

ETHANOL PRODUCTION AND SPATIAL DISTRIBUTION OF SUGAR INDUSTRIES IN SOLAPUR DISTRICT: A GEOGRAPHICAL PERSPECTIVE

Mr. Kusumade A. S., Dr. Naiknaware B.S.

Ph.D Research Student, Department of Geography, K. B.P. Mahavidyalaya, Pandharpur

Professor and Head, Department of Geography, K. B.P. Mahavidyalaya, Pandharpur

Article Info	ABSTRACT
Article History: Received: 18th Sep 2025 Accepted: 02nd Oct 2025 Published: 17th Oct 2025 Keywords: Ethanol production, Sugar industry, Solapur district, Cooperative factories, Private factories, Irrigation, Spatial distribution, Agro-industries, Renewable energy, Regional disparities.	Ethanol production and the sugar industry together play a transformative role in India's agro-based economy. Sugar factories, traditionally engaged in processing sugarcane into sugar, have diversified into ethanol production by using sugarcane juice and molasses, thereby contributing to renewable energy under India's Ethanol Blending Programme. This dual role strengthens rural economies by ensuring farmer income, generating employment, and reducing dependence on fossil fuels. In this context, Solapur district of Maharashtra has emerged as a leading center of sugar and ethanol production despite its semi-arid climate and irregular rainfall. The present study, based on both primary data from field visits and secondary sources such as the Pradeshik Sakhar Sahsanchalak Karyalaya and the District Socio-Economic Abstract (2023-24), analyzes the temporal growth of ethanol production between 2018-19 and 2022-23 and examines the spatial distribution of sugar industries in 2023-24. The results show that ethanol production increased from 930 KLPD in 2018-19 to 1140 KLPD in 2022-23, with recovery rates improving from 10.2% to 10.5%. High production years coincided with good monsoons and strong cooperative and private sector participation, while 2019-20 recorded the lowest production (660 KLPD, 8.28% recovery) due to drought. Spatially, the district's 38 sugar factories are unevenly distributed: Karmala, Malshiras, and Pandharpur (5 each) form high-concentration zones supported by canal irrigation and fertile black soils, whereas drought-prone Akkalkot and Sangola lag behind with only one unit each. The study concludes that Solapur's sugar and ethanol industries are vital drivers of agro-industrial growth, renewable energy generation, and rural development. However, the uneven geographical distribution reflects the dominance of irrigation facilities, soil fertility, and cooperative strength, pointing to the need for policy interventions to balance industrial growth across drought-prone tehsils.

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INTRODUCTION

The sugar industry forms the backbone of Solapur district's agro-based economy, shaping agricultural practices, industrial growth, and rural livelihoods. Situated in the semi-arid zone of Maharashtra, Solapur has long faced challenges of low and uncertain rainfall, yet the expansion of irrigation networks such as the Ujani, Neera, and Sina projects has encouraged large-scale sugarcane cultivation. This agricultural base has fostered the rise of cooperative and private sugar factories which not only process sugar but also contribute to industrial diversification through ethanol production. Ethanol, derived from sugarcane juice and molasses, has acquired national importance under India's Ethanol Blending Programme as a renewable fuel that reduces dependence on fossil energy and supports rural economies. In Solapur, ethanol production has steadily increased between 2018–19 and 2022–23, rising from 930 KLPD to 1140 KLPD, along with improved recovery rates. This growth reflects the combined role of cooperative initiatives, private sector participation, favorable policies, and the resilience of farmers in maintaining sugarcane supply despite climatic uncertainties. Simultaneously, the spatial distribution of sugar industries across Solapur's eleven tehsils highlights significant geographical disparities. Tehsils like Karmala, Malshiras, and Pandharpur, endowed with fertile black soils and assured irrigation, have emerged as high-concentration sugar industry zones, each with five factories, while drought-prone areas such as Sangola and Akkalkot remain at the lower end with just one factory each. This uneven spread demonstrates the influence of irrigation facilities, soil fertility, and cropping patterns on industrial growth and regional development. Thus, studying ethanol production and the spatial distribution of sugar industries in Solapur district from a geographical perspective is vital for understanding regional disparities, resource dependency, and the broader role of agro-industries in promoting rural socio-economic sustainability.

STUDY AREA

Solapur district, located in the southeastern part of Maharashtra, is a part of the semi-arid Deccan Plateau and is spread between 17°10' to 18°32' North latitude and 74°42' to 76°15' East longitude, covering an area of about 14,845 sq km. Administratively, the district is divided into eleven tehsils namely Akkalkot, Barshi, Karmala, Madha, Malshiras, Mangalvedha, Mohol, North Solapur, South Solapur, Sangola and Pandharpur. Solapur city serves as the district headquarters. Geographically, the district lies on a gently undulating basaltic plateau covered with fertile black cotton soil (Regur), which is particularly suitable for sugarcane cultivation in irrigated areas. The climate is semi-arid, with hot summers, low and irregular rainfall, and high evapotranspiration, while the average annual rainfall is between 500–700 mm, falling mainly during the southwest monsoon from June to September.

The drainage system of the district is supported by the Bhima, Sina, Maan, Nira and Sina rivers, as well as the Ujani dam on the Bhima river and the canal networks of the Nira and Sina rivers, which ensure water supply for agriculture. Agriculture is the backbone of the district's

economy, with sugarcane being the major irrigated crop, while jowar, bajra, pulses and oilseeds dominate the monsoon region. Industrially, Solapur has developed into a major sugar producing region with 38 sugar factories (2023–24), both cooperative and private, unevenly distributed across the tehsil. These factories not only process sugarcane but also contribute to renewable energy through ethanol production, which has become increasingly important under India's ethanol blending program. The sugar and ethanol industries in Solapur play a key role in providing employment, strengthening cooperative movements, ensuring market linkages for farmers, and contributing to energy security and rural socio-economic development.

LOCATION MAP

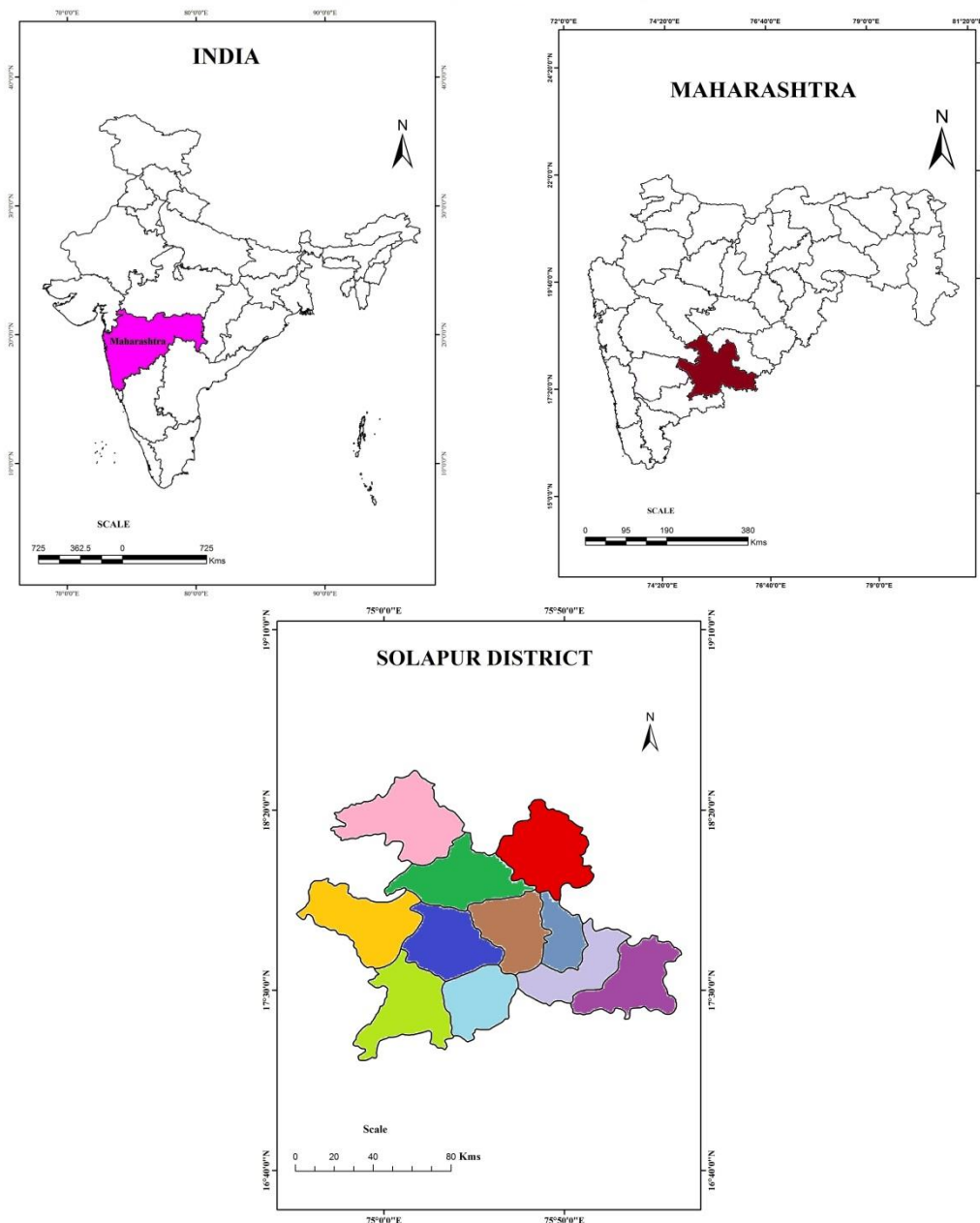


Fig. 1

OBJECTIVES

1. To analyze the temporal growth of ethanol production in Solapur district between 2018–19 and 2022–23.
2. To examine the role of cooperative and private sugar factories in ethanol production and industrial development.
3. To study the spatial distribution of sugar industries in Solapur district during 2023–24

DATA BASE AND METHODOLOGY

The present study on the ethanol production and distribution of sugar industries in Solapur district is based on both primary and secondary sources of data. Secondary data has been collected from official records such as the annual reports and statistical abstracts published by the *Pradeshik Sakhar Sahsanchalak Karyalaya, Solapur*, the *Socio-Economic Abstract of Solapur District (2023–24)*, and government publications from the Directorate of Economics and Statistics, Maharashtra, along with research articles, journals, and policy documents related to the ethanol blending programme and sugar industry development. Primary data was also generated through field visits to selected sugar factories and informal interviews with cooperative leaders, factory managers, and farmers in order to gain practical insights into sugarcane supply, ethanol production processes, operational challenges, and socio-economic impacts on rural communities. The data was systematically compiled into tables and represented through figures and maps to show both the temporal trends in ethanol production between 2018–19 and 2022–23 and the spatial distribution of sugar industries during 2023–24.

For analysis, ethanol production data was classified into high, moderate, and low categories based on production levels and recovery rates, while the tahsilwise distribution of sugar industries was grouped into high, medium, and low categories according to the number of factories. Comparative analysis was used to examine year-to-year variations in ethanol output, and spatial analysis helped in identifying regional disparities in industrial concentration. Correlation was studied between irrigation availability, soil fertility, and sugar industry growth, while graphical tools such as bar diagrams, line graphs, and thematic maps were applied for visual interpretation. The interpretation of results was carried out in relation to agro-climatic conditions, irrigation potential, cooperative movements, and government policy support, thereby highlighting the dual role of sugar industries in industrial diversification and ethanol production for renewable energy along with their wider impact on rural socio-economic development.

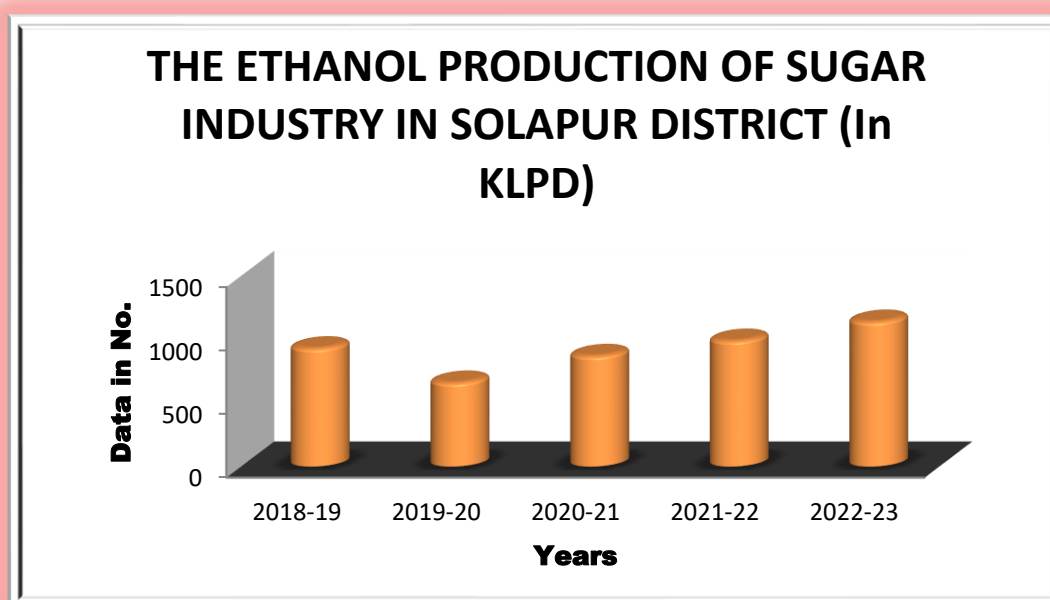
THE ETHANOL PRODUCTION OF SUGAR INDUSTRY IN SOLAPUR DISTRICT

The sugar industry in Solapur district plays a vital role in both agriculture and industry, with cooperative and private factories contributing significantly to sugar and ethanol production. Ethanol, produced from sugarcane juice and molasses, has gained importance under India's Ethanol Blending Programme as a renewable fuel, reducing dependence on fossil fuels and supporting rural economy. In Solapur, ethanol output has shown steady growth, rising from 930 KLPD in 2018-19 to 1140 KLPD in 2022-23, along with improved recovery rates. This highlights the district's growing role in energy sustainability and industrial diversification.

Table No. 1**THE ETHANOL PRODUCTION OF SUGAR INDUSTRY IN SOLAPUR DISTRICT**

Sr. No.	Year	Co-operative Sugar Industries	Private Sugar Industries	Industry Ethanol Production in KLPD	Total sugar recovery for juice & Ethanol (%)
1	2018-19	11	20	930	10.2
2	2019-20	9	13	660	8.28
3	2020-21	10	19	870	9.6
4	2021-22	12	21	990	9.9
5	2022-23	15	23	1140	10.5

Source: The Pradeshik Sakhar Sahsanchalak Karyalaya, Solapur.

**Fig. No. 1**

Above table no. 1 and Fig. no. 2V shows Ethanol Production of Sugar Industry between 2018-19 and 2022-23 in Solapur district.

Between 2018-19 and 2022-23, the ethanol production of the sugar industry in Solapur district shows different variations which can be classified into high, medium and low levels, each influenced by specific factors. The high production years - 2018-19, 2020-21, 2021-22 and 2022-23 - recorded more than 900 KLPD, which reached 1140 KLPD in 2022-23 and recorded a recovery of 10.5%. This high level was mainly due to favourable monsoon conditions, higher availability of sugarcane, expansion of cooperative and private factories and strong government initiatives under the ethanol blending programme. The moderate production level of 870 KLPD and 9.6% recovery rate in 2020-21 was a result of seasonal fluctuations in sugarcane supply and operational challenges faced by some factories, which led to stable but not peak production. Ethanol production was at its lowest in 2019-20, when ethanol production fell to 660 KLPD and recovered only 8.28%, mainly due to drought conditions, reduced sugarcane production due to low rainfall and fewer factories operating that year. This overall trend makes it clear that ethanol production in Solapur is not only dependent on industrial capacity but is also highly sensitive to climate change, agricultural productivity and policy support.

SUGAR INDUSTRIES

Sugar industries are the backbone of Solapur's agro-based economy, providing employment, market linkages, and rural development. The cultivation of sugarcane, supported by irrigation from rivers and canals, has encouraged the growth of cooperative and private sugar factories across the district. In 2023-24, Solapur recorded **38 sugar industries**, with the highest concentration in Karmala, Malshiras, and Pandharpur (5 each), while Akkalkot and Sangola have only one unit due to limited water resources. This distribution reflects the close relationship between irrigation facilities, fertile soils, and industrial development, making sugar factories vital drivers of agriculture and socio-economic change in the region.

TABLE NO. 2
SOLAPUR DISTRICT : DISTRIBUTION SUGAR INDUSTRIES
(2023-24)

Sr. No.	Name of Tahsil	Sugar Industries
1	Akkalkot	1
2	Barshi	3
3	Karmala	5
4	Madha	4
5	Malshirus	5
6	Mangalwedha	4
7	Mohol	4
8	North Solapur	4
9	Pandharpur	5
10	Sangola	1
11	South Solapur	2
Total		38

Source: Socio-Economic Abstract of Solapur District (2023-24)

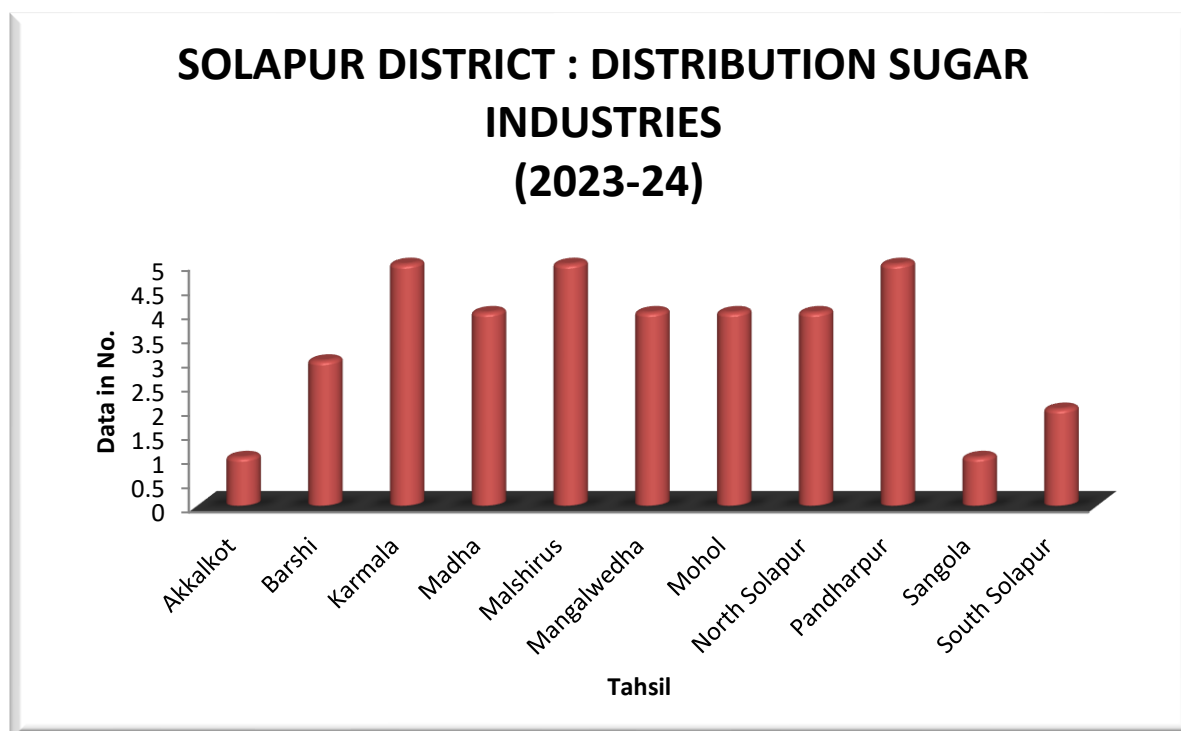


Fig. No. 3

The distribution of sugar industries in Solapur district during 2023-24 highlights the uneven spread of agro-based industries that directly reflect the geographical conditions, irrigation potential and cropping patterns. When classified into high, medium and low categories, clear regional disparities become evident.

In the high category, tehsils like Karmala (5), Malshiras (5) and Pandharpur (5) emerge as major centres of concentration of sugar industry. These regions benefit from fertile black cotton soil and extensive availability of irrigation water from projects like Neera, Ujani and Sina canal systems. The dominance of sugarcane cultivation provides a stable supply of raw material, which encourages cooperative and private sugar factories. In addition, strong cooperative movements, rural leadership and proximity to transport routes further strengthen the industrial base in these tehsils.

The medium category includes Madha (4), Mangalwedha (4), Mohol (4) and North Solapur (4). The sugar industry in these regions is significant but relatively low compared to the upper tier due to semi-arid conditions, erratic rainfall and uneven irrigation coverage. Canals and well irrigation support local sugarcane farming, but the total area under cultivation is limited. Nevertheless, the presence of four factories in each tehsil indicates that sugar industries have established a stable foothold in areas where agricultural conditions are moderately favourable.

The lower tier includes Barshi (3), South Solapur (2), Akkalkot (1) and Sangola (1). The number of sugar industries in these tehsils is low due to limited irrigation facilities, dominance of dryland crops such as jowar, pulses and oilseeds and scarcity of water. For example, Sangola, although

important for pulses, is unsuitable for sugarcane due to frequent droughts, while Akkalkot has poor irrigation from Solapur city and a high urban influence. Despite moderate agricultural activity in Barshi and South Solapur, there are fewer industries as sugarcane is not a major crop and other economic activities such as trade, services and mixed farming are more prominent.

Thus, the spatial pattern of sugar industries in Solapur district shows a strong correlation with irrigation infrastructure, soil fertility and cooperative strength. The sugar industry is more concentrated in well-irrigated and fertile talukas, while drought-prone and water-scarce regions lag behind. This highlights the important role of geographical and socio-economic factors in determining the industrial geography of Solapur district.

KEY FINDINGS

- 1) The sugar industry in Solapur district has expanded both in terms of number of factories (38 in 2023-24) and ethanol production capacity (1140 KLPD in 2022-23). This not only reflects the growth in traditional sugar processing but also diversification into renewable energy through ethanol production.
- 2) Cooperative sugar factories are the backbone of rural development, while private factories are increasingly dominant (23 private vs. 15 cooperatives in 2022-23). Together, they have strengthened ethanol production and provided resilience to seasonal fluctuations in sugarcane supply.
- 3) Irrigation through Ujani, Nira and Sina canals, fertile black soil and dominance of sugarcane have resulted in higher ethanol production and recovery rates in high concentration areas like Karmala, Malshiras and Pandharpur (5 factories each). In contrast, drought-prone talukas like Sangola and Akkalkot contributed less (only 1 factory each), indicating that industrial growth is dependent on agro-climatic conditions.
- 4) Ethanol production reached its peak with good rainfall and strong factory participation (2018-19, 2020-21, 2021-22 and 2022-23). On the other hand, 2019-20 was the low point with 660 KLPD production and only 8.28% recovery, due to drought and low sugarcane availability. This highlights the vulnerability of both the sugar and ethanol sectors to rainfall variability.
- 5) Sugar industries provide direct employment, market linkages and rural income, while ethanol production aligns Solapur with India's ethanol blending programme, reducing fossil fuel dependency. Thus, the district is not only an agro-industrial hub but also a growing contributor to energy sustainability.
- 6) The presence and performance of sugar factories and ethanol production are closely linked to the irrigation network, soil fertility and cooperative strength. Regions with canal irrigation and fertile soil dominate industrial growth, while drought-prone tehsils lag behind.

CONCLUSIONS

The study of the spatial distribution of ethanol production and sugar industries in Solapur district clearly demonstrates the dual role of these agro-based industries in strengthening the regional economy and India's renewable energy goals. Ethanol production in the district has increased significantly from 930 KLPD in 2018-19 to 1140 KLPD in 2022-23, reflecting the combined efforts of cooperatives and private factories, favorable government policies, and the resilience of farmers in maintaining sugarcane supply despite climate uncertainty. At the same time, the spatial distribution of sugar industries highlights significant geographical disparities, with high-concentration areas such as Karmala, Malshiras, and Pandharpur benefiting from fertile soil and canal irrigation, while drought-prone regions such as Sangola and Akkalkot are underrepresented. This uneven spread highlights the crucial role of irrigation infrastructure, soil fertility, and cooperative strength in shaping the industrial geography. Overall, the research concludes that while the sugar and ethanol industries in Solapur are important for boosting rural development, employment, and energy sustainability, regional imbalances need to be addressed through improved irrigation facilities, climate-resilient policies, and policy support to ensure balanced and sustainable industrial growth across all talukas in the district.

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