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Transformation of Communication and Transport Network over thirty Years: A Case Study on Haldia Town, Purba Medinipur, West Bengal, India.

Prosenjit Saha[1], Dr. Moitrayee Das[2], Dr. Mitali Ghosh[3]
[1]SACT, *Geography Department, Memari College, PurbaBardhaman, West Bengal, India.*
[2.] Associate Professor, Post Graduate Department of Geography, Haldia Govt. College, Purba Medinipur, West Bengal, India.
[3.] Assistant Professor, Post Graduate Department of Geography, Sambhu Nath College, Birbhum, West Bengal, India.
Corresponding Author : Dr. Mitali Ghosh

Abstract
The Haldia Industrial Town, located in Purba Medinipur district of West Bengal, has experienced significant infrastructural and economic development over the past few decades. This study aims to detect and analyze the decadal changes in the communication and transportation networks of the Haldia region using geospatial techniques and remote sensing data. With the help of satellite imagery from 1995 and 2025, spatial and temporal changes in road networks, transportation corridors, and connectivity patterns have been assessed. Image classification, vector mapping, and change detection techniques were applied using GIS tools to evaluate the expansion, modification, and intensity over time. The results indicate a marked increase in road density, connectivity to the port and industrial areas, and enhanced linkages to nearby urban centers, driven by industrial growth and government policies. This decadal transformation has had a significant impact on regional mobility, land use patterns, and urban expansion. The study demonstrates the effectiveness of remote sensing and GIS technologies as tools for monitoring urban and infrastructural development, offering valuable insights for future urban planning and sustainable development in industrial towns like Haldia.

Keywords: *Connectivity, Remote Sensing GIS, Road, Transformation, Transport network.*

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I.Introduction

Transportation network is an important key factor in any urban planning and developmental decision-making processes (Maity et al., 2017) and monitoring and analyzing these changes are essential for sustainable urban planning, efficient resource management, and infrastructure optimization. The transformation of communication and transport networks represents one of the most significant infrastructure challenges of the 21st century. As urbanization accelerates and global connectivity demands increase, traditional methods of network analysis have proven insufficient to capture the complex, multi-scale dynamics of modern transportation and communication systems (Gundala, 2024). The integration of remote sensing technologies with Geographic Information Systems (GIS) has emerged as a transformative approach, enabling researchers to monitor, analyze, and predict network changes with unprecedented spatial coverage, temporal frequency, and analytical sophistication (Pasupuleti, 2024). Remote sensing, defined as the acquisition of information about objects or phenomena without direct physical contact, has evolved from simple aerial photography to sophisticated multi-sensor platforms capable of capturing diverse electromagnetic signatures across various spectral, spatial, and temporal resolutions (Thakur et al., 2024). When combined with GIS—systems designed to capture, store, manipulate, analyze, and display geographically referenced data—these technologies provide a powerful framework for understanding the complex relationships between infrastructure networks, urban development patterns, and socioeconomic processes (Wang, 2025). This study presents a comprehensive assessment of the transport and communication transformations in Haldia using remote sensing data. It highlights the methodology used for change detection, the key findings regarding infrastructure expansion, and the implications for future urban and industrial development. The study contributes to a better understanding of how industrial towns evolve over time and how geospatial technology can aid in effective planning and decision-making.

II.Literature Review

1. Development of Communication and Transport Networks:

Communication and transport infrastructures have been at the core of driving urban-industrial development in Haldia, Purba Medinipur, over the past three decades. The interdependency between communication and transport systems allows for the mobility of people, goods, and information, which are principal determinants of regional progress, as Rodrigue (2016) and Morley (2011) point out. Haldia's evolution from an industrial township to a diversified urban hub echoes this international phenomenon. Extensification of telecommunication networks and road connectivity has increased access and drawn Haldia within larger economic corridors.

2. Industrialization, Urban Growth, and Network Expansion:

Industrialization-fueled growth in the landscape of Haldia has revolutionized its transport system to a large extent. Karan, Mandal, and Das (2024) noted that during 1992-2022, there was intensified industrial development, which remade land use patterns, resulting in an increased surface temperature profile as a consequence of high-density infrastructural buildup. Likewise, Maity, Mallick, and Rudra (2020) discovered that urban development in Haldia Municipality was strongly associated with hybrid road network growth, which encompasses industrial and residential areas. Similar investigations in Delhi (Kumar & Sharma, 2022) and Agartala (Santra et al., 2018) complement the positive correlation between urban development and land transformation due to transport.

3. Technological and Geospatial Perspectives:

Technological developments in remote sensing (RS) and geographic information system (GIS) have transformed monitoring and planning of transport systems. Zhang and Guindon (2005) and Banister and Stead (2004) highlighted how satellite data and ICT innovations increase knowledge of transport sustainability. Recent studies, for instance, Gundala (2025) and Pasupuleti (2024), show the application of RS and GIS in transport planning towards sustainable mobility. In West Bengal, Dasmahapatra (2023) used connectivity analysis to measure road network efficiency in a methodological context applicable to Haldia's urban planning.

4. Sustainable Network Transformation and Data-Based Mobility:

The intersection of communication, geospatial intelligence, and transport management creates new avenues for sustainable urban growth. Thakur, Virk, and Nanda (2024) identify some emerging trends in geospatial intelligence in support of data-based policy-making. Mithun et al. (2022) and Naikoo et al. (2022) further highlight the role of spatially explicit models in achieving balance between land-use efficiency and mobility. For Haldia, these observations point toward the development of intelligent transport systems (ITS), with RS-GIS integration facilitating adaptive planning of infrastructure for economic and environmental resilience.

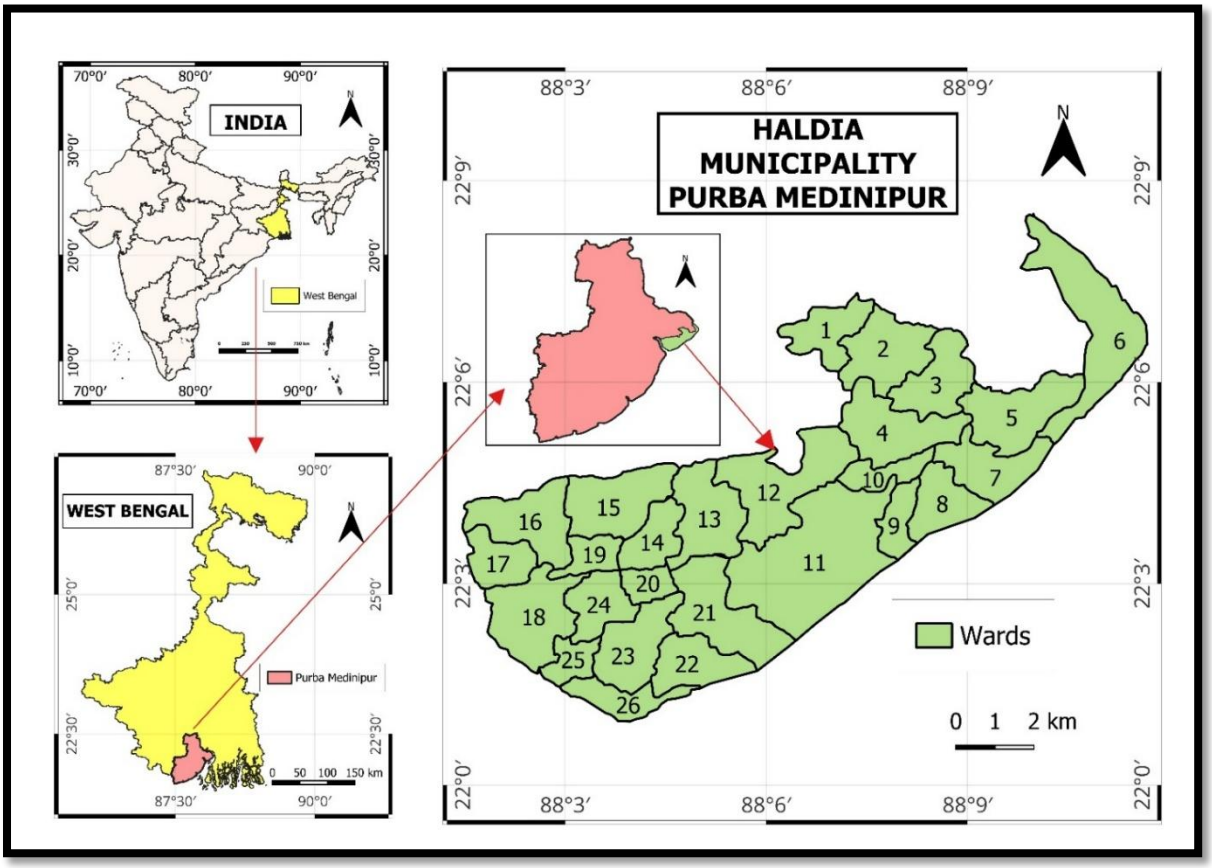
III.Objectives

- The main objective of our research is to identify the changes in the communication network in industrial city of Haldia over 30 years.
- To Compare Different Time Frames – Perform a comparative study of transportation and communication networks over different decades to understand development trends of the communication network.
- To evaluate the direction and nature of spatial expansion in road and transport networks with reference to industrial zones, residential areas, and port activities.

IV.Study Area

Haldia, an important industrial town in the Purba Medinipur district of West Bengal, India, is located between latitude 22.025°N to 22.060°N and longitude 88.050°E to 88.130°E. It is situated approximately 120 km southwest of Kolkata and lies at the confluence of Haldi and Hooghly River, making it a crucial centre for trade, industry, and urban development. The town has witnessed significant industrial and urban expansion over the past few decades due to the presence of key industries such as Haldia Petrochemicals, Indian Oil Corporation, Tata Chemicals, and Exide Industries. The presence of these industries has led to rapid urbanization and infrastructure development in the area. Additionally, Haldia's proximity to Kolkata, the state capital, further enhances its economic importance and connectivity.Development of Haldia Dock Complex that enhanced the port infrastructure and capacity and Establishment of Haldia Petrochemicals Limited (HPL) in 1994, marking a major industrial milestone. Expansion of petrochemical and chemical industries influence the development and improvement road and rail connectivity in this area. As a result of its development history, Haldia has grown from a small town to a major port and industrial city that has become significant to the economic landscape of Eastern India.

***Map no.1**: Location Map of the Study Area*



***Source:** Computed by the authors*

V.Methodology

The present work has been carried out based on secondary data such as satellite images collected from the USGS portal (https://earthexplorer.usgs.gov/) and Google Earth Engine. The LANDSAT satellite images for two time periods i.e. 1995 and 225, have been collected (table 1). The historical imagery collection of Google Earth Engine is also used for cross reference.

Haldia Municipality boundary has been prepared using the map collected from the Haldia Municipality web portal and the Survey of India (SOI) free map service portal.For both periods, two false colour composites (FCC) and true colour composite (TCC) were prepared using the Blue, Green, Red, and NIR bands.The images were first classified using a supervised maximum likelihood method to visualize the road network.

***Table 1*: Details of LANDSAT satellite images**

Platform	Sensor	Reference (Path/Row)	Resolution (m)	Acquisition Date
Landsat 5	Thematic Mapper (TM)	138/045	30	28h January, 1995
Landsat 8	Operational Land Imager (OLI)	138/045	30	15th February,2025

***Source:** Computed by the authors*

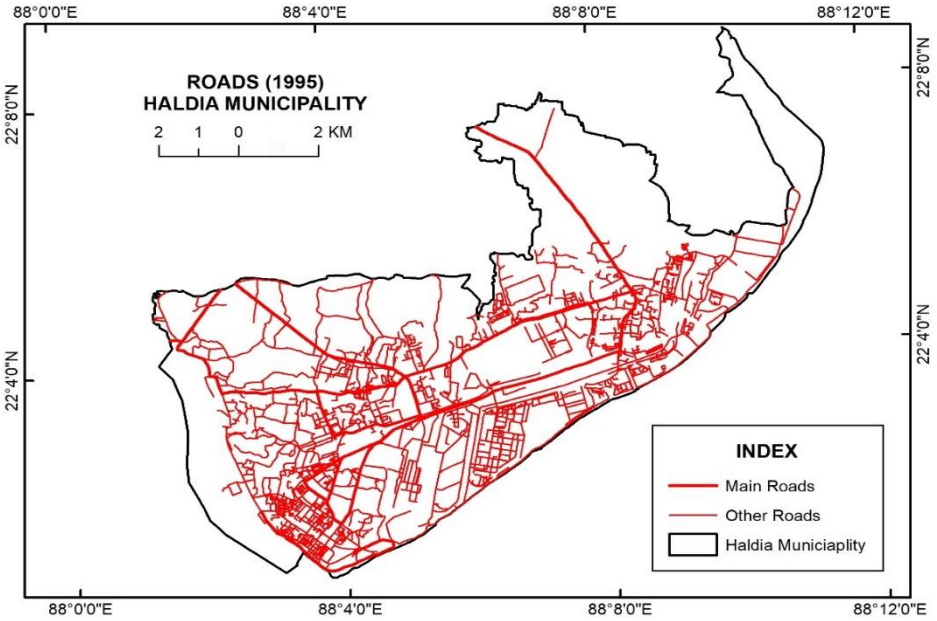
Then all the road networks were digitized using the classified images, FCCs, TCCs, and Google Earth images. Two transport network maps for 1995 and 2025 have been prepared and compared to identify the changes that occurred over the span of thirty years.

VI.Result and Discussion

Road Classification on the basis of Transport Map (1995):

The transport infrastructure of Haldia in 1995 reflects the foundational stage of its urban and industrial development. During this period, the town was undergoing early phases of industrialization, with port operations and petrochemical industries beginning to influence regional growth.

Map no 2:*Road Network Map of Haldia Municipality (1995)*



Source: *Computed by the authors*

This classification highlights the existing transportation hierarchy and connectivity patterns that supported the movement of goods, services, and people. The use of GIS in mapping this infrastructure enables a clear visual interpretation of the town's transport framework and provides a valuable baseline for comparing future developments. By analyzing this map in relation to subsequent years, it becomes possible to detect and quantify decadal changes in Haldia's transport and communication systems, especially in relation to its growing industrial significance.The map entitled "Roads (1995) – Haldia Municipality" represents the road network infrastructure of Haldia, an important industrial township in Purba Medinipur district of West Bengal, as it existed in the year 1995. It visually distinguishes between main roads and other (secondary and tertiary) roads within the boundary of Haldia Municipality using different line thicknesses.

Key characteristics of road network based on map (1995) features:

1. Main Roads (Thick Red Lines):

The main roads are clearly visible as arterial connectors, suggesting the major transport routes used for both industrial and public movement. They appear to be structured in a radiating pattern, connecting key industrial zones to peripheral and residential areas.

2. Other Roads (Thin Red Lines):

These roads show a denser network, particularly in the southwestern and central zones. This density implies residential clustering or small-scale industrial/commercial units requiring local road accessibility.

3. Spatial Distribution:

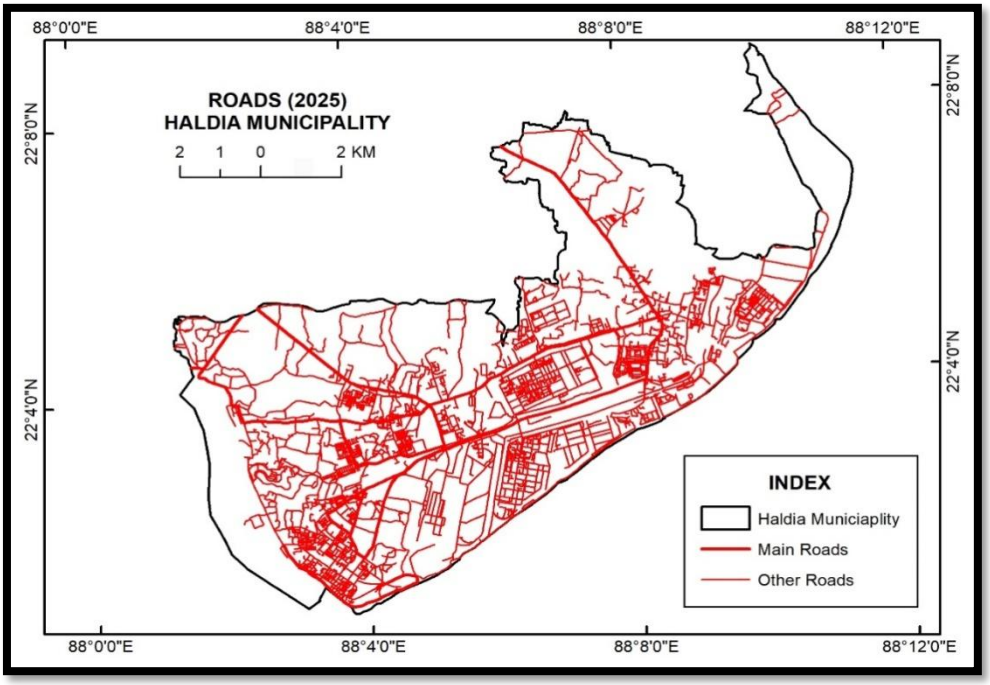
- South-western Region: High concentration of both main and secondary roads—indicating older, more developed urban/industrial areas.
- Eastern Corridor: Linear development along what seems to be a major arterial road—possibly aligned with port connectivity or railway lines.
- Northern & north-western Zones: Comparatively sparse road network—indicative of either undeveloped or under-planned zones during 1995.

Road Classification on the basis of Transport Map (2025):

The transportation framework of an industrial town is a vital indicator of its urban functionality and economic connectivity.Haldia, located in the Purba Medinipur district of West Bengal, has emerged as a significant industrial and port-based city, necessitating a robust and evolving transport network.A detailed representation of the municipality's road infrastructure by categorizing it into main roads and secondary (other) roads.This classification, derived using Geographic Information System (GIS) techniques, offers a spatially accurate and analytically rich understanding of road hierarchy and distribution.The use of remote sensing and GIS allows for precise mapping and monitoring of transport development, making it a crucial tool for assessing decadal changes in communication networks.This map serves as a foundational layer in analyzing the expansion, connectivity, and future planning potential of Haldia's transport infrastructure in response to rapid

industrialization and urban growth.The given map number three depicts the transport network of Haldia Municipality in the year 2025, based on data derived using remote sensing and GIS techniques. It distinguishes between main roads and other roads within the municipal boundary, delineated in black. The red lines represent the road infrastructure, with bold lines for main roads and thinner lines for other/local roads.

Map no 3:*Road Network Map of Haldia Municipality (2025)*



Source: *Computed by the authors*

Key characteristics of road network based on map (2025) features:

1. Main Roads (Thick Red Lines): These are the arterial roads forming the core communication spine of the municipality. They traverse longitudinally and transversely across the town, enhancing intra-urban connectivity.

- One major longitudinal corridor runs from southwest to northeast, likely aligning with the port/industrial corridor.
- Another major road cuts through the central region, ensuring industrial and residential access.

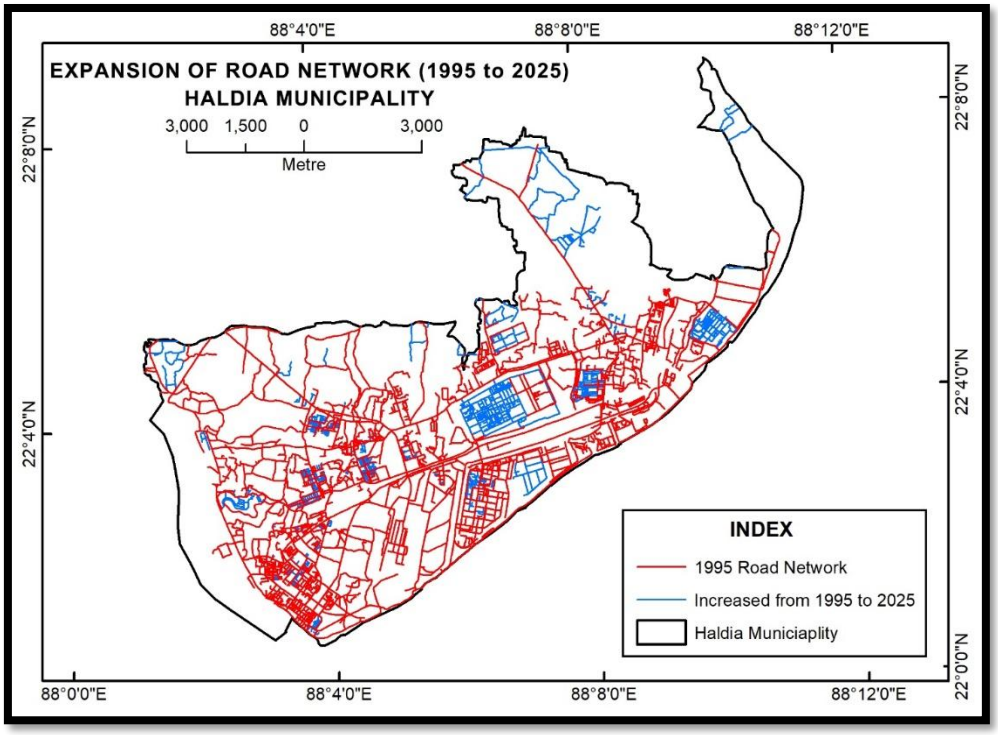
2. Other Roads (Thin Red Lines): These represent secondary or feeder roads.

- They form a dense and intricate grid-like pattern in the southern and southeastern parts, indicating developed industrial or residential areas.
- Northern parts show relatively sparse road distribution, suggesting either industrial storage zones, ecological zones, or less developed areas.

Expansion of Road Network of Haldia Municipality (1995–2025):

Comparative GIS-based analysis of the transport network of an urban-industrial town serves as a critical indicator of its socio-economic development and spatial growth. The study area i.e. Haldia Municipality has experienced a

Map no 4: Expansion of *Road Networkof Haldia Municipality (1995-2025)*



Source: *Computed by the authors*

substantial infrastructural expansion over the past few decades, particularly in its road transport system. By comparing maps from 1995 and 2025, the study highlights the spatial pattern of road development and its implications for urban planning, accessibility, and industrial connectivity.

Table No. 2:*Comparative Observation of Road Network (1995 vs. 2025)*

Aspect	1995	2025	Change
Total Road Length (estimated)	120–150 km (visual estimate)	220–250 km (visual estimate)	70–100 km increase
Main Road Density	Sparse, limited to central zones	Dense, extended in all directions	Major growth in northern and north-eastern sectors
Other RoadDevelopment	Scattered,unconnected segments	Interconnected grid pattern	Substantial rise in internal connectivity
Urban Access & Coverage	Limited to core industrial areas	Nearly full municipal coverage	Better integration of residential-industrial zones
Transportation Efficiency	Lower, with fewer alternate routes	Higher, with multiple bypass routes	Improved mobility and traffic distribution

Source: *Computed by the authors*

This analysis provides crucial insights for policymakers and urban developers focused on sustainable and efficient transport infrastructure in industrial towns.In the last 30 years the total road length has been doubled (Table 2) in the Haldia Municipality area that signifies a rapid urban expansion of the communication network.Development of new roads leading to a greater pressure on the transport management of the area which needs to be address in a planned manner to manage the increasing traffic.

VII.Relevance of this study

The study of decadal change detection in communication and transportation networks in Haldia Industrial Town holds significant importance for several reasons.

- Strategic Industrial Relevance: Haldia is a major industrial hub and port city in eastern India. Understanding the evolution of its transport infrastructure is crucial for assessing how industrial growth has influenced regional connectivity and logistics efficiency.
- Urban Planning and Policy Formulation: By identifying trends in the expansion and transformation of transport networks, the study provides essential insights for planners and policymakers to design sustainable urban infrastructure and transportation systems.
- Assessment of Infrastructural Development: The study highlights how remote sensing and GIS can be used to monitor physical changes in transport and communication networks over time, offering a scientific basis for assessing developmental progress.
- Environmental and Land Use Impact: Changes in transport infrastructure are often linked to land use conversion and environmental implications. This study helps understand how road and communication expansion has influenced urban sprawl, green cover loss, and land use patterns.
- Support for Smart City and Industrial Corridor Development: As India moves towards smarter cities and economic corridors, this research provides foundational data for integrating geospatial technologies in managing industrial towns like Haldia.
- Technological Advancement in Monitoring: The application of satellite imagery and geospatial tools in detecting changes over time illustrates the modern, efficient, and cost-effective techniques for infrastructure monitoring and management.

VIII.Conclusion

The transportation infrastructure has grown dramatically over three decades, supporting urban-industrial expansion and enhancing connectivity in Haldia.The analysis showcases how remote sensing and GIS techniques help detect spatial-temporal changes in transportation infrastructure. The decadal comparison aligns with industrial development and urbanization trends in Haldia. Such findings support policy-making, infrastructure planning, and sustainable urban development.

References:

[1]. Banister, D., & Stead, D. (2004). Impact of information and communications technology on transport. *Transport Reviews*, *24*(5), 611–632. https://doi.org/10.1080/0144164042000206060

[2]. Dasmahapatra, N. D. (2023). Measuring the Urban Road network pattern using connectivity analysis: A micro-level study in Egra Municipality, West Bengal. *International Journal of Science and Research Archive*, *8*(2), 117–127. https://doi.org/10.30574/ijsra.2023.8.2.0209

[3]. Faiyetole, A. A., & Adewumi, V. A. (2023). Urban expansion and transportation interaction: Evidence from Akure, southwestern Nigeria. *Environment and Planning B Urban Analytics and City Science*, *51*(1), 57–74. https://doi.org/10.1177/23998083231169427

[4]. Gundala, V. (2025). Geospatial Techniques for Sustainable Transportation Planning: Insights from Remote Sensing Applications in Andhra Pradesh, India. *Research Square (Research Square)*. https://doi.org/10.21203/rs.3.rs-5743055/v1

[5]. Karan, S., Mandal, S., & Das, S. (2024). Assessment of Landscape Change and its Relationships with Surface Temperature and Geo-spatial Indices during 1992 - 2022 at Haldia Industrial Region, West Bengal, India. *Knowledge-Based Engineering and Sciences*, *5*(2), 54–74. https://doi.org/10.51526/kbes.2024.5.2.54-74

[6]. Kumar, J., & Sharma, R. (2022). Highway peripheral urbanization, industrialization and land use change: a case study of NH-48 in National Capital Region, Delhi, India. *GeoJournal*, *88*(3), 2969–2981. https://doi.org/10.1007/s10708-022-10783-5

[7]. Maity, B., Mallick, S. K., & Rudra, S. (2020). Integration of urban expansion with hybrid road transport network development within Haldia Municipality, West Bengal. *The Egyptian Journal of Remote Sensing and Space Science*, *24*(3), 471–483. https://doi.org/10.1016/j.ejrs.2020.10.005

[8]. Mithun, S., Sahana, M., Chattopadhyay, S., Chatterjee, S., Islam, J., & Costache, R. (2022). Comparative framework for spatially explicit urban growth modeling for monitoring urban land-use efficiency and sustainable urban development (SDG 11.3.1): a study on Kolkata metropolitan area, India. *Geocarto International*, *37*(27), 17933–17970. https://doi.org/10.1080/10106049.2022.2136259

[9]. Morley, D. (2011). Communications and transport: The mobility of information, people and commodities. *Media Culture & Society*, *33*(5), 743–759. https://doi.org/10.1177/0163443711404466

[10]. Naikoo, M. W., Rihan, M., Shahfahad, N., Peer, A. H., Talukdar, S., Mallick, J., Ishtiaq, M., & Rahman, A. (2022). Analysis of peri-urban land use/land cover change and its drivers using geospatial techniques and geographically weighted regression. *Environmental Science and Pollution Research*, *30*(55), 116421–116439. https://doi.org/10.1007/s11356-022-18853-4

[11]. Padam, S., & Singh, S. K. (2004). Urbanization and Urban Transport in India: The search for a policy. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.573181

[12]. Pasupuleti, M. K. (2024). GeoDynamics: innovating urban spaces with GIS and remote sensing technologies. (pp. 316–335). https://doi.org/10.62311/nesx/97896

[13]. Rodrigue, J. (2016). The role of transport and communication infrastructure in realising development outcomes. In *Palgrave Macmillan UK eBooks* (pp. 595–614). https://doi.org/10.1057/978-1-137-42724-3_33

[14]. Santra, A., Mitra, S., &Debbarma, D. (2018). Impact of urbanization on land use changes in Agartala City, India. *Research Journal of Humanities and Social Sciences*, *9*(2), 407. https://doi.org/10.5958/2321-5828.2018.00070.0

[15]. Singh, N. K., Devi, G., & Nathawat, M. S. (2022). An Assessment of the Land Consumption Pattern in the Peri-Urban Area of the City of Varanasi using Geospatial Techniques. *Zenodo (CERN European Organization for Nuclear Research)*. https://doi.org/10.5281/zenodo.8167130

[16]. Thakur, N., Virk, A., & Nanda, V. (2024). Geospatial Intelligence: A Comprehensive review of Emerging trends and applications in 2024. *International Journal of Research Publication and Reviews*, *5*(9), 376–381. https://doi.org/10.55248/gengpi.5.0924.2413

[17]. Wang, J. (2025). Analysis of regional transportation networks and socioeconomic spatial distribution based on remote sensing image supervised classification: a case study of Taizhou City. *Applied and Computational Engineering*, *144*(1), 237–243. https://doi.org/10.54254/2755-2721/2025.23377

[18]. Zhang, Y., & Guindon, B. (2005). Using satellite remote sensing to survey transport-related urban sustainability. *International Journal of Applied Earth Observation and Geoinformation*, *8*(3), 149–164. https://doi.org/10.1016/j.jag.2005.08.005