

From Connectivity to Spatial Transformation: Evaluating Highway Corridor Impacts on Settlement Dynamics and Land Use Patterns

Deepak Kumar Das^{1*}, Akhand Pratap Singh¹

¹Department of Civil Engineering, Shri Rawatpura Sarkar University, Raipur, India

Abstract—Highway corridor development has emerged as a critical driver of spatial transformation and regional growth, particularly in rapidly developing regions. This study examines the influence of the Bhubaneswar-Puri express highway corridor on settlement dynamics, land use patterns and socio-economic development in Odisha, India. The corridor plays a significant role in enhancing regional connectivity, reducing travel time and facilitating the movement of people and goods, thereby acting as a catalyst for economic expansion. The research adopts an integrated analytical approach to evaluate how improved accessibility along the corridor reshapes settlement structures and encourages the emergence of new growth centers. The findings indicate a noticeable shift in land use patterns, with increased urbanization, development of commercial zones, and expansion of residential areas along the highway. The corridor also contributes to the formation of satellite settlements and redistribution of population density, reflecting its strong spatial influence. In addition to economic benefits, the study critically assesses environmental and social dimensions associated with corridor development. Changes in land use and pressure on natural ecosystems highlight the need for sustainable planning interventions. Furthermore, the study emphasizes the importance of inclusive development by addressing accessibility to social infrastructure such as healthcare, education and public services for communities along the corridor.

Index Terms— Highway Corridor, Settlement Dynamics, Land Use Change, Regional Development, Urbanization, Spatial Transformation, Environmental Sustainability, Social Equity.

1. Introduction

The direct effects of an expressway passageway on development patterns and settlement patterns create complex results that determine how space and economic conditions develop in a region. Thruways operate as fundamental transportation routes which enable people to travel between different areas resulting in economic progress for their connection between different regions. The establishment of a highway corridor brings about economic growth which leads to increased business activities during its development phase. The phenomenon leads to the establishment of development centers which include business districts and industrial zones and residential areas to form a spatial hierarchy throughout the corridor. The highway system provides various accessibility

options which create a direct impact on settlement patterns because people tend to establish their homes in areas near the transportation route. The planning recommendations for the corridor extend their effects to both urban areas and rural communities through changed land use patterns and increased transportation links. The planning process needs to evaluate three main factors which include environmental effects, community displacement risks, and the need for sustainable development methods to balance between advantages and disadvantages. The introduction of a roadway tunnel creates a major change to the development landscape because it alters how people settle in areas while driving economic progress and requiring detailed planning to achieve its positive effects and minimize potential obstacles.

A. What is Highway Corridor?



Fig. 1. Highway corridors

The interstate hallway shows a specific route which operates as the designated path for both road construction and road maintenance activities. Interstates serve as crucial transportation routes which enable swift and efficient vehicle movement between different geographical areas and urban centers and state boundaries. The hallway in this situation describes a specific area which extends through the complete distance of the parkway while including both the street construction area and its surrounding territory. Parkway entry points receive careful design to boost transportation efficiency which takes into account landscape features and population distribution and economic growth patterns along the route.

*Corresponding author: akhandpratap651@gmail.com

B. Problem Statement

The transportation infrastructure development in social systems which are developing through urbanization creates spatial and economic changes in regions. The development of a new highway corridor creates planning difficulties which need to be resolved through detailed evaluation because it will improve network accessibility. The research investigates how introduced roadway corridors will affect development patterns and settlement patterns throughout the studied area.

Spatial Dispersion of Improvement: The presentation of another interstate might change the current examples of advancement inside the area. The effective metropolitan planning process and resource distribution process require people to understand how spatial distribution patterns develop over time.

Influence Ashore Use: The creation of a parkway corridor system will change land development patterns throughout the area. The identification of land use changes requires examination of three main categories which include residential areas and commercial zones and industrial sections of the city.

Foundation and Administration Arrangement: The expressway hall expansion will create problems for current infrastructure and operational systems. The population's well-being depends on evaluating the capacity of utilities and public services and social amenities.

Ecological Worries: The extension of settlements and framework related with the expressway can have natural repercussions. The assessment of natural impact requires evaluation of air and water quality changes together with wildlife habitats and green space assessment for sustainable development purposes.

Social and Financial Differences: The forthcoming expressway upgrades will result in unpredicted changes which will affect how people access resources and opportunities. The study needs to examine social and economic effects which impact different population groups as the research work develops through its equitable development and growth stages.

Transportation Organization Enhancement: The evaluation of the roadway hall's capacity must be conducted to assess its impact on transportation efficiency improvements. This process requires a comprehensive examination of existing traffic conditions to determine proper traffic management solutions and develop strategies for better access to current transportation systems.

Versatility and Transformation Arranging: The identification of probable weaknesses and threats which emerge from the new expressway hall needs to be conducted because it serves as the main requirement for developing flexible response plans and adaptive planning approaches. The research aims to solve complex problems which will enable planners and policymakers and stakeholders to understand how a new roadway entrance will affect their city development and settlement patterns. The study aims to provide comprehensive research which will support informed decision-making and sustainable urban development practices.

C. Research Objective

- Investigate how throughway hallways affect social elements because they influence how people feel about their community and their personal happiness and their daily activities.
- The study examines how expressway hallway design affects the environment by studying its impact on air pollution noise pollution and the destruction of natural habitats.
- The development of sustainable settlement patterns along highway corridors requires the establishment of rules which protect existing green spaces and various development types through intelligent infrastructure design
- The policymakers and metropolitan planners need to receive informed arrangement recommendations which will boost positive outcomes from roadway passageways while minimizing their potential negative effects on development.

D. Limitations

- The review's dependability relies on the available information which includes details about parkway hall development and settlement patterns and economic indicators. The discovery strength will decrease because of incomplete or problematic information.
- The various regional conditions which exist throughout the different areas create obstacles for changing rehearsal schedules and managing financial resources and adapting to local geographical features. The study will face difficulties in achieving universal research conclusions because of the varying characteristics which exist in different regions.
- The review's profundity might be limited by time imperatives, which prevent researchers from studying long-term patterns. The long-term effects of parkway entryways on urban development can only be assessed through a complete study that requires more than a brief observation period.
- The existing study shows that people from different networks, organizations, and government offices have different views about the research topic. The study will report results from different research hypotheses but the research outcomes will limit the available findings.
- The urbanization process creates challenges which make it difficult to forecast upcoming urban development trends. The review's discoveries might be time-delicate, mirroring a particular period as opposed to representing possible changes from here on out.

2. Literature Review

The research study about highway corridor planning effect on urban development and settlement distribution patterns represents a fundamental research area because transportation systems lead to significant urban development. Research about

the connection between freeway corridors and development settlement patterns shows an existing research gap despite multiple studies which analyzed transportation planning and its effects on various social aspects. Research studies currently focus on how road construction impacts city planning while they fail to assess how these two systems work together. The research gap needs to be filled because it prevents people from understanding how highway systems and city planning systems work together to create development patterns which are both sustainable and balanced. The region needs this solution because it helps create all-inclusive plans which combine transportation and land use planning to build up resilient and thriving communities. The existing research lacks sufficient analysis of how different regions establish their planning guidelines because researchers focused solely on studying specific geographical contexts. The development of interstate corridors depends on the specific economic and environmental conditions which exist in each region. Planners need to conduct detailed regional research to develop planning solutions which match the unique requirements and challenges of each region, which will lead to successful urban development that matches local conditions. The research community currently lacks enough studies which investigate how highway entrances affect urban development and settlement patterns over extended time periods. The research of these development patterns needs to determine future changes because it helps envision possible obstacles and create sustainable urban planning systems. The complete research gap closure will provide vital information about how cities grow and help city officials and planners understand how highway development affects the built environment permanently. Addressing the research gap about highway entrance planning effects on development and settlement patterns enables researchers to create better environmental approaches which benefit all people living in the study area.

3. Methodology

A. Data Collection

1) Primary Data Collection

The planning implications primary data collection needs to use direct evidence from both authoritative figures and planning stakeholders. The collection process includes these elements:

- The team conducts physical site surveys to investigate the 61.8-kilometer section of NH 316 which includes 187 different settlements and various environmental social and economic conditions.
- The research study will conduct interviews with

essential stakeholders who include government officials and urban planners and environmental experts and local community representatives.

- The survey process involves distributing structured questionnaires which collect responses about planning-related perceptions and planning-related concerns.

2) Secondary Data Collection

- Secondary data is harnessed from existing literature, reports, documents poultry to a given highway corridor, including:
- There are various government reports outlining policies and regulations set out by the local government regarding what an individual can do with his/her piece of land.
- The existing reports must be reviewed to understand the expected environmental effects and the planned environmental protection methods which scientists have developed.
- The World Bank Documents contain policies and guidelines which researchers need to evaluate their effects on both local and national environmental conditions.

B. Data Analysis

Collected data, which includes details about settlements, population distribution (85,631 along NH 316), and corridor area (126.471 sq km), undergoes rigorous analysis using appropriate tools and techniques. The road is segregated into grids at 5.5 km intervals for a comprehensive understanding.

C. Limitations of the Study

The study acknowledges its research boundaries through its identification of three specific research limits which include data unavailability and time restrictions and resource limitations. The research chapter presents its methodology through a detailed description of the research design and data collection methods and analysis procedures and ethical standards and research limitations. The selected research method establishes a strong basis to conduct a detailed assessment of how planning practices impact development progress and settlement distribution in areas along NH 316.

4. Analysis and Data Interpretation

A. Bhubaneswar-Puri

The 4-laning project for National Highway 203 which now operates as NH-316 in the Bhubaneswar-Puri section reached its successful completion in 2017. The infrastructure project

Table 1

Settlements	Details	Population Distribution (along NH 316)	Corridor Area (km ²)
123	Town centers, villages	85,631	126.471

Table 2

Comparison of Bhubaneswar and Odisha

Feature	Bhubaneswar	Odisha
Population	1.1 Million	42 Million
Economy	IT, Education, Health Care	Agriculture, Mining
Infrastructure	Well-developed	Less developed
Standard of living	Higher than state average	Lower than national average

which extended 67.25 kilometers aimed to create better transportation links between Bhubaneswar and Puri in Odisha, India. The total project cost amounted to Rs. 500.29 crore, which reflects a major financial commitment toward building this essential transportation route. The project included various essential components which enhanced both regional infrastructure and traffic movement throughout the area. The construction project created four bypasses which functioned as bus stops that buses could use to pick up passengers. The major bridge which had four operational lanes, served as an important highway component that increased road capacity and highway capability. The construction project included two minor bridges which had two operational lanes each, designed to accommodate variations in local geographic features. A four-lane Railway Over bridge (ROB) was built to create uninterrupted road and rail connections which improved all transportation systems. The design of the project included two Vehicular Underpasses, which created uninterrupted road access in designated locations. The creation of a toll plaza established a funding source which would maintain the improved highway system. The project included ten Bus Bays which established public transport amenities for passengers to access the bus service. The two Truck Lay bays established along the corridor were intentionally located to handle logistics operations, which resulted in smoother goods transportation along the route. The 4-laning project on the Bhubaneswar-Puri section of NH-316 reached its 2017 completion, which marked an important achievement for regional infrastructure development. The project expanded the road capacity through multiple construction projects which enhanced both traffic control systems and safety measures while improving connections between Bhubaneswar and Puri.

B. The Role of NH 316 in Odisha

The Bhubaneswar to Puri Section of National Highway 316 functions as an essential transportation link which connects important economic centers through its route between Uttara and Pipili and Dandamkundapur and Sakhigopal and Chandanpur. The corridor functions as a vital route because it provides daily access to over 8000 users who need to travel its entire length. People use this route for various purposes which range from work commuting to vacation trips and other personal activities. The Bhubaneswar to Puri corridor holds great importance because its current function generates benefits which affect all economic and social and human development components throughout the entire region. The National Highway 316 development through its initial construction and later expansion activities brought about major improvements to regional transportation networks. Highway development and improvement work have created direct advantages which help maintain uninterrupted traffic flow on the highway system. The corridor now operates with improved efficiency because of shorter travel times which have transformed it into the main commuting route. The system uses passenger safety measures as its main focus to build an efficient transportation network which users can trust for their safety needs.

The Indian government has made a major investment to

develop and improve highway systems throughout the country. The financial commitment extends beyond the physical materials of asphalt and concrete because it demonstrates that established transport networks drive complete development. The Bhubaneswar to Puri corridor generates effects that extend beyond its immediate area to impact neighboring areas. The corridor functions as an economic link that connects active commercial hubs by enabling movement between them. The highway improvements lead to better access which results in increased economic activity for the nodes located along the route that includes Uttara, Pipili, Dandamkundapur, Sakhigopal, and Chandanpur. The whole region benefits from this development which leads to increased economic prosperity. The business sector experiences growth while trade activities increase which results in a better economic environment for the entire region. The corridor serves as a unifying element that connects different social groups within the community. Over 8,000 people who travel to work each day create opportunities for social contacts and cultural sharing between different communities. The area establishes a network of connected communities who depend on one another for their development. The corridor serves as a route for people to experience life together through celebrations and daily activities. The Bhubaneswar to Puri corridor creates new possibilities for human development through its existing framework. The system enables people to travel between locations which helps them find jobs and maintain their economic stability. The corridor creates a major effect on tourism because it links Bhubaneswar with Puri which is a city known for its rich cultural heritage. The region experiences an increase in tourism activities while its traditional cultural practices remain intact and are actively promoted through this initiative.



Fig. 2. NH 316

The National Highway 316 Bhubaneswar to Puri Section represents more than its function as a roadway. It showcases the entire journey from development to progress and connectivity. The road carries vehicles which for daily operation bring both drivers and the essential hopes and dreams and economic resources belonging to nearby communities. The corridor serves as a demonstration of how properly designed infrastructure systems can create better economic social and human development outcomes for areas which maintain strong connections. The corridor proves that building transportation systems will lead to national prosperity and citizen happiness.

C. Methodology

The impact assessment study serves as an essential tool which enables researchers to evaluate how the transport corridor affects development in nearby regions and settlement patterns that develop along the highway. The study examines how various factors, including economic activities and demographic changes and social dynamics and infrastructure development, affect settlements. The transportation corridor requires an impact assessment study which examines its effects on adjacent regions and the development of settlements along the highway. The study aims to identify all the different ways that a transport corridor affects settlements by studying how economic activities and demographic shifts and social dynamics and infrastructure development evolve over time. The study serves two essential purposes which include assessing immediate impacts and creating a detailed understanding of permanent effects that will help achieve sustainable development objectives. The assessment process begins with the evaluation of economic activities as the primary element that will be examined. The transport corridor serves as a trade route which enables surrounding communities to start economic activities. The corridor creates economic benefits for both its direct connections and the surrounding areas which experience secondary effects. The settlements become economically better off when economic activities experience growth through increased trade volume and new business creation and better access to markets. The economic changes require assessment because they demonstrate how the transport corridor affects the economic development of neighboring regions. The impact assessment study analyzes demographic changes as a fundamental component of its research. The corridor affects population movements through migration and settlement patterns which creates changes in demographic composition. The analysis requires determining whether the transport corridor attracts people who move from rural areas to urban centers or whether it promotes uniform population growth between these areas. The study uses demographic data to analyze how population changes create social problems and social implications for society. Social dynamics form a nuanced layer of the impact assessment, which analyzes how communities and social structures undergo transformation through social impacts. The corridor functions as a social interaction catalyst through its role in improving connectivity which enables cultural sharing among different communities. The study needs to identify positive social impacts which create stronger social links and shared cultural experiences and social problems which include equity challenges and inclusivity issues and cultural heritage protection problems. Social dimension analysis becomes essential for developing strategies which need to use positive elements while reducing negative social effects. The corridor impacts settlements through its infrastructure development which creates physical changes in the entire area. The study investigates how the transport corridor affects infrastructure development by examining both road networks and utility systems and public service facilities. The study assesses when the corridor creates infrastructure enhancements which enable better goods and people movement, and when

infrastructure development projects need to fix problems related to congestion and environmental protection. The corridor relationship with infrastructure development requires understanding because it forms the basis of all sustainable urban and rural planning methods.

The impact assessment study which studied a transport corridor's effects on settlements along the highway requires multiple research methods to complete its work. The research needs to investigate economic and demographic and social and infrastructural elements because this investigation needs to identify the complex relationships between these elements. The study shows immediate impacts through its exploration of these parameters while providing important information to help policymakers and urban planners and community stakeholders reach their sustainable development goals. The study functions as a guide which helps societies and regions that transport corridors connect to use their transformative power in a responsible manner.

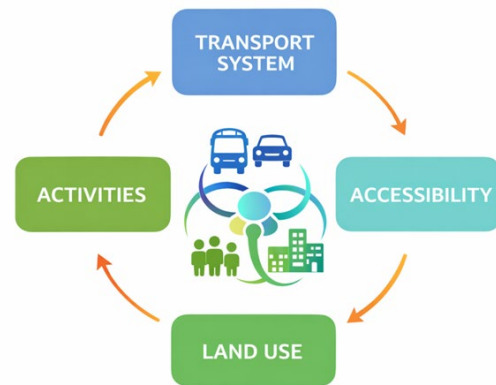


Fig. 3. Illustrates the mutual Inter-Dependency of land use and transportation

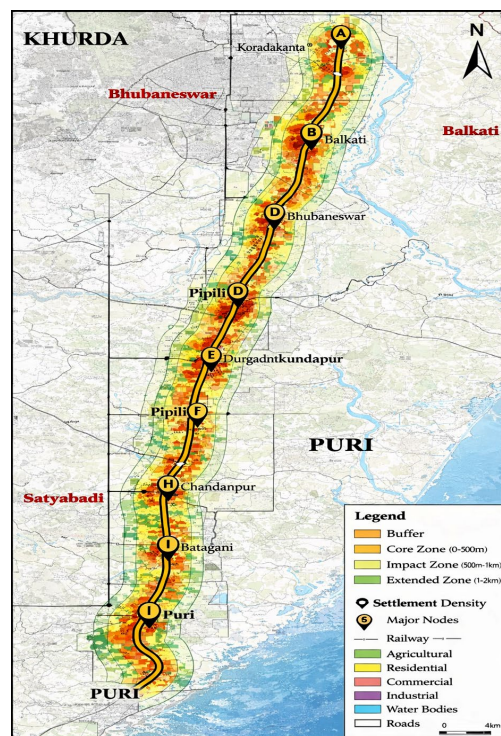


Fig. 4. Bhubaneswar to puri section

The demographic study from Bhubaneswar to Puri along NH 316 has revealed complete details about the settlement patterns and the distribution of residents in the area. The 61.8 km stretch contains 187 settlements which include 25 urban areas and 162 rural areas. The corridor has a total population of 85,631 people which helps to reveal the various demographic groups that exist in the region. Dandamukundapur has the largest number of residents, while Chandanpur has the second most inhabitants in the area. The corridor has a total area of 126.471 square kilometers which includes a 1 kilometer extension on both sides of NH 316. The geographical area and the population distribution along the road can be shown through the process of precise border establishment. The data reveals how populations move in different settlements while showing the demographic information which exists throughout the entire corridor. The detailed information functions as a basic resource which will be used to conduct more extensive research and develop strategic plans while also helping to identify the particular requirements and obstacles which exist along the NH 316 corridor.

charts demonstrate that four-person households represent the most prevalent family structure which shows that both graphs depict the same family size pattern.

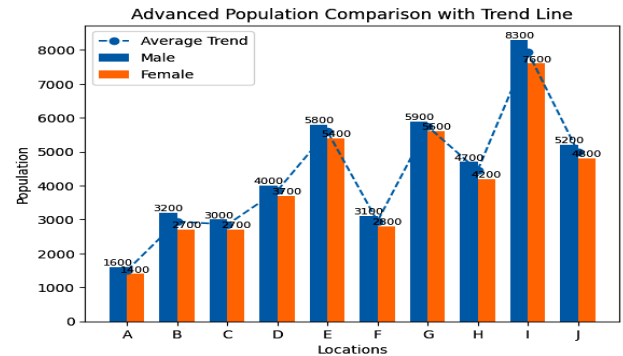


Fig. 6. Number of people by gender

Table 5
Socio economic level

Socio-Economic level	Percentage
Primary	42%
Secondary	48%
Tertiary	10%

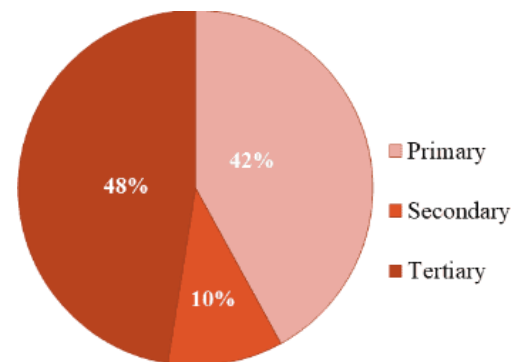


Fig. 7. Population map visually represents the socio-economic levels

Table 3
Household size distribution in two populations

Household Size	Percentage (Left Pie Chart)	Percentage (Right Pie Chart)
1	16%	19%
2	7%	7%
3	14%	10%
4	13%	13%
5	13%	13%
6	8%	9%
7	10%	12%
8 or more	4%	3%
Average Household Size	5	5

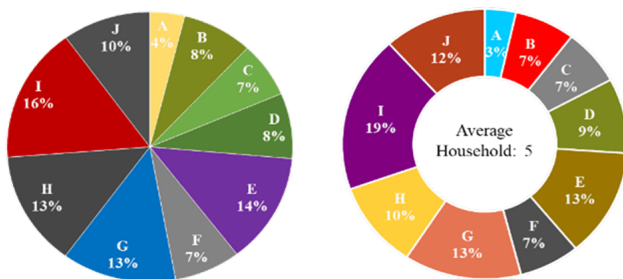


Fig. 5. Household size distributions in two populations

The analysis of two pie charts which show US household sizes demonstrates multiple significant patterns and matching characteristics between the two visual representations. The first finding shows that both pie charts display an average household size of 5 people which establishes a consistent trend of moderate-sized households throughout the studied area. The

The Population Map in Figure 7 shows the socio-economic distribution along NH 316 from Bhubaneswar to Puri section. The entire area shows Grid I as the location with the highest number of working people.

The table 6 shows how people distribute across different categories (A through J) based on their employment status, which includes two groups: "Working" and "Non-Working." The "Working" category shows that Category J has the highest number of employed individuals at 10,610, while Categories F and E follow with 5,836 and 4,871 employed people, which suggests these sectors serve as important community areas.

Table 4
Number of people by gender

Category	A	B	C	D	E	F	G	H	Total
Male	3211	3067	7974	5393	5572	5291	4130	1329	39997
Female	-	-	-	-	-	-	-	-	-
Total	3211	3067	7974	5393	5572	5291	4130	1329	39997

Table 6
Working and non-working

Category	A	B	C	D	E	F	G	H	J
Working	1873	3588	3262	2279	4871	5836	4356	4195	10610
Non-Working	1133	2500	2803	3042	3281	5328	6773	7195	3543

Table 7
Socio economic environment

Category	Working	Non-Working
A	1873	1133
B	3588	2500
C	3262	2803
D	2279	3042
E	4871	3281
F	5836	5328
G	4356	6773
H	4195	7195
J	10610	3543

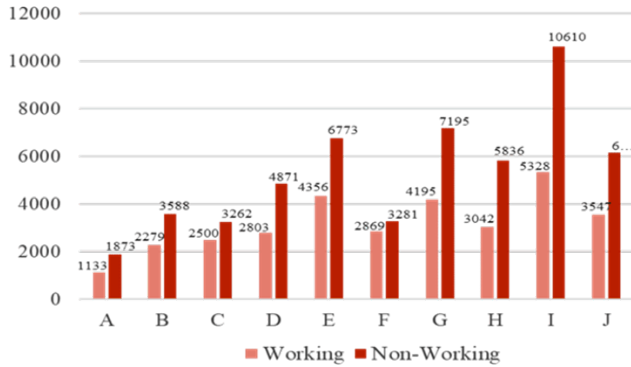


Fig. 8. Working and non-working population

Table 8
Working and non-working population

Category	Working Age Population	Non-working Age Population
A	69	12
B	63	19
C	60	21
D	-	35
E	-	33
F	-	30
G	44	30
H	32	12

The table 8 shows the working-age population and non-working-age population data for various categories from A to H. In Category A, there are 69 individuals in the working-age population and 12 in the non-working-age population.

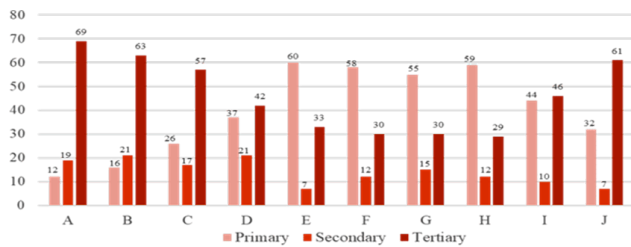


Fig. 9. Workforce participation rate

Table 9
Working age population and non-working age population

Category	Working Age Population	Non-working Age Population
A	69	12
B	63	19
C	60	21
D	-	35
E	-	33
F	-	30
G	44	30
H	32	12

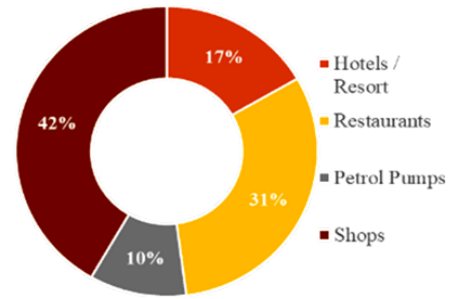


Fig. 10. Workforce participation populations

The Workforce Participation Population shows the economic activity distribution through grids which run along NH 316 from Bhubaneswar to Puri section. Grid E shows the most people who work in primary activities because it has the highest number of people who practice this work.

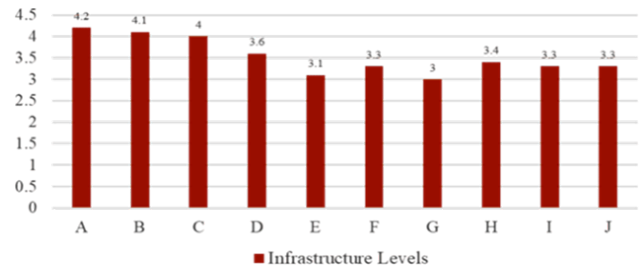


Fig. 11. Infrastructure levels

Table 10
Infrastructure levels

Category	Percentage
Physical	37%
Social	63%

The table 10 presents a breakdown of categories labeled as "Physical" and "Social," each accompanied by its respective percentage.

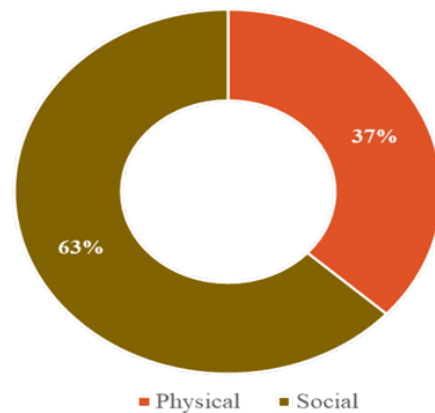


Fig. 12. Workforce participation populations

Table 11
Percentage of budget allocated to different areas

Category	Percentage
Education	30%
Health	25%
Public	13%
Utilities	21%
Recreational	11%
Religious	0%

The table 11 shows how different percentages are distributed among three groups which are named "Power" "Water" and "Sanitation." The percentages show how important different resources distribution is for particular situations which involve either infrastructure development or service delivery or resource management activities.

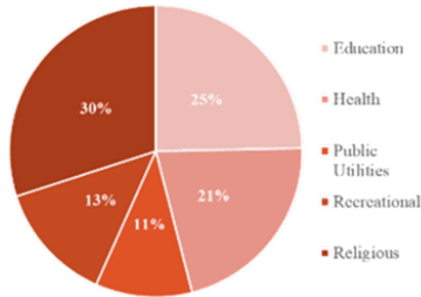


Fig. 13. Social infrastructure

Table 12
Delineates the distribution of percentages

Category	Percentage
Power	20%
Water	25%
Sanitation	55%

The table 12 shows how different percentages are distributed among three groups which are named "Power" "Water" and "Sanitation." The percentages show how important different resources distribution is for particular situations which involve either infrastructure development or service delivery or resource management activities.

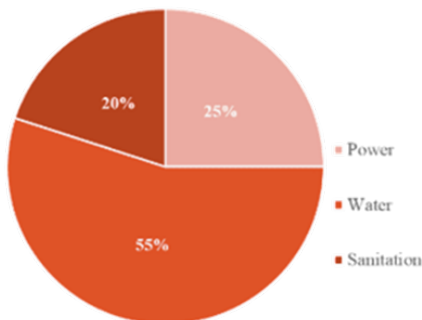


Fig. 14. Physical infrastructure

Table 13
Distribution of Percentages

Category	Percentage
Power	20%
Water	25%
Sanitation	55%

The table 13 presents percentage distributions across three categories which include Power and Water and Sanitation. The percentage comparison between the different categories demonstrates a clear preference for resource distribution which establishes sanitation as the top priority followed by water and power. The analysis enables researchers to see how different

critical categories receive funding in the specific context of the study which helps them comprehend how the study prioritizes various resources.

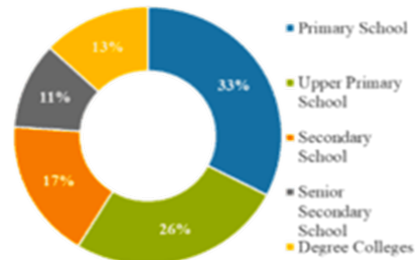


Fig. 15. Educational activities

Table 14
Percentage distribution by category

Category	Percentage
6%	6%
13%	13%
31%	31%
50%	50%
Veterinary	Unknown (not specified in the graph)
Howpatal	Unknown (not specified in the graph)

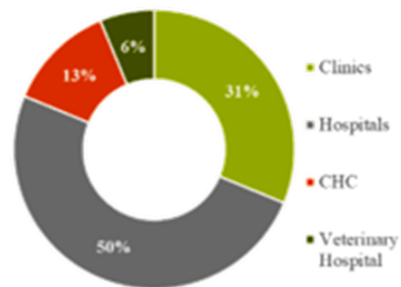


Fig. 16. Health activities

Table 15
Distribution of community facilities

Station	Percentage
Post Office	18%
Police Station	27%
Hall	37%
Others	9%

The table 15 presents percentage distribution data for various station types which includes Post Office and Police Station and Hall and Others.

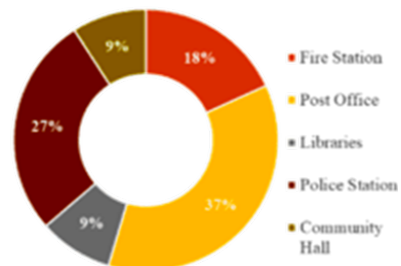


Fig. 17. Public utilities

The corridor land use depiction in Figure 18 uses Arc GIS software to create a graphical representation which serves as an essential resource for defining the area's characteristics and operational capabilities.

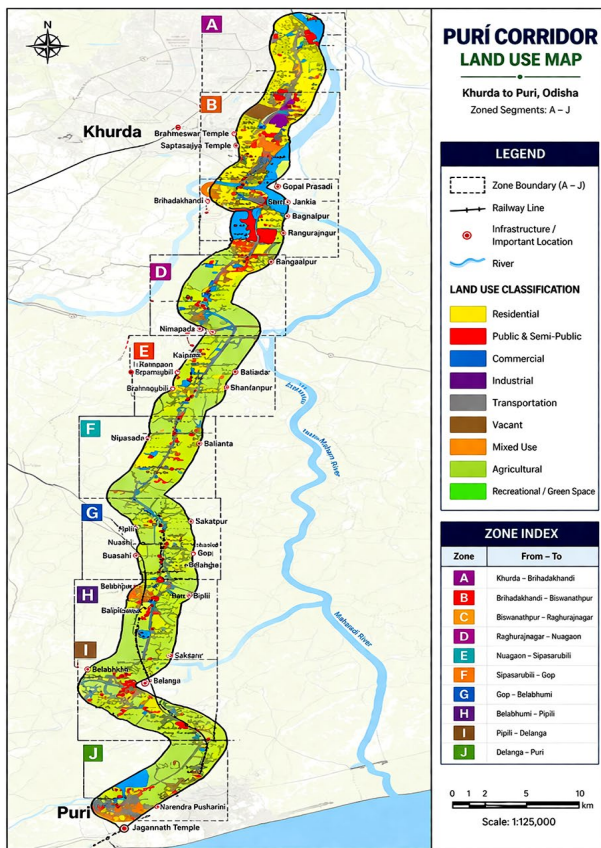


Fig. 18. Land use map

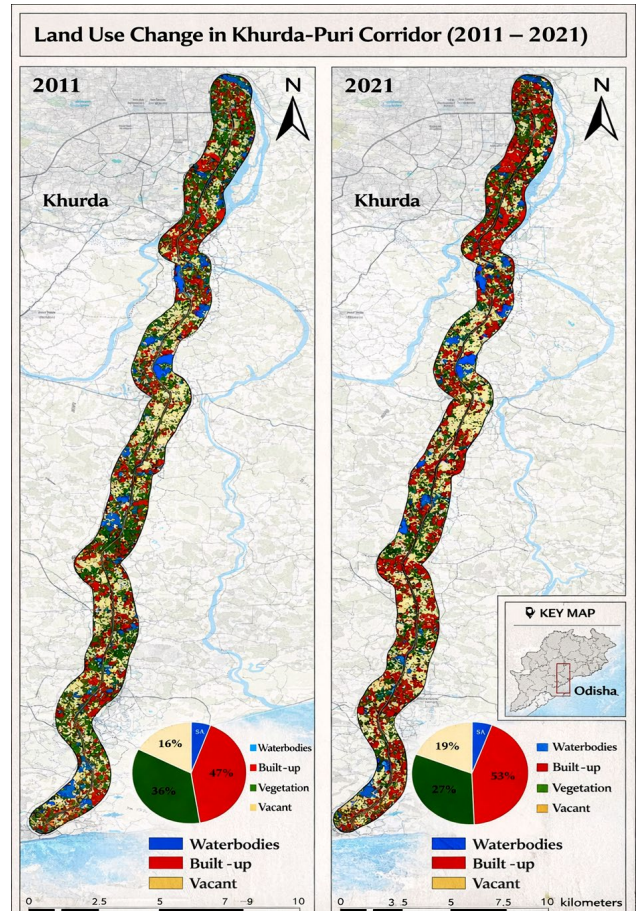


Fig. 20. Land cover change

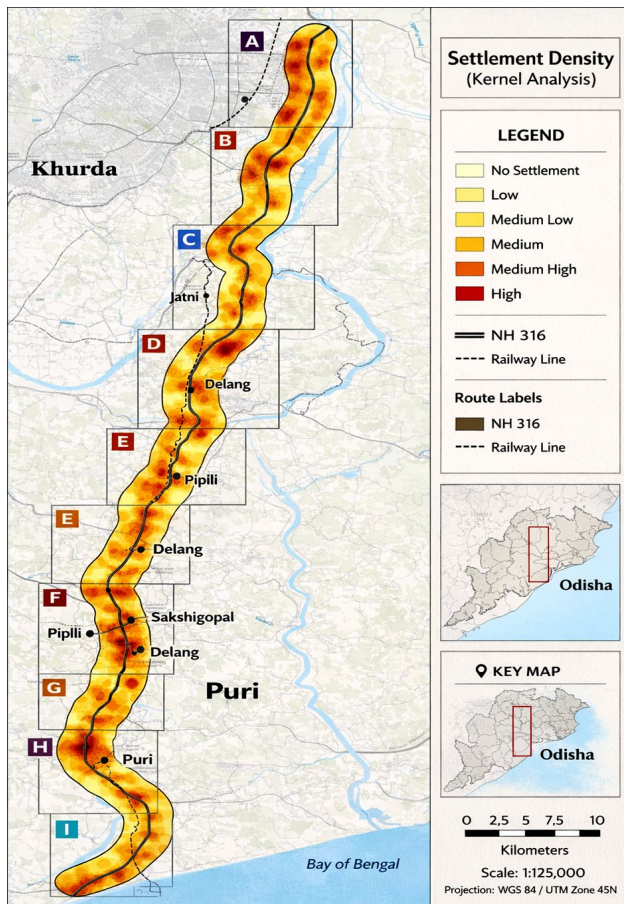


Fig. 19. Settlement structure through kernel density

5. Result and Discussion

The development index results from assessing three different areas which include demographic data and socio-economic conditions and infrastructure development.

The Development Index measures the average value of Demography and socio-economic indicators and infrastructure services that exist throughout the corridor.

Grid I and E will be developed by combining Transit Oriented Development (TOD) with their existing infrastructure. The TOD framework provides sustainable urban development through its design which combines land use and transportation systems to create high density mixed land-use areas. The main objective of the project is to enhance infrastructure development while constructing an eco-tourism corridor which will bring economic benefits.

A. Vision of Transit Oriented Development Integration

Enable Transformation: One of the assistance providers is transit-oriented development which is already in the system.

Compact Walkable Communities: The enthusiast, so they can have compact, walkable, and affordable communities to produce-where nothing is very remote for the purposes of living, procreate, et cetera.

Accessible Public Transport: The project aims to enhance public transport accessibility for nearby settlements which will result in increased use of public transport and promote environmentally friendly transportation methods.

Table 16
Grid F illustrates lowest levels of development in the stretch

Category	Grid F Value	Interpretation
Demographics	2.6	This is the lowest score for demographics across all rows, potentially indicating an unfavorable age structure, low population density, or limited educational attainment.
Socio-Economic	3.1	While not the lowest score, it's still significantly lower than most other regions. This might suggest challenges with income levels, employment opportunities, or access to essential goods and services.
Infrastructure	3.3	Again, not the lowest but still one of the weakest scores. This could point to underdeveloped transportation networks, inadequate communication infrastructure, or poor housing quality.
Overall Score	3.2	The lowest overall score in the table indicates Grid F lagging behind in all three crucial aspects of development compared to other regions.

Table 17
Grid A and B has the highest levels of development as they are a part of BMC

Category	Grid A	Grid B	Interpretation
Demographics	2.3	3.2	Both grids score above average, suggesting favorable age structure, population density, and education levels. Grid B potentially has a slight edge.
Socio-Economic	2.1	2.7	Both grids excel in this category, indicating strong income levels, employment opportunities, and access to amenities. Grid B exhibits slightly higher economic prosperity.
Infrastructure	4.2	4.1	Both grids boast exceptional infrastructure, with well-developed transportation, communication networks, and utilities. Grid A has a slight lead in infrastructure development.
Overall Score	4.3	4.3	Both grids achieve the highest overall score, demonstrating well-rounded development across all categories. They are statistically tied in overall development.

Table 18
Grid I and E are the Transition zones where development in terms of infrastructure is required

Grid	Infrastructure Score	Interpretation	Recommendations
I	3.2	Moderately developed infrastructure, falling below the average of neighboring grids.	<ul style="list-style-type: none"> - Invest in upgrading transportation networks (roads, bridges). - Improve communication infrastructure (internet access, mobile coverage). - Enhance existing utilities (water supply, sanitation, waste management).
E	3.1	Relatively weak infrastructure, among the lowest scores in the corridor.	<ul style="list-style-type: none"> - Prioritize significant infrastructure improvements. - Expand and modernize transportation infrastructure. - Bridge infrastructure gaps in communication networks. - Address critical needs in essential utilities.

Table 19
Levels of development index

Grid	Demography	Socio-Economic	Infrastructure	Levels of Development
A	2.3	2.1	4.2	4.3
B	3.2	2.7	4.1	4.3
C	2.8	2.9	4	3.8
D	3.5	3.3	3.6	3.6
E	4.4	4.2	3.1	3.8
F	2.6	3.1	3.3	3.2
G	4.1	4.3	3.1	3.6
H	4	3.9	3.4	3.6
I	4.9	4.8	3.2	4
J	3.8	4	3.3	3.9

Mixed Land use: The corridor area with mixed land use requires public amenities and recreational open spaces together with shopping areas to fulfill basic work needs.

Infrastructure upliftment: The construction work needs to proceed because it will improve both the infrastructure system and the standard of living for residents who live in the corridor area.

B. Implementing Strategies and Recommendations








The implemented strategies will boost inter municipal collaboration within the corridor which connects two districts. The primary requirement establishes shared objectives and shared advantages which both parties will attain through their identical understanding of their common identity. The collaborative framework enables municipalities to achieve development targets which create a bonding experience for their communities and produce joint advances. The corridor

development plan will boost tourist activities through its recognition of the area as a cultural heritage site. The corridor enables business expansion while it functions as a key resource for visitors who wish to experience the area's authentic historical sites. The area between high commercial zones will serve as the primary location to develop various land uses which will support economic growth. The planned development approach creates new business activities which will lead to increased employment opportunities while it decreases travel expenses and enhances transportation access. The development proposal recommends building corridor areas through the creation of interconnected mini-city clusters. The designed development plan establishes a network of towns which will optimize both land distribution and infrastructure design through its appropriate spacing between settlements. The corridor development plan prioritizes healthcare as it requires building more medical facilities along the highway to improve

safety conditions and reduce accident aftermath. The proposed system of Transit-Oriented Development (TOD) will help increase female workforce participation in the labor market. The implementation of TOD will decrease travel distance requirements which will boost female employment and bring

economic advantages. The buffer zones require immediate action to stop urban development from expanding beyond their boundaries. The proposed strategy allows the populated areas to develop compact developments which provide easy access to the transit corridor. The developed method enables companies

Table 20
TOD criteria with applicability in grid I and E

S. No.	Criteria	Applicability	
		Grid I	Grid E
1	 Population Density Mixed Land use	Population Density of 1081.48/sqkm. Highest populated village is Chandanpur.	Population Density of 880.36/sqkm. Highest populated village is Dandamukundapur.
2	 Walk/Cycle	Propose Diverse functions of land along NH & near major Settlements to ensure accessibility. Increase in employment opportunities.	Propose Mixed Land use pattern in the road junctions & in major settlements. Would lead to reduction in Transport Cost (Time & Operation Cost).
3	 Economic Development	Widening and maintenance of the roads connecting the Settlements to the NH so as to promote walk /cycle.	To develop inclusive habitat so that people dependent on public Transport can walk/cycle to transits tops of NH.
4	 Mass Transit System	Major work force is engaged in Tertiary activities. Attract external audience for transit and boost the Cultural economies. Greater participation of women and senior citizens in work force.	Major work force is engaged in Primary activities. Localization of business would ensure lower Local price and wider choice. Would lead to creation of jobs in non-agricultural sectors of the economy.
5		Malatipatapur Bus Stand with Bus transit stops and Malatipatapur Railway Station are the major transit stations of the section.	Bus transit stops along the NH are the major transit stations. High density zones would increase the share of transit of public transport.
6	 User-Friendly Accessibility	To meet the daily needs use of Public transport or by cycling /walking result in reduction in Pollution & congestion.	To ensure development with special attention to safety of women, children, senior citizen and differently able by creation of basic infrastructures.
7		Existing local roads with in the corridor needs to be Redeveloped & maintained. To establish a dense road network ensuring safe & easy Movement along with connectivity of NMTs.	To promote live able and affordable communities, which are compact, walkable and accessible? To ensure development with special attention accessibility for senior Citizen and differently abled.

to consolidate their financial resources which leads to better infrastructure management and supports the establishment of sustainable development methods that reduce costs.

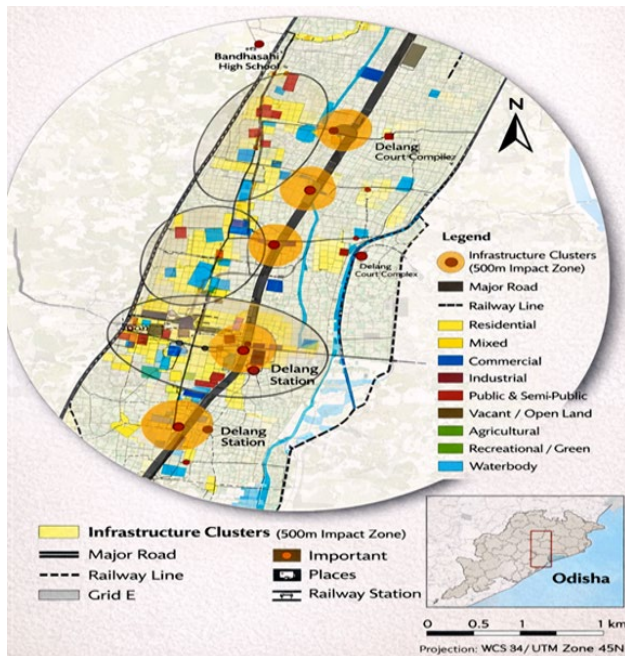


Fig. 21. Grid E Proposed land use map

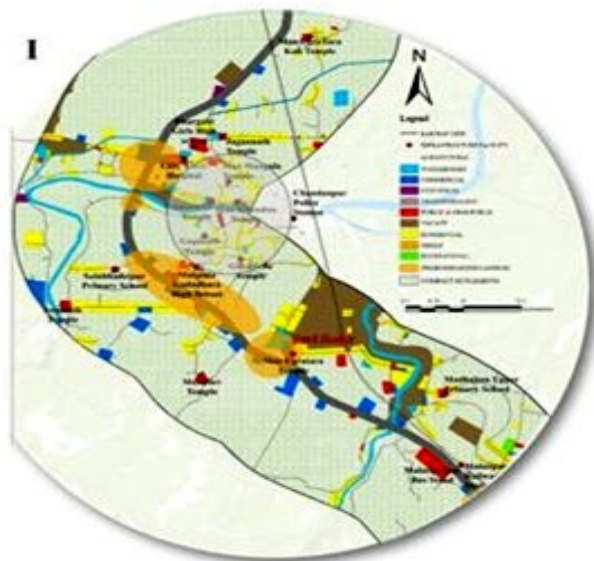


Fig. 22. Grid I Proposed land use map

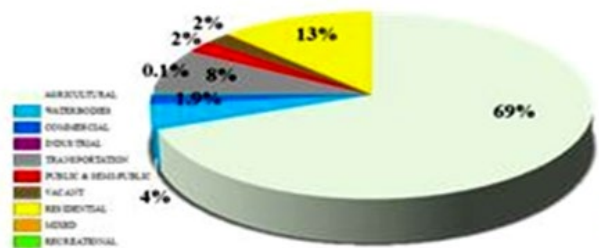


Fig. 23. Land use percentage of grid E

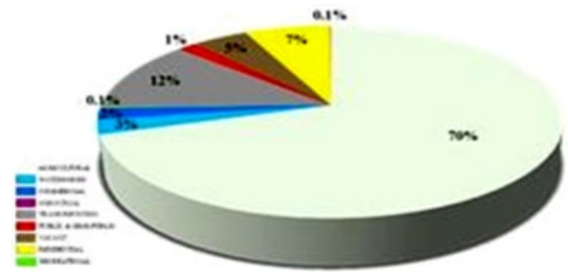


Fig. 24. Land use percentage grid I

6. Conclusion

The research findings indicate that Transit-Oriented Development (TOD) implementation in transition areas along NH 316 from Bhubaneswar to Puri would result in considerable economic benefits and improved living standards for the local population. The base of this recommendation relies on the established connection between land use patterns and transportation systems. The relationship between these two elements needs to be understood and used for sustainable urban development. The research presents an extensive evaluation of growth drivers which demonstrates the important impact of demographic changes and socio-economic factors and existing corridor infrastructure on growth. The study creates a complete picture of the corridor's current status by defining existing facility indexes and studying settlement distribution. The assessment establishes a vital base which supports strategic choices and specific actions that drive balanced and resilient growth.

The strategic implementation of Transit-Oriented Development (TOD) serves as an effective solution for urban development challenges. The planning method of TOD establishes transit-based development through its combination of land use and transportation systems into compact areas which include multiple types of buildings. Through its development functions, TOD establishes essential transportation links which enhance both land development efficiency and public access to different locations. The application of TOD principles in NH 316 requires developers to establish all types of development sites for residential and commercial and institutional use at locations which provide access to transit terminals. The study promotes local road redevelopment projects because all transport systems operate as interconnected links. The enhanced local roads within the corridor create better access to all areas while providing direct transit connections to nearby towns. The integrated system operates successfully because it develops active regions which people can explore on foot while they reach public transport and public facilities and work locations. The research demonstrates how land use patterns and transportation systems exist in a mutually dependent relationship. The proposed integration of Transit-Oriented Development, coupled with the redevelopment of local roads, is envisioned as a successful strategy to catalyze economic growth and elevate the standard of living in the transition areas along NH 316. The complete method to urban planning achieves sustainable urban development through its ability to build resilient systems which create better living conditions for

all people who live in the corridor.

References

- [1] W. Chen, Y. Zeng, and J. Zeng, "Impacts of traffic accessibility on ecosystem services: An integrated spatial approach," *Journal of Geographical Sciences*, vol. 31, pp. 1816–1836, 2021.
- [2] Z. Chen, Y. Zhou, and K. E. Haynes, "Change in land use structure in urban China: Does the development of high-speed rail make a difference?" *Land Use Policy*, vol. 111, Art. no. 104962, 2021.
- [3] M. Diao, Y. Zhu, and J. Zhu, "Intra-city access to inter-city transport nodes: The implications of high-speed-rail station locations for urban development," *Urban Studies*, vol. 54, no. 10, pp. 2249–2267, 2017.
- [4] S. Dong *et al.*, "An evaluation of the economic, social, and ecological risks of China–Mongolia–Russia high-speed railway construction," *Journal of Geographical Sciences*, vol. 28, no. 7, pp. 900–918, 2018.
- [5] M. R. Dove, "Rubber versus forest on contested Asian land," *Nature Plants*, vol. 4, pp. 321–322, 2018.
- [6] A. S. Flecker *et al.*, "Reducing adverse impacts of Amazon hydropower expansion," *Science*, vol. 375, no. 6582, pp. 753–760, 2022.
- [7] M. Granovetter, "Economic action and social structure: The problem of embeddedness," in *The Sociology of Economic Life*. Routledge, 2018, pp. 22–45.
- [8] T. Guillaume *et al.*, "Carbon costs and benefits of Indonesian rainforest conversion to plantations," *Nature Communications*, vol. 9, Art. no. 2388, 2018.
- [9] T. Brinkhoff, "The principal agglomerations of the world," [Online]. Available: <https://www.citypopulation.de/en/world/agglomerations/>
- [10] P. Wang and P. Waddell, "UrbanSim: Modeling urban development for land use, transportation, and environmental planning," *Journal of the American Planning Association*, vol. 68, no. 3, pp. 297–314, 2002.
- [11] Y. Wang *et al.*, "Impacts of linear transport infrastructure on terrestrial vertebrate species and conservation in China," *Global Ecology and Conservation*, vol. 38, Art. no. e02207, 2022.
- [12] C. Xiao *et al.*, "Population boom in the borderlands globally," *Journal of Cleaner Production*, vol. 371, Art. no. 133685, 2022.
- [13] C. Xiao *et al.*, "Sentinel-2 red-edge spectral indices suitability for mapping rubber boom," *International Journal of Applied Earth Observation and Geoinformation*, vol. 93, Art. no. 102176, 2020.
- [14] C. Xiao *et al.*, "Global border watch: From land use change to joint action," *International Journal of Applied Earth Observation and Geoinformation*, vol. 103, Art. no. 102494, 2021.
- [15] C. Zeng *et al.*, "Effect of complex road networks on intensive land use in Beijing–Tianjin–Hebei," *Land*, vol. 9, no. 12, Art. no. 532, 2020.
- [16] J. Zhai *et al.*, "Spatio-temporal patterns of land-use changes in the Mekong River Basin," *Land*, vol. 11, no. 6, Art. no. 927, 2022.
- [17] F. Zheng *et al.*, "Impact of the Kunming–Bangkok highway on land use changes," *Land*, vol. 10, no. 9, Art. no. 991, 2021.
- [18] F. Zheng, C. Xiao, and Z. Feng, "Impact of armed conflict on land use changes in border areas," *Land Degradation & Development*, vol. 34, no. 3, pp. 873–884, 2023.
- [19] Z. Zeng *et al.*, "Highland cropland expansion and forest loss in Southeast Asia," *Nature Geoscience*, vol. 11, pp. 556–562, 2018.
- [20] P. Adler and R. Florida, "Geography as strategy," *Regional Studies*, vol. 54, no. 5, pp. 610–620, 2020.
- [21] S. P. Bharule and T. Kidokoro, "Indian cities in transition," in *Proc. APPS Conference*, Nagoya, Japan, 2017.
- [22] C. L. Chen *et al.*, "Spatial implications and planning challenges of high-speed rail," *European Planning Studies*, vol. 27, no. 3, pp. 415–433, 2019.
- [23] Ministry of Statistics and Programme Implementation, "National industrial classification," 1998. [Online]. Available: <http://mospi.nic.in>
- [24] H. Komikado *et al.*, "High-speed rail, accessibility, and regional innovation," *Technological Forecasting and Social Change*, vol. 167, Art. no. 120697, 2021.
- [25] J. Murakami and R. Cervero, "High-speed rail and economic development," in *High-Speed Rail and Sustainability*.
- [26] H. Yang, *High-speed railways and urban networks in China*. Enschede: Ipskamp Printing, 2018.
- [27] H. Yang *et al.*, "Spatial structure of high-speed railways and urban networks in China," *Tijdschrift voor Economische en Sociale Geografie*, vol. 109, no. 1, pp. 109–128, 2018.