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A Geographical Study of Raw Material-Based Industry in Chandrapur District of Maharashtra

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Abstract

This study examines the geographical distribution and economic significance of raw material-based industries in the Chandrapur District of Maharashtra. The district, rich in coal, limestone, iron ore, and forest resources, has developed into a major industrial hub, with its economy centered on coal mining, cement manufacturing, ferroalloy production, and paper industries. This study analyzes the spatial patterns of these industries in relation to resource availability, explores the factors influencing industrial location, evaluates environmental implications, and assesses the socio-economic development resulting from industrial activities. Research findings indicate that while these industries have contributed significantly to regional development and employment generation, they have simultaneously posed severe environmental challenges, including air and water pollution, land degradation, and public health issues. The study concludes with policy recommendations for sustainable industrial development, emphasizing the need for balanced growth that addresses both economic prosperity and environmental conservation.

Keywords: *Raw material-based industries, industrial geography, environmental impact, sustainable development, mineral resources, industrial location*

Introduction:

The Chandrapur district, situated in the eastern part of Maharashtra, India, represents a classic case of a resource-rich region where industrial development has been primarily driven by the availability of natural resources. The district's economy has transformed significantly over the decades, evolving from an agriculture-dominated landscape to an industrial hub. This transformation is largely attributed to the abundance of natural resources, particularly coal, limestone, iron ore, and forest resources, which have attracted various industries to establish operations in the region of East Kalimantan. The geographical pattern of industrial development in Chandrapur presents an interesting case study for understanding the relationship between resource availability and industrial location. The concentration of raw material-based industries in specific areas within the district has created distinctive industrial landscapes characterized by mining operations, processing plants, and the associated infrastructure. This spatial clustering has profound implications for the region's economic geography, influencing settlement patterns, transportation networks, and overall regional development. This study aims to provide a comprehensive geographical analysis of raw material-based industries in the Chandrapur district by examining their spatial distribution, factors influencing their location, economic contributions, and environmental implications. By adopting a geographical perspective, this study seeks to understand the complex interplay between natural resources, industrial activities, and sustainable development in Maharashtra's resource rich regions.

Objective:

1. To examine the spatial distribution and resource dependency of raw material-based industries in Chandrapur.
2. To evaluate the key determinants influencing industrial location and their socio-economic outcomes in the district.
3. To assess environmental impacts and develop policy strategies for sustainable industrial development in the region

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Literature Review:

The geographical study of raw material-based industries is a core theme in economic geography, with foundational theories such as Weber's (1929) model highlighting how transportation, labor costs, and agglomeration influence industrial location, particularly for resource-dependent sectors. Later studies, including those by Isard (1956) and Smith (1981), expanded this framework to include factors such as market access, energy, and policy. In India, research has primarily focused on regional patterns of industrialization, resource availability, and associated environmental impacts. For instance, Pathak (1999) underlined how natural resources shape Maharashtra's industrial landscape, and Singh (2007) explored the environmental consequences of resource extraction in Central India. Despite being resource-rich and heavily industrialized, the Chandrapur district has seen limited comprehensive geographical analysis. Existing studies have mainly targeted specific sectors, such as the impact of mining on groundwater quality (Kumar et al., 2024). Official reports have identified Chandrapur as a critically polluted region. This study addresses this research gap by offering an integrated geographical analysis of raw-material-based industries in Chandrapur. It synthesizes spatial, economic, and environmental dimensions to better understand patterns of industrial development and their implications, thereby contributing a holistic perspective to the literature.

Data Collection & Research Methodology

Data were collected from both primary and secondary sources to thoroughly assess Chandrapur's industrial, environmental, and socioeconomic contexts. Primary data were obtained from field surveys, structured interviews with key stakeholders, and direct on-site observations to understand the industrial activities and community impacts. Secondary data sources included official reports (such as District Industrial Profiles, Census 2011, and Maharashtra government publications), industry profiles from company websites and annual reports, published environmental studies, satellite images, resource maps, and scholarly articles. Socio-economic indicators were compiled at the taluka level for a comprehensive analysis of the study. This study integrates spatial, statistical, qualitative, and environmental methods to examine raw material-based industries in the Chandrapur district. First, GIS-based spatial analysis maps industry sites against coal, limestone, and forest resources, transport corridors, and settlements. Second, secondary data from the District Industrial Centre, MIDC, and CPCB were analyzed to quantify industrial output, employment trends, and pollution levels. Third, purposive case studies of coal mines, cement plants, ferroalloy units, and paper mills explored their operational processes, resource flows, and mitigation strategies. Fourth, environmental impact assessment evaluates air, water, and soil quality using CPCB records and field measurements. Finally, structured interviews with officials, industry experts, and community leaders captured the policy, industry challenges, and local perceptions.

Geographical Overview of Chandrapur District:

The Chandrapur district is located in eastern Maharashtra, in India's Vidarbha region, encompassing an area of approximately 11,443sq km between 19°30'–20°45' North latitude and 78°46'–80°00' East longitude. It is bordered by Nagpur and Wardha to the north, Yavatmal to the west, Gadchiroli to the east, and Telangana to the south. The district's landscape is a mosaic of plains, gently rolling hills, and expansive forests, forming part of the elevated Deccan Plateau, with heights ranging from 200m to 600m above sea level. Major rivers, including the Wardha to the west and Wainganga to the east, along with tributaries such as the Erai and Zarpat, create a rich drainage system that has guided both settlements and industrial growth. Chandrapur experiences a subtropical climate, marked by extremely hot summers (often exceeding 45°C), mild winters, and an average annual rainfall of 1,200 mm, mostly from June to September during the southwest monsoon. The region's geology is defined by the Gondwana formation, which is famous for its extensive coalfields (notably in the Wardha Valley) and significant reserves of limestone, dolomite, iron ore, and clay. These mineral resources have fostered a thriving raw-material-based industrial sector, particularly in urban centers and in emerging industrial clusters. The district's vegetation is primarily tropical dry deciduous forest, especially prominent in the east, where the Tadoba Andhari Tiger Reserve is located. These forests have historically provided substantial bamboo resources, supporting industries such as paper manufacturing and construction. According to the 2011 Census, Chandrapur had a population of approximately 2.2 million, with a density of 192 persons per square km (sq. km). Urbanization stands at 35% and is focused on major towns and industrial hubs. Overall, Chandrapur's geography, which is rich in minerals and forests, has significantly shaped its settlements, industry, and economic development

Raw Material-Based Industries in the Chandrapur District

Chandrapur district hosts a diverse range of raw material-based industries, primarily entered around the exploitation and processing of locally available natural resources. The major industries in the district include

Table 1: Mineral Resources in Chandrapur District

Mineral	Estimated Reserves (Million tons)	Major Locations
Coal	3,500	Ghuggus, Ballarpur, Rajura, Warora
Limestone	800	Rajura, Korpana, Gadchandur
Iron Ore	50	Chandrapur, Mul
Clay	120	Warora, Bhadravati

1. Coal Mining Industry

Chandrapur's most prominent industry is coal mining, owing to the district's significant inclusion in the Wardha Valley Coalfield one of Maharashtra's principal coal-bearing formations. The mining landscape is dominated by Western Coalfields

Limited (WCL), a government-owned enterprise under Coal India Limited. The main coal-producing clusters are identified as the Ballarpur, Chandrapur, and Majri Areas, with both underground and opencast operations, such as those in Ghuggus, Sasti, Durgapur, and Majri. Notable among these are the Amalgamated Yekona I and II, with an annual output of 3.44 million tons, and the Bhatadi mine. The aggregate coal production, running into millions of tonnes annually, primarily supplies thermal power plants, cement factories, and other industries both within and beyond the district boundaries. The spatial clustering of coal mines near the Wardha Valley underscores the critical role of raw material proximity in mining geography.

2. Cement Industry

The genesis and growth of the cement industry in Chandrapur can be explicitly attributed to the vast deposits of high-grade limestone, which is the principal component of cement manufacturing. Major industrial entities, such as UltraTech Cement (Manikgarh Cement Works) and Ambuja Cement, have established large-scale plants with captive limestone mines spanning hundreds of hectares (e.g., 493 ha in Rajura Tehsil). Cement plants typically lie within close proximity (often within 70-80 km) to the raw material source, thereby minimizing transportation costs, a core tenet of Weber's theory of industrial location favoring raw material-oriented siting for bulk-reducing industries. The substantial limestone reserves, estimated to last several decades, provide a sustainable basis for the continued operation and further expansion of the cement sector in the district.

3. Ferro-Alloy Industry

The Chandrapur Ferroalloy Plant (CFP), managed by Steel Authority of India Limited (SAIL), is a critical node in India's ferroalloy production landscape. Established in 1976, the CFP is nationally significant as the only public-sector producer of manganese-based ferroalloys. The plant leverages the locational juxtaposition of local coal and manganese ore sourced from adjacent regions to produce high-carbon ferroalloys, such as ferro-manganese, silico-manganese, and other alloys vital for the steel industry. This spatial co-location exemplifies the resource linkage model, where interrelated industries aggregate to derive logistical and economic synergies.

4. Paper Industry

Another example of resource-based industrialization is the Ballarpur paper mill (BILT Graphic Paper Products Ltd.), which is historically reliant on bamboo from the dense forests of Chandrapur and the adjoining Gadchiroli. The evolution of the industry reflects adaptive raw material sourcing, shifting from pure bamboo to incorporating hardwood, eucalyptus, and other fibrous materials in response to resource availability and sustainability imperatives. The initial location, which was proximate to bamboo-rich forests, provided a decisive advantage in terms of raw materials.

5. Other Sectors

Ancillary industries include thermal power generation (e.g., Chandrapur Super Thermal Power Station utilizing local coal), refractory units based on regional clays and minerals, rice mills processing locally grown paddy, and nascent silk-yarn production leveraging indigenous sericulture in the Nagbhid and Saoli talukas of Chandrapur.

Table -2 Major Raw Material-Based Industries in Chandrapur District

Industry Type	Number of Units	Employment (Direct)	Annual Production Capacity
Coal Mining	12	15,000	30 million tons
Cement Production	4	3,500	8 million tons
Paper Manufacturing	1	2,000	200,000 tons
Ferro-Alloy Production	1	800	100,000 tons
Thermal Power Generation	1	2,500	2,920 MW

Factors Influencing Industrial Location:

The geographical concentration of raw material-based industries in specific locations within the Chandrapur district can be attributed to several locational factors:

Availability of Raw Materials: The dominant factor influencing industrial location in Chandrapur is proximity to raw material sources. For weight-losing industries such as cement, where the raw material (limestone) loses weight during processing, locating close to the source of raw materials minimizes transportation costs. Similarly, in the paper industry, proximity to bamboo-rich forests has historically determined the location of the Ballarpur paper mill. Coal mining operations are tied to the geographical distribution of coal deposits in the Wardha Valley Coalfield.

Transportation Infrastructure: Chandrapur's well-developed transportation network has facilitated industrial development. The district is well connected to both rail and road networks. The Delhi-Chennai railway line passes through Chandrapur, providing connectivity to major markets across the country. Major highways connect the district to other industrial centers in Maharashtra and the neighbouring states. The availability of transportation infrastructure has enabled the movement of raw materials and finished products, thereby supporting the industrial operations.

Power Availability: The presence of the Chandrapur Super Thermal Power Station ensures a reliable supply of electricity for industrial operations. This is particularly important for energy-intensive industries such as cement production and ferroalloy manufacturing. The power plant is strategically located near coal mines to minimize the fuel transportation costs.

Water Resources: The availability of water from the Wardha, Wainganga, and Erai rivers has supported industrial activities in Gadchiroli district. Water is essential for various industrial processes, including coal washing, cement production, and paper manufacturing. Industries are often located along or near these water sources to ensure a steady water supply.

Land Availability: The relatively lower population density in certain parts of Chandrapur district has facilitated the acquisition of large tracts of land required for industrial establishments, particularly mining operations and large manufacturing units. This factor has been significant in the establishment of opencast coal mines, which require extensive land use.

Government Policies and Incentives

State government policies, such as tax incentives, subsidized land, and improved infrastructure, have promoted industrial development in less developed regions, such as Chandrapur, Maharashtra. These measures have attracted industries to the district, supported by agglomeration economies from the clustering of related firms that share suppliers, labor, and infrastructure. Historically, decisions such as the colonial-era establishment of paper mills in Ballarpur, which leveraged local bamboo, laid the groundwork for further industrialization. While the availability of raw materials remains a key factor in the location of industries, recent trends show growing importance of environmental concerns and social acceptance when making industrial location decisions in Chandrapur.

Case Studies of Key Industries

To provide a deeper understanding of the geographical and operational aspects of raw material-based industries in Chandrapur, this section presents detailed case studies of key industrial units representing different sectors.

Case Study 1: Western Coalfields Limited (WCL)

WCL operates multiple coal mines in the Chandrapur district, with operations spread across Ballarpur, Chandrapur, and Majri areas. The Bhatadi coal mine, located in Bhatadi Village, exemplifies the company's mining operations in the district. This opencast mine extracts coal from the Wardha Valley Coalfield, with the extracted coal primarily supplying thermal power plants and cement factories in the region. Mining operations involve overburden removal, coal extraction, and transportation to consumer units. The spatial impact of these operations is significant, with mining activities directly altering the landscape through excavation, overburden dumps, and other associated infrastructure. Mines employ thousands of workers, contributing significantly to local employment. The geographical advantages of WCL's operations include the high quality of coal reserves and proximity to major consumers, such as the Chandrapur Super Thermal Power Station. However, operations also face challenges related to land acquisition, rehabilitation of affected communities, and environmental management, particularly controlling air pollution and managing mine water discharge.

Case Study 2: UltraTech Cement's Manikgarh Cement Works

UltraTech Cement's Manikgarh unit, located in Gadchandur, Tehsil Korpana, is a significant cement manufacturing facility in the district. The plant has captive limestone mines spread across 493 hectares in Naokari and Kusumbi villages in the Rajura Tehsil. The geographical proximity of the plant to its raw material source minimizes transportation costs and ensures the consistent quality of input materials. The plant's operations include limestone mining, crushing, grinding, clinker production and cement packaging. The production process is energy-intensive, with coal from nearby mines serving as the primary fuel source. The unit has implemented various technological upgrades to improve energy efficiency and reduce emissions, and has received recognition for sustainable mining practices from the Indian Bureau of Mines. The plant's location exemplifies the principles of Weber's location theory, with proximity to raw materials being the dominant factor. However, operations also benefit from good transportation connectivity, with rail links facilitating the distribution of finished products to markets across central and southern India.

Case Study 3: Chandrapur Ferroalloy Plant (CFP):

Established in 1976, the Chandrapur Ferroalloy Plant is a strategic unit of the Steel Authority of India Limited (SAIL). Located in Chandrapur, it is the only public sector unit engaged in the production of manganese-based ferroalloys in the country. The plant produces high-carbon ferroalloys, silico-manganese, and medium-carbon ferroalloys, which are essential inputs for steel production. The plant's location was influenced by the availability of manganese ore in the broader region and coal from nearby mines in the region. The production process involves smelting manganese ore with coal in submerged arc furnaces, resulting in ferroalloys with varying manganese contents. CFP employs approximately 800 workers and plays a crucial role in the steel manufacturing value chain. While the plant contributes to the district's industrial output and employment generation, it faces challenges related to energy costs, raw material quality, and environmental compliance, particularly in terms of controlling air emissions.

Case Study 4: BILT Graphic Paper Products' Ballarpur Paper Mill

The Ballarpur paper mill is one of the oldest industrial establishments in Chandrapur district. Historically, its location was determined by its proximity to bamboo-rich forests, which served as the primary raw material for paper production. Over time, the raw material mix has evolved to include hardwood, eucalyptus, and other fibrous raw materials. The mill's operations include raw material preparation, pulping, papermaking, and finishing. The production process is water-intensive, with mills drawing water from nearby water bodies. The plant has faced challenges related to raw material supply, particularly bamboo, owing to changing forest management policies and leasing arrangements. This has led to adaptations in the raw material procurement strategy. The paper mill case illustrates how changing resource availability and regulatory frameworks can impact industrial operations. Despite these challenges, the unit remains a significant employer in the region and has implemented various environmental management measures to reduce its ecological footprint. These case studies highlight the diverse operational dynamics of raw material-based industries in the Chandrapur district, their geographical significance, and the challenges they face in maintaining sustainable operations.

Environmental Implications:

The Chandrapur district faces severe environmental challenges, primarily due to its heavy industrialization centered around coal mining and related industries. The Chandrapur Super Thermal Power Station, cement plants, and ferroalloy units

emit large quantities of particulate matter, sulfur dioxide, and nitrogen oxides, contributing to severe air pollution. Coal mining operations generate significant dust, further degrading air quality and leading to Chandrapur's classification as a Critically Polluted Area with a high CEPI score. This pollution considerably affects the respiratory health of residents. Concurrently, water bodies are contaminated by coal mine discharges containing heavy metals and suspended solids, along with industrial effluents from paper mills and cement factories, adversely impacting water quality. Mining, especially opencast coal mining, has drastically transformed Chandrapur's landscape by clearing extensive tracts of natural vegetation and creating vast overburden dump sites. Studies in the Erai watershed have revealed that mining activities have led to the loss of over 2,100 hectares of land, including agricultural and forest areas, causing land subsidence and disrupting natural drainage and settlements. Limestone quarrying and waste dumps in the Rajura tehsil have further altered the regional ecology and aesthetics. Industrial development has caused significant deforestation and habitat fragmentation, threatening biodiversity and wildlife corridors linked to the Tadoba-Andhari Tiger Reserve and complicating conservation efforts. Resource depletion is a critical concern as coal and limestone are intensively extracted as non-renewable resources. Chandrapur's coal-based industries also contribute heavily to greenhouse gas emissions, posing challenges in reconciling industrial growth with climate change mitigation. This situation calls for improved resource conservation, sustainable mining practices, pollution control, and economic diversification to ensure environmental and social sustainability in the region.

"A study by Kumar et al. (2024) assessed groundwater quality in Chandrapur Taluka and found that while chloride levels remained relatively stable between 2014 and 2018, concerns persist about long-term impacts of industrial activities on groundwater resources."

Pollution Control Measures:

In response to environmental concerns, various pollution control measures have been implemented in industries in Chandrapur, including:

1. Electrostatic precipitators and bag filters are installed in thermal power plants and cement factories to control particulate emissions.
2. Implementation of effluent treatment plants in paper mills and other water-intensive industries.
3. Adoption of mine water treatment systems and recirculation in coal-mining operations.
4. Land reclamation and afforestation in mined-out areas are also important.
5. Continuous environmental monitoring systems are used in major industrial units.

Despite these measures, environmental challenges persist, highlighting the need for more stringent enforcement of environmental regulations and the adoption of cleaner technologies across all industrial sectors. The environmental implications of industrial activities in Chandrapur underscore the complex trade-offs between economic development and environmental conservation in resource-rich areas. Balancing these competing interests remains a significant challenge for policymakers and industry stakeholders alike.

Table 3: Environmental Quality Parameters in Chandrapur (2024)

Parameter	Average Value	National Standard	Status
PM10 (µg/m³)	95	60	Exceeds
PM2.5 (µg/m³)	52	40	Exceeds
SO2 (µg/m³)	18	50	Within Limits
NOx (µg/m³)	38	40	Within Limits
CEPI Score	**72.6**	**>70 (Critical)**	**Critical**

Socioeconomic Development and Challenges

The development of raw material-based industries in the Chandrapur district has brought significant socio-economic benefits and challenges. Key industries, such as coal mining, the Chandrapur Ferro Alloy Plant, cement factories, and paper mills, have generated stable employment with better wages than agriculture, improving living standards. This industrial growth has diversified the economy, reducing dependence on agriculture, especially in drought-prone areas, and expanded the service sectors linked to industrial activities. Infrastructure improvements in transportation, power, and water management have supported both industries and local communities. Urbanization around industrial hubs, such as Chandrapur city, Ballarpur, and Warora, has enhanced access to amenities, education, and health care, promoting regional development. These industries also contribute significantly to government revenue through taxes, royalties, public services, and development projects. However, the district faces ongoing challenges in balancing industrial advancement with sustainable socioeconomic progress to ensure long-term benefits for its population.

Table 4: Socio-Economic Indicators of Chandrapur District

Indicator	Value	State Average
Per Capita Income (INR)	142,500	160,000
Literacy Rate (%)	80.4	82.3
Urban Population (%)	35.1	45.2
Industrial Employment (%)	28.5	18.7
Agricultural Employment (%)	52.3	53.8

Challenges:

Industrial development in the Chandrapur district, mainly driven by mining and manufacturing, has spurred economic growth but has also posed significant challenges. Land acquisition has displaced many communities, especially farmers from over 50 villages, disrupting their livelihoods and causing socio-economic instability in the area. Environmental pollution has increased health issues, such as respiratory, skin, and waterborne diseases, straining local healthcare. Development is uneven, with urban industrial areas enjoying better infrastructure and services, whereas rural regions face poor access to education, healthcare, and jobs, leading to inequality in development. A skill mismatch forces reliance on outside labor, limiting the benefits for locals. The dependence on coal and limestone extraction raises concerns about long-term economic sustainability amid global shifts toward cleaner energy. Labor disputes, workplace safety problems, and transitional cultural challenges also impact social harmony and industrial stability in China. Various social development indicators highlight the complex balance between growth and the community's welfare. Chandrapur's future demands inclusive, sustainable approaches addressing displacement, health, skills, environment, and equitable progress.

Policy Recommendations and Future Directions

Based on the analysis of raw material-based industries in the Chandrapur district, several key policy recommendations are proposed to promote sustainable industrial development. First, sustainable resource management requires comprehensive mapping and long-term planning, alongside efficient technologies and circular economy practices, such as recycling mining by products to minimize waste. Second, stringent environmental protection through emission standards, green belt development, ecological restoration, and real-time monitoring is essential for curbing pollution. Third, economic diversification should focus on adding value to local resources, developing knowledge-based industries, sustainable tourism such as eco-tourism at the Tadoba Andhari Tiger Reserve, and modernizing agriculture to create alternative livelihood opportunities. Fourth, social development requires tailored training centres to boost employment, improved healthcare focusing on industrial health issues, and ensuring fair community consultations and compensation for displaced populations. Fifth, technological innovation must prioritize clean technologies, renewable energy integration, and digital transformation to enhance efficiency and reduce the carbon footprint. Lastly, institutional strengthening through a coordinated district-level platform, stronger regulatory agencies, and integrated data systems is necessary for better oversight, enforcement, and data-driven policymaking to ensure balanced industrial growth and environmental and social well-being.

Conclusion:

This geographical study of raw material-based industries in the Chandrapur district explores how natural resources have shaped the region's industrial landscape. Chandrapur's abundant coal, limestone, and forest reserves have attracted significant industrial investments, making it a key industrial hub in Maharashtra. The distribution of industries in the district closely follows the availability of resources: coal mining is prominent in the Wardha Valley, cement plants are clustered near limestone deposits, and the paper industry has historically thrived in areas rich in bamboo forests. These clusters have generated economic growth, employment, and infrastructure development, thereby transforming the local economy. However, this growth has come at a significant cost. Intensive industrial activity has made Chandrapur one of the most critically polluted areas in India. Environmental challenges, such as air and water pollution, land degradation, and health issues affecting local communities, highlight the drawbacks of unchecked industrialization. Socio-economic outcomes are mixed; while there have been improved employment and living standards, the region also faces issues of displacement, unequal development, and overreliance on non-renewable resources.

Looking ahead, Chandrapur must carefully balance the ongoing industrial growth with environmental and social sustainability. This necessitates adopting cleaner technologies, improved resource management, and more inclusive development strategies. The Chandrapur case provides vital lessons for other resource-rich regions, demonstrating the importance of integrating economic development with natural resource protection and community well-being to achieve lasting prosperity for current and future generations.

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Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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