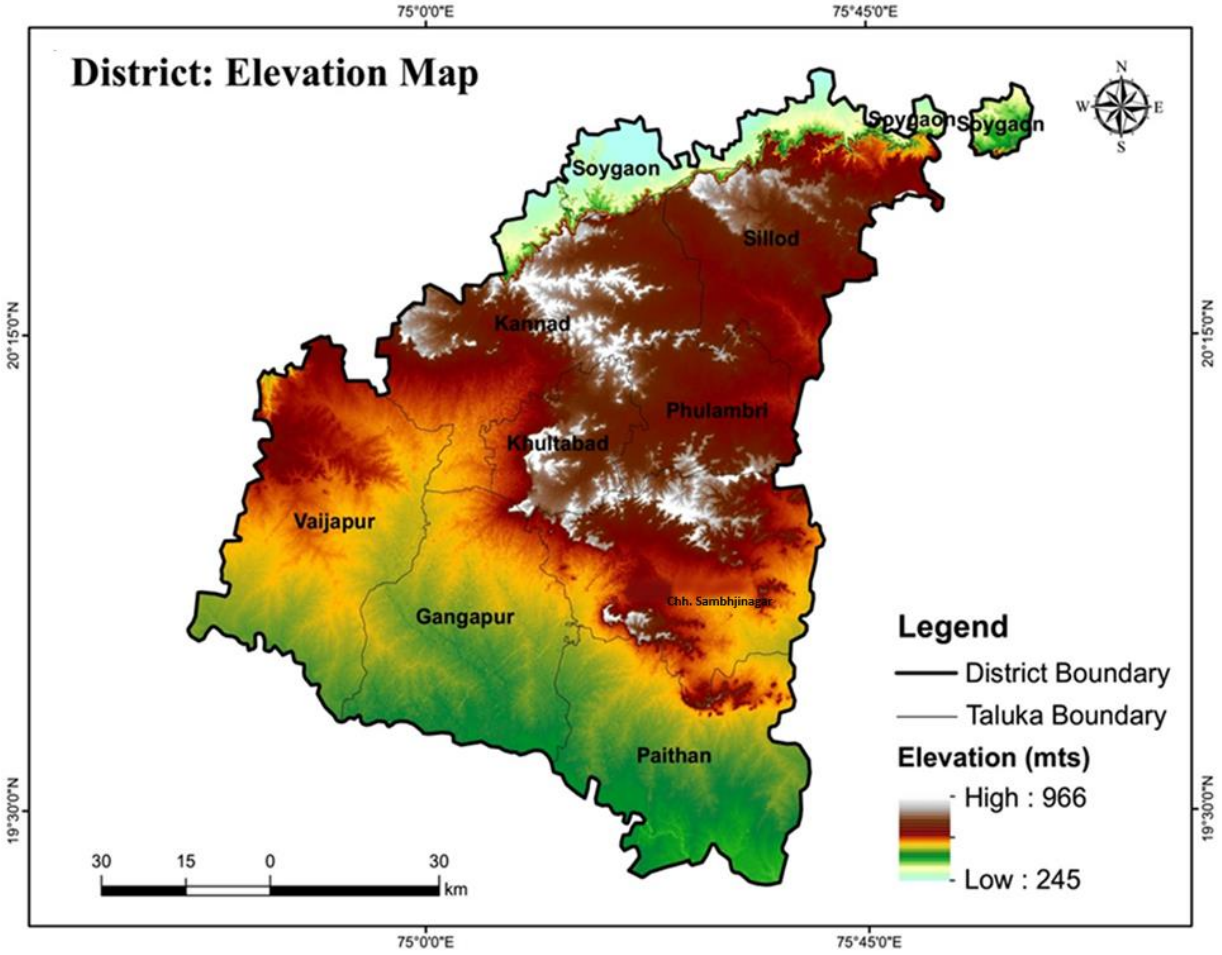
Low-Elevation Areas: The central and southern regions of the district are characterized by widely spaced contour lines, suggesting a relatively flat or gently sloping landscape. These areas have lower elevation numbers, typically ranging from 400 to 500 meters. This flat topography is indicative of the fertile plains of the Godavari basin.

Topographical Gradients: The map clearly visualizes the gradient of the land. The terrain becomes progressively steeper as you move from the central plains towards the northern and western hill ranges. This

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IX September 2025

topographical variation is a critical factor influencing the district's agricultural patterns, as demonstrated in the previous research abstract.

In essence, the contour map provides a detailed look at the physical landscape of the Chhatrapati Sambhajinagar district, highlighting the distinct division between the high-altitude, rugged hills and the low-lying, flat river basins.



Elevation Map:

This map is a visual representation of the land's height above sea level, with different colors indicating different elevations.

Legend and Elevation Range: The map's legend uses a color gradient to show elevation in meters. The lowest areas, marked in light green, are around 245 meters, while the highest points, shown in brown and white, reach up to 966 meters.

High-Elevation Areas: The map clearly shows that the highest elevations are concentrated in the northern and western parts of the district.

The talukas of Kannad, Soygaon, and Sillod in the north, and Vaijapur in the west, contain significant hilly and undulating terrain, represented by the deep brown and white color patches. This aligns with the fact that these areas are part of the Satmala and Ajanta hill ranges.

Low-Elevation Areas: The lowest elevations are found in the central and southern regions of the district.

The vast plains around Chhatrapati Sambhajinagar city, Gangapur, Paithan, and parts of Phulambri are depicted in various shades of green, indicating their relatively low and flat topography. These areas correspond to the fertile Godavari river basin.

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In summary, the map provides a clear visual understanding of the district's geomorphology. It distinctly illustrates the contrast between the high-altitude, hilly regions in the north and west and the low-lying, flat plains in the center and south, which is a key factor influencing agricultural practices and land use in the district.

Plane regions of Chh. Sambhajinagar district come in the Godavari basin, and the average height of the region is also 440 m above sea level. Some part of Vaijapur, Gangapur, Paithan tahsil is plain, but that of Sillod's Soygaons, Phulambri's, Khultabad's tahsil is hilly, and the remaining part is in the form of plain basins of Godavari, Purna, and Sukhna. Shivana is a fertile river. Godavari has an entrance in the Sambhajinagar district. It is called the southern Ganga, and Sambhajinagar is also called the river's land. This region lies to the west of the Ajantas mountain region and stretches all the way to the south. There are two parts of this region, the Godavari and Shivana valleys, and the second is the Tapi valley.

The Godavari and Shivana valleys lie to the south and west side of the Ajanta region. Kannad tahsil comes in the eastern part, and tahsils such as Gangapur and Vaijapur lie in this region entirely. The second part is the Tapi Valley region. The Tapi valley region lies north of the Ajintha mountain range, and some parts of Soygaon and Kannad tahasil fall within this region.

Influence of Landforms on Agriculture:

The district's agriculture can be divided into two primary zones based on landforms:

River Basins and Plains: The low-mendacity regions along the Godavari and its tributaries have deep, fertile black soils perfect for crops that require rich nutrients and adequate water. Those areas are hubs for high-yield, commercial plants like sugarcane and cotton. The flat terrain additionally permits the smooth use of tractors and other modern-day farm gadgets.

Hilly and Undulating regions: The northern and western components of the district, characterized by rugged terrain, have thin, rocky soils with poor water retention. Right here, agriculture is essentially rain-fed, specializing in hardy, low-enter plants like bajra, jowar, and pulses such as tur and gram. Those crops are nicely suited to dry conditions and require minimal soil preparation.

Influence of Slope:

Slope is an important element influencing both soil and water management.

Mild Slopes and Flatlands: In these areas, water runoff is slight, leading to higher soil moisture retention. This allows farmers to grow crops that require consistent watering and allows for the construction of irrigation channels and bore wells.

Steeper Slopes: On steeper slopes, speedy water runoff causes vast soil erosion, making the land less fertile. Farmers frequently practice contour farming or terracing to mitigate this. The crops grown right here commonly have deep root systems to anchor the soil and are tolerant of drier situations.

Crops cultivated according to landforms and slope in Chhatrapati Sambhajinagar district

Landform / Slope	Characteristics	Representative Talukas	Major Crops Cultivated
Flat Plains (Godavari Basin)	Deep black soils, fertile, gentle slope, high irrigation availability	Paithan, Gangapur, Vaijapur	Sugarcane, Cotton, Wheat, Vegetables (onion, tomato, brinjal)
Undulating Plains / Gentle Slopes	Moderately fertile soils, partial irrigation,	Chhatrapati Sambhajinagar,	Jowar (Sorghum), Soybean, Tur (Pigeon pea),

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IX September 2025

	prone to soil erosion	Phulambri, Khultabad	Maize, Sunflower
Hilly and Steep Slopes (Satmala & Ajanta Ranges)	Shallow soils, steep gradients, rainfed, low irrigation	Kannad, Soygaon, Sillod	Bajra (Pearl millet), Pulses (gram, mung, urad), Groundnut, Minor Millets

Flat Plane

Topography: Fertile alluvial and black cotton soils, gentle slope, good irrigation availability.

Sugarcane (water-intensive, grown under canal/well irrigation)

Cotton (Kharif season, suited to deep black soils)

Wheat (Rabi season, supported by irrigation)

Vegetables (tomato, onion, brinjal, etc., near market centres)

Undulating Plains / Gentle Slopes

Topography: Moderately fertile soils, partial irrigation, prone to waterlogging/erosion in places.

Major Crops:

Jowar (Sorghum)

Soybean

Tur (Red gram / Pigeon pea)

Maize

Sunflower (as oilseed crop)

Hilly and Steep Slopes (Satmala and Ajanta ranges)

Topography: Shallow soils, steep gradient, low irrigation, high erosion risk.

Major Crops:

Bajra (Pearl millet) – drought resistant

Pulses (gram, mung, urad)

Groundnut (in small patches)

Minor millets (occasionally grown in higher slopes)

CONCLUSION

This study has successfully demonstrated the profound influence of landforms and slope on agricultural cropping patterns in the Chhatrapati Sambhajinagar district of Maharashtra. By integrating geospatial analysis with field observations, the research confirms a clear and direct relationship between the district's varied topography and the cultivation of specific crops. The fertile, low-lying plains of the Godavari basin, with their deep black soils and gentle slopes, are the agricultural hub for water-intensive, high-yield commercial crops like sugarcane and cotton. In stark contrast, the rugged, hilly terrains of the northern and western regions,

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IX September 2025

characterized by steeper slopes and shallow soils, are better suited for traditional, drought-resistant millets and pulses.

The findings underscore that geomorphological factors are not merely incidental but are fundamental determinants of agricultural practice. By aligning cropping patterns with the natural landscape, farmers in the region have, over generations, developed a system that is both productive and adapted to the environmental conditions. The study's conclusions have significant implications for long-term agricultural planning, emphasizing the need for location-specific strategies that consider the unique topographical characteristics of each micro-region. Integrating these insights into agricultural policy can help optimize land use, enhance resource efficiency, and promote environmental sustainability, thereby securing the region's food supply for the future.

The analysis confirms that landforms and slope are primary drivers of agricultural cropping patterns in Sambhajinagar district. The dichotomy between the fertile, irrigated plains and the rain-fed, drought-inclined hills dictates which plants thrive in each region. To ensure the long-term sustainability of agriculture in the vicinity, destination guidelines should cognizance on promoting water-efficient farming in the plains and inspire the use of soil conservation techniques in hilly areas. This strategic alignment of farming practices with the herbal landscape is critical for environmental resilience and economic stability.

SUGGESTIONS

Land-Use Planning: Adopt landform-based crop zoning to guide farmers in selecting crops suitable for plains, slopes, and hilly terrains.

Soil and Water Conservation: Implement contour bunding, terracing, farm ponds, and watershed management in hilly regions to reduce erosion and enhance water retention.

Irrigation Development: Expand micro-irrigation techniques (drip and sprinkler) in undulating and hilly terrains to optimise scarce water resources.

Crop Diversification: Encourage pulses, oilseeds, and millets in dryland regions to improve soil health and reduce dependence on water-intensive crops.

Agroforestry and Horticulture: Promote tree-based farming (mango, custard apple, pomegranate) in slope areas to combine income generation with soil conservation.

Farmer Capacity Building: Conduct training on sustainable cropping practices, soil health management, and climate-resilient agriculture.

Policy Support: Government schemes should prioritise drought-prone talukas like Kannad, Soygaon, and Vaijapur with subsidies for rainwater harvesting, crop insurance, and soil treatment measures.

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