Planning the Peri-Urban Expansion: A Case of Ring Road of Bhubaneswar, Capital Region, Odisha

Bachelor of Planning

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DECLARATION

I **PRAGYA KOLPAL** Scholar No **2211002117** hereby declare that the thesis titled Planning the peri Urban Expansion: A Case of Ring road f Bhubaneshwar, Capital Region, Odisha submitted by me in partial fulfilment for the award of degree of Bachelor of Planning, at Maulana Azad National Institute of Technology, Bhopal, India, is a record of Bonafide work carried out by me. The matter/result embodied in this thesis has not been submitted to any other University or Institute for the award of any degree or diploma.

Pragya

Signature of the Student

Date: 08/05/26

CERTIFICATE

This is to certify that the declaration made by **PRAGYA KOLPAL** is true to the best of my knowledge and that the student has worked under my guidance for one semester in preparing this thesis.

RECOMMENDED

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Date: 8/05/26

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सारांश

भुबनेश्वर, ओड़िशा की राजधानी तथा तेजी से विकसित होने वाला शहर, अपनी सफलता की दौड़ में आगे बढ़ रहा है। जैसे-जैसे शहर का केंद्रीय क्षेत्र संतृप्त होता जा रहा है, विकास शहर की सीमाओं की ओर फैल रहा है — उन नाजुक स्थानों में जहाँ शहर ग्रामीण परिदृश्य से मिलता है। इन सीमान्त क्षेत्रों में रहने वाले लोगों के लिए यह विस्तार अक्सर योजना का नहीं, बल्कि भौगोलिक संयोग का परिणाम है।

यह शोध 111 कि.मी. कैपिटल रीज़न रिंग रोड (सीआरआरआर) को केवल एक आवाजाही मार्ग के रूप में नहीं, नीति निर्माण की एक रीढ़ के रूप में देखता है जो इस अनियंत्रित विकास को रहने योग्य, सेवायुक्त बस्तियों में व्यवस्थित कर सकती है — कंक्रीट डाले जाने से पहले ही।

यह शोध पिछले 15 वर्षों में शहर के विस्तार (स्प्रॉल) का विश्लेषण करता है और 2035 तक के संभावित विकास का अनुमान लगाता है। CA-मार्कोव मॉडलिंग और GIS मानचित्रण तकनीकों का उपयोग करते हुए, शोध विकास के ताप क्षेत्रों (Growth Heat Zones) और सेवा अंतरालों (इंफ्रास्ट्रक्चर गैप्स) की पहचान करता है।

समाधान का केंद्रीभूत तत्व भूमि संचयन (Land Pooling) है — एक मानवीय दृष्टिकोण वाला दृष्टिकोण जो भूमिधारकों को साझेदार मानता है। वे अपनी भूमि का एक हिस्सा सार्वजनिक उपयोग — पार्क, सड़कें, सेवाएँ — के लिए देते हैं, और बदले में उन्हें छोटा लेकिन मूल्यवान एवं सेवायुक्त भूखंड मिलता है। इससे सुनिश्चित होता है कि भुबनेश्वर केवल बड़ा नहीं होता, बल्कि बहुकेंद्रीय (Polycentric) शहर बनता है — सभी निवासियों के लिए समान और सतत।

शोध भुबनेश्वर विकास प्राधिकरण (BDA) क्षेत्र में तीन प्रमुख विकास आलोक क्षेत्रों (Hot Zones) की पहचान करता है। उत्तरी फ्रिंज में ज्ञान गलियारा (Knowledge Corridor), दक्षिण-पश्चिम फ्रिंज में आवासीय विस्तार, और दक्षिणी फ्रिंज में औद्योगिक/लॉजिस्टिक्स नोड शामिल हैं। प्रत्येक क्षेत्र के लिए एक विशिष्ट भूमि संचयन योजना प्रस्तावित है जो ओड़िशा भूमि संचयन नियम, 2015 के अनुरूप है। उत्तरदायी शासन, वित्तीय व्यवहार्यता, और सड़क, जल, सीवरेज और खुली जगह जैसी बुनियादी सेवाओं के सर्वत्र उपलब्ध होने को सुनिश्चित करते हुए यह शोध भुबनेश्वर के लिए एक नियंत्रित विकास का रीढ़ मॉडल प्रस्तुत करता है।

ABSTRACT

Bhubaneswar, the capital of Odisha and one of India's most significant planned cities, is facing a development paradox: while its core has been shaped by decades of master planning, its peri-urban periphery is expanding rapidly and chaotically, driven by market forces far outpacing the reach of statutory governance. The city's spatial footprint has grown by approximately 89.7% between 2010 and 2025, absorbing surrounding villages and spilling into the rural hinterland of the Bhubaneswar Development Authority (BDA) jurisdiction. This unmanaged edge growth, which now accounts for nearly 68.3% of all new construction in the BDA region, is creating a fragmented urban landscape characterized by acute infrastructure deficits, governance vacuums, and environmental vulnerabilities.

At the centre of this dynamic is the proposed 111 km Capital Region Ring Road (CRRR) — a transformative piece of infrastructure that has the potential to either exacerbate existing sprawl patterns or serve as a "planning backbone" for organized peri-urban development. This study investigates the Ring Road not merely as a mobility corridor, but as a once-in-a-generation opportunity to reshape the spatial structure of the Bhubaneswar metropolitan region through proactive, integrated planning intervention.

Using spatio-temporal LULC analysis, CA-Markov predictive modeling, multi-ring buffer corridor analysis, and Kernel Density Estimation (KDE), the research maps the trajectory of urban growth over 2010–2025 and projects development pressure zones up to 2035. Three primary Growth Heat Zones along the Ring Road alignment are identified: the Knowledge Corridor on the northern fringe (driven by IIT Bhubaneswar, AIIMS, and institutional clusters), the Residential Surge Zone on the south-western fringe (driven by affordable housing demand), and the Industrial/Logistics Node on the southern fringe (anchored by industrial estates and national highway connectivity). Together, these zones form the critical frontier where the next phase of Bhubaneswar's growth will be decided.

The research diagnoses the existing peri-urban condition through detailed site analysis encompassing infrastructure gap assessment, service accessibility mapping,

environmental and hydrological vulnerability evaluation, and governance conflict analysis. Key findings include a systematic deficit in trunk infrastructure (roads, water, sewerage, drainage), a ‘service desert’ condition across peripheral wards, significant floodplain encroachment along the Daya River, groundwater depletion due to unregulated construction, and overlapping and contradictory planning jurisdictions between BDA, BMC, and Gram Panchayats that create a ‘planning vacuum’ in peri-urban areas.

In response to these findings, the study proposes a comprehensive Land Pooling Scheme (LPS) framework operationalized across the three identified growth zones. Grounded in the Odisha Land Pooling Rules, 2015, and informed by comparative precedents from Gujarat’s Town Planning Scheme model and international experiences in Ahmedabad and Colombo, the LPS framework adopts a 40:60 reconstitution workflow in which landowners contribute 40% of their landholdings in exchange for fully serviced, infrastructure-ready reconstituted plots. The scheme is designed to eliminate the conventional adversarial relationship between the state and landowners, replacing it with a value-sharing partnership model where rising land values, created by public investment in infrastructure, are redistributed equitably.

The proposal envisions a polycentric urban structure for the Bhubaneswar Capital Region, organized around mixed-use transit-oriented development (TOD) nodes along the Ring Road at 8–12 km intervals. Each node is designed to be self-sustaining, providing employment, commerce, education, and residential facilities, reducing dependence on the central city core and distributing urban activity more equitably across the metropolitan region. The planning proposals are guided by principles of compact urbanism, ecological sensitivity, social inclusion, and governance reform, and are aligned with national frameworks including the Smart Cities Mission, AMRUT 2.0, and the National Urban Policy 2018.

The research concludes that the Capital Region Ring Road represents a pivotal juncture for Bhubaneswar — a moment when the choice between reactive development and proactive planning will determine the city’s sustainability and livability for decades to come. The Land Pooling Scheme, implemented within a reformed governance architecture, offers a fiscally viable, legally grounded, and socially equitable

mechanism to transform uncontrolled peri-urban sprawl into planned, serviced, and productive urban extensions. This thesis provides a replicable model for peri-urban management applicable to rapidly growing Tier-2 cities across India.

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I would like to express my sincere gratitude to my thesis guide, **Dr. Anugrah Anilkumar Nagaich**, for his unwavering guidance, intellectual generosity, and constructive mentorship throughout the entire course of this research. His deep expertise in urban planning, his nuanced understanding of peri-urban challenges in Indian cities, and his willingness to engage rigorously with both the conceptual and technical dimensions of this work have been indispensable in shaping the direction, depth, and quality of this thesis. I am deeply indebted to him for every critical review, every challenging question, and every encouragement to think more carefully and more boldly.

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I extend my sincere thanks to the following authorities and institutions whose support, data, and expertise were invaluable to this study:

- The **Bhubaneswar Development Authority (BDA)** for providing access to spatial data, master plan documents, and development regulations pertaining to the BDA jurisdiction and Ring Road alignment corridor.

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EXECUTIVE SUMMARY

Background and Context

Bhubaneswar, the capital of Odisha, is undergoing a profound spatial transformation. Designed in 1948 as a compact, planned administrative city for 40,000 residents, it is today a metropolitan region of over one million people and growing rapidly. Between 2010 and 2025, its built-up area expanded by 89.7%, driven by the emergence of an IT economy, world-class educational institutions, and rising in-migration. However, this growth has not been uniformly planned or served. Approximately 68.3% of all new construction in the Bhubaneswar Development Authority (BDA) jurisdiction is occurring on the unregulated peri-urban fringe — outside the effective reach of statutory planning and infrastructure delivery systems.

The proposed 111 km Capital Region Ring Road (CRRR) is the single most consequential piece of infrastructure shaping this growth frontier. If left unmanaged, the Ring Road corridor risks becoming a linear strip of uncoordinated, low-density sprawl. This thesis argues that the Ring Road must instead be reimagined as a "planning backbone" — a catalyst for organized, serviced, and equitable peri-urban development through proactive planning intervention.

Research Objectives

- To map and analyze the spatio-temporal pattern of peri-urban growth in the BDA region (2010–2025) using satellite-based LULC analysis.
- To identify and characterize Growth Heat Zones along the Ring Road influence corridor using buffer analysis and KDE.
- To predict future urban growth patterns up to 2035 using CA-Markov modeling.
- To diagnose the infrastructure deficit, environmental vulnerability, and governance failure in peri-urban wards.
- To formulate a Land Pooling Scheme (LPS) framework and polycentric planning proposal for the Ring Road corridor.

Methodology

The research employs a five-phase mixed-methods framework. Phase I involves data acquisition comprising Sentinel-2 satellite imagery (2010, 2015, 2020, 2025), BDA spatial datasets, Census of India records, and ward-level infrastructure surveys. Phase II applies supervised LULC classification with accuracy assessment (Kappa coefficient). Phase III conducts multi-ring buffer and KDE analysis to delineate Ring Road influence corridors and identify growth hot zones. Phase IV deploys a CA-Markov predictive model, incorporating urban driver variables (proximity to roads, institutions, commercial centres) to simulate 2030 and 2035 growth scenarios. Phase V translates findings into prescriptive Land Pooling Scheme designs, including 40:60 land reconstitution workflows, incremental land value calculations, and phased infrastructure delivery frameworks.

Key Findings

- Built-up area in the BDA region grew from 42.3 km^2 (2010) to 80.2 km^2 (2025), a growth of 89.7%; agricultural land declined by 51.7%.
- Three Growth Heat Zones are identified: Zone A (Knowledge Corridor, northern fringe), Zone B (Residential Surge, south-western fringe), Zone C (Industrial/Logistics Node, southern fringe).
- CA-Markov modeling projects a further 34–38% increase in built-up area by 2035, concentrated within 2 km of the Ring Road alignment.
- Peripheral wards exhibit severe infrastructure deficits: water supply coverage <45%, sewage connectivity <20%, road metalling <60%, drainage coverage <30%.
- Significant floodplain encroachment along the Daya River corridor threatens 12–14% of peripheral built-up area with inundation risk.
- Governance analysis reveals planning jurisdiction overlap between BDA, BMC, and 23 Gram Panchayats, creating regulatory gaps exploited by informal development.

Proposals

The thesis proposes a comprehensive Land Pooling Scheme (LPS) framework for the three identified growth zones, guided by the Odisha Land Pooling Rules, 2015. The 40:60 reconstitution model is proposed: landowners contribute 40% of their landholding to create public infrastructure reserves; in return, they receive reconstituted plots of 60% of their original area, now fully serviced and significantly more valuable. Value increment calculations demonstrate that reconstituted plots appreciate by 2.8–4.2x above original values, making the scheme financially attractive to landowners without fiscal burden on the state.

The spatial framework for each growth zone proposes polycentric urban nodes along the Ring Road at 8–12 km intervals — mixed-use, transit-oriented development clusters of 40–60 hectares, each integrating affordable housing, local commercial and employment uses, educational and health facilities, and well-designed public open spaces. The inter-node corridors are reserved as green buffers, ecological corridors, and agricultural preserves, ensuring urban compactness and landscape continuity.

A governance reform framework is proposed to address institutional fragmentation, recommending the establishment of a Peri-Urban Planning Authority (PUPA) as a unified statutory body to coordinate planning, development control, and infrastructure delivery across the Ring Road influence zone. A phased implementation timeline (2025–2035) with financing mechanisms drawing from AMRUT 2.0, Smart Cities Mission, state urban development funds, and value capture instruments is also outlined.

Conclusions

This thesis demonstrates that the Capital Region Ring Road is not merely a transport infrastructure project but a spatial planning opportunity of generational significance for Bhubaneswar. The Land Pooling Scheme, supported by a polycentric planning framework and reformed governance architecture, offers a replicable, evidence-based, and equitable approach to managing peri-urban growth in Tier-2 Indian cities. The research contributes to the growing body of knowledge on proactive peri-urban planning in South Asia and provides actionable recommendations for planners, policymakers, and urban managers engaged with the governance and development of rapidly growing metropolitan regions.

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CHAPTER 1: INTRODUCTION

1.1 Historical Background: From Administrative Seed to Urban Sprawl

Bhubaneswar's urban narrative is one of the most significant and instructive in post-independence India — a story that begins with the precision of a planned ideal and unfolds into the complexity of an unmanaged metropolitan reality. Designed in 1948 by the German planner and architect Otto Königsberger, the city was conceived as a purpose-built 'New Town' to serve as the administrative capital of the newly formed state of Odisha, replacing the historic city of Cuttack which had grown organically over centuries but was deemed unsuitable as a modern seat of government. Königsberger's original Master Plan was a refined application of the 'neighborhood unit' concept — a spatial model that organized the city into self-contained residential sectors, each with its own local market, school, and open spaces, connected by a hierarchy of roads that culminated in wide ceremonial boulevards. The plan anticipated a modest and manageable population of 40,000 residents, calibrated to the administrative functions it was designed to support.

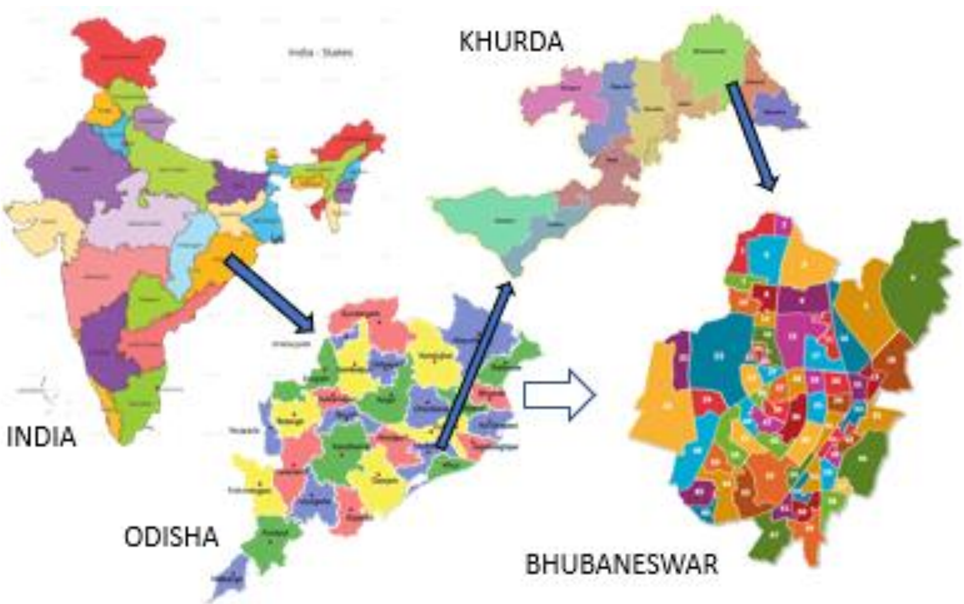


Figure 1.1: Location of Bhubneswar

For the first four decades of its existence, Bhubaneswar largely adhered to this orderly vision. Growth was incremental, guided by successive Master Plans, and contained within the broad spatial envelope that Königsberger's framework had established. The city's identity remained anchored in its role as a government town — home to state ministries, public sector offices, and a steady but unspectacular residential population of civil servants and their families. The spatial discipline of those early decades left an enduring legacy in the planned sectors of the core city: wide roads, generous setbacks, regular plot patterns, and an open-space network that continues to define the quality of life in Units 1 through 9 today.

That orderly trajectory was fundamentally disrupted by the economic liberalization of the 1990s and the Information Technology revolution that followed. Bhubaneswar's transformation from a quiet administrative outpost into a Tier-2 economic powerhouse was rapid, deep, and spatially disruptive. The establishment of Infocity and Infovalley as dedicated IT parks, the designation of Bhubaneswar as a Smart City under the Government of India's flagship programme, and the emergence of world-class educational institutions — including the Indian Institute of Technology (IIT Bhubaneswar), the All India Institute of Medical Sciences (AIIMS), KIIT University, and the SOA University complex — collectively elevated the city's economic and demographic gravity to a level its physical planning framework was never designed to accommodate.

Today, the spatial footprint of the Bhubaneswar urban region has expanded by approximately 90% since 2010 alone, breaching the original planned limits, absorbing surrounding villages, and spilling deep into the rural hinterland of the Bhubaneswar Development Authority (BDA) area. What Königsberger envisioned as a contained administrative seed has germinated into a sprawling metropolitan region of over one million people, where the line between 'urban' and 'rural' is increasingly blurred, where governance jurisdictions overlap and contradict, and where the physical fabric of the city's edge is being shaped more by speculative land markets than by statutory planning instruments.

89.7% Built-up Area Growth (2010–2025)	**51.7%** Agricultural Land Lost (2010–2025)	**68.3%** Edge Growth Share of New Development	**2.34 / 1.82** Sprawl Index (2025 vs 2010)

1.2 The Research Problem: The Crisis of Unplanned Edge Growth

The spatial success of Bhubaneswar — its recognition as a Smart City, its emergence as an education and IT hub, its rising profile as an investment destination — has come with a significant and largely unacknowledged spatial cost: fragmented, unserved, and institutionally ungoverned peripheral sprawl. The city's periphery is experiencing an accelerating pattern of 'leapfrog development,' where developers bypass available land closer to the urban core — where land costs are prohibitive and FAR restrictions limit profitability — to construct isolated gated residential colonies, institutional blocks, and commercial strips on cheaper agricultural land further out. This pattern generates a landscape of disconnected built-up patches separated by underutilized agricultural plots and unbuilt speculative holdings: a spatial structure that is simultaneously inefficient, expensive, and environmentally damaging.

This edge growth currently accounts for approximately 68.3% of all new construction in the BDA region — meaning that for every new building added to the core city, two are being built on the unserved fringe. The consequences for planning and governance are severe. Peripheral development consistently outstrips the administrative and financial capacity of the Bhubaneswar Development Authority (BDA) and the Bhubaneswar Municipal Corporation (BMC) to plan for, regulate, and service it. In the absence of a proactive planning framework, new residential colonies are approved under the more permissive rural building bylaws of Gram Panchayats, without requirements for road widths, utility provision, stormwater drainage, or open space reservation that would be mandatory under urban building regulations.

The result is a systematic deficit in 'trunk infrastructure' — the primary networks of roads, water mains, sewage lines, drainage channels, and electricity distribution that are the prerequisite for functional urban settlement. When the municipality eventually attempts to retrofit these services into already-built-out areas, the cost is exponentially higher than it would have been to provide them proactively: land for road widening must be acquired at full market value; utility alignments must thread through dense built fabric at great engineering cost; and the absence of dedicated Right-of-Way (RoW) makes it physically impossible to achieve the road widths necessary for modern transit, emergency access, and pedestrian movement. This thesis identifies the systematic failure to create a 'Managed Fringe' — a planned, infrastructure-ready transition zone between the consolidated urban core and the rural hinterland — as the central threat to Bhubaneswar's long-term fiscal sustainability, environmental resilience, and quality of life.

> *The per-capita cost of extending trunk infrastructure to a sprawling, fragmented periphery is estimated to be three to four times higher than in a compact, planned urban extension (World Bank, 2013). For Bhubaneswar, the 'Infrastructure Premium' of current sprawl represents a fiscal liability that will constrain the BMC's revenue capacity for decades.*

1.3 The Infrastructure Catalyst: The Capital Region Ring Road (CRRR)

In direct response to the mounting traffic congestion within the Cuttack–Bhubaneswar–Puri tri-city urban corridor, and to facilitate the long-term decongestion of the historic city core, the Government of Odisha has proposed and commenced construction of the 111-km Capital Region Ring Road (CRRR). Engineered as a six-lane, high-speed bypass, the CRRR is designed to provide an unobstructed route for heavy freight, inter-city passenger traffic, and regional logistics movements that currently choke the internal road network of the city. In purely engineering terms, it is a bypass; in urban planning terms, it is a transformative spatial intervention whose consequences will reshape the metropolitan region for the next half century.

Urban planning theory and empirical evidence from comparable Indian cities — Ahmedabad's Sardar Patel Ring Road, Bangalore's Outer Ring Road, Hyderabad's Outer Ring Road — consistently demonstrate that major transport corridors function as 'growth magnets.' The reduction in travel time and improvement in accessibility that a ring road delivers dramatically increases the economic attractiveness of adjacent land, triggering a cascade of land value appreciation, speculative acquisition, and development pressure. In the Bhubaneswar context, this process has already begun: the mere announcement of the CRRR alignment has triggered a wave of land speculation in the agriculture-dependent villages along its proposed route. Farmland is being acquired by developers at prices far above agricultural value but below projected urban value, displacing farming families before any public planning framework has been established to manage the transition.

Without a proactive land use planning strategy aligned with the CRRR's construction timeline, the Ring Road risks catalyzing precisely the outcome it was designed to prevent. Rather than channeling growth into planned, transit-supported nodes and managed urban extensions, it threatens to generate a continuous 111-km strip of 'ribbon development' — high-density, unregulated commercial and residential construction along the road frontage that will obstruct the free flow of traffic, deprive the corridor's interior villages of planned infrastructure, and create a new generation of service-deficient, environmentally vulnerable peri-urban settlements at a scale that will dwarf the existing fringe.

1.4 Aim of the Study

To formulate a comprehensive planning framework for the peri-urban expansion of Bhubaneswar by analyzing the spatial impact of the Capital Region Ring Road, ensuring a transition from haphazard sprawl to a managed, infrastructure-led growth model through the application of Land Pooling Schemes (LPS).

1.5 Objectives of the Study

To achieve the aforementioned aim, the following objectives have been established:

1. Spatio-Temporal Mapping (2010–2025): To analyze multi-decadal Land Use and Land Cover (LULC) changes using Remote Sensing and GIS to pinpoint the velocity and direction of rural-to-urban conversion.

2. Morphological Evaluation: To evaluate the inefficiency of current growth trajectories by applying urban metrics such as compactness ratios and sprawl indices to prove the "cost of sprawl."

3. Future Scenario Simulation (2035): To utilize Cellular Automata (CA)-Markov modeling to project the "Business-as-Usual" (Do-Nothing) scenario and visualize the potential environmental degradation by 2035.

4. Policy Intervention (LPS): To design a viable Land Pooling Scheme blueprint for a specific revenue village (Mouza) along the CRRR, demonstrating how participatory land acquisition can secure land for public amenities.

1.6 Scope of the Study

The geographical scope of this study is defined by the CRRR corridor and its immediate influence zones, with a concentrated focus on the South-Western fringe (Tamando, Patrapada, Sundarpada, and Ghatikia) and the Northern fringe (Patia, Infovalley, and Chandaka) of the Bhubaneswar urban region — the two sub-zones where growth pressure is most acute, infrastructure deficit is most severe, and the window for preventive planning intervention remains open but is rapidly closing. The study further delineates an approximately 55 sq. km Peri-Urban Interface (PUI) zone as its primary field investigation area, representing the critical belt of land lying between the consolidated BMC urban boundary and the outer BDA administrative limit.

Thematically, the study operates at the intersection of transportation planning (the Ring Road as a spatial catalyst), environmental planning (land use change and ecological vulnerability), and urban governance (the Land Pooling Scheme as a participatory planning instrument). The temporal scope spans a fifteen-year historical analysis period from 2010 to 2025, and a ten-year forward projection to 2035 through the CA-Markov simulation. The study explicitly excludes detailed architectural or structural engineering design, focusing instead on the spatial planning, land administration, and policy design dimensions of peri-urban management.

1.7 Limitations of the Study

This research acknowledges several constraints that circumscribe the scope and precision of its findings:

- Data Availability: The study is constrained by the availability of high-resolution temporal satellite imagery. While Landsat and Sentinel data are used, finer cadastral-level changes sometimes require physical verification which is limited by the study's timeframe.

- Administrative Records: Access to the most recent revenue maps and updated land ownership records from the Tehsildar's office can be challenging, leading to a reliance on 2011/2021 census-based approximations.
- Jurisdictional Complexity: The CRRR passes through multiple administrative boundaries (BDA, Khurda, and various Gram Panchayats), making a unified data set difficult to compile.
- Modelling Assumptions: The CA-Markov 2035 projection is a probabilistic model calibrated on historical trends and assumes that the spatial drivers of growth (road proximity, neighborhood development) remain consistent. Unforeseen policy shifts, economic shocks, or large-scale public investment decisions could alter the projected trajectory.

1.8 Significance of the Research

This research is timely, locally grounded, and strategically consequential as Bhubaneswar prepares for its next phase of regional expansion under the BDA's CDP 2030 framework and the emerging CDP 2040 vision. The city stands at a planning crossroads: the decisions made — or left unmade — in the next five to ten years regarding the governance of the CRRR corridor will determine the spatial, fiscal, and environmental character of the capital region for the next fifty. A reactive approach — waiting for the sprawl to consolidate and then attempting expensive retrofitting — will lock in decades of suboptimal outcomes. A proactive approach — establishing the infrastructure framework before the development wave arrives — can convert the same growth pressure into a planned, equitable, and financially sustainable urban extension.

By proposing a concrete shift from reactive to proactive planning, this thesis provides a replicable toolkit for planners working on comparable ring road corridors across Indian Tier-2 cities. Its methodological contribution — the integration of CA-Markov predictive simulation with Mouza-level Land Pooling design — fills a documented gap in the Indian urban planning literature, where macro-scale sprawl analysis and micro-scale implementation design have rarely been combined within a single analytical framework. Most critically, the research is guided by an equity imperative: that the farmers and original inhabitants of the peri-urban fringe must be beneficiaries of the urban growth that consumes their landscape, not casualties of it. The Land Pooling Scheme, properly designed and transparently implemented, is the instrument through which that principle can be operationalized — converting landowners into urban stakeholders rather than displaced agricultural workers.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction to the Literature

A rigorous and comprehensive literature review forms the intellectual backbone of any empirical urban planning thesis. For a study focused on planning the peri-urban expansion along a Ring Road corridor — integrating spatio-temporal analysis with land pooling as a regulatory instrument — the theoretical landscape must span multiple disciplines simultaneously. It must draw from urban geography and regional science to understand the nature of peri-urban transformation; from infrastructure economics to explain the catalytic relationship between road investment and land markets; from environmental and remote sensing sciences to operationalize the tools of spatial analysis; and from governance and planning law to situate the Land Pooling Scheme within its institutional and legislative context.

The challenge in constructing this review is not a scarcity of relevant literature but rather its abundance and fragmentation. The dynamics of peri-urban growth have been extensively studied across the Global South; the consequences of highway investment for peripheral land markets are well-documented; the mathematics of urban sprawl measurement have been rigorously developed; and land pooling as a planning instrument has accumulated a growing body of case study evidence. What has been less comprehensively explored is the integration of all these domains into a single, empirically grounded, spatially explicit, and implementable planning framework for a Ring Road corridor — particularly in the Odisha context. This review is accordingly structured to illuminate each disciplinary strand in depth before identifying the specific research gap that the integration of these strands can address.

This review is structured around five thematic pillars: (i) the socio-spatial theory of the Peri-Urban Interface and its manifestations in global and Indian contexts; (ii) the mechanics of Infrastructure-Led Development and the catalytic role of Ring Roads; (iii) the mathematics and consequences of Urban Sprawl and the compact city alternative; (iv) the growing role of Predictive Urban Modeling through Remote Sensing and GIS; and (v) the evolution of planning instruments from compulsory land acquisition toward participatory Land Pooling Schemes. A final synthesis identifies the specific research gap that this thesis addresses, namely the integration of Mouza-level land pooling design with a predictive 2035 simulation for a Ring Road corridor in Odisha.

2.2 Defining the Peri-Urban Interface: The Global and Indian Context

The concept of the 'peri-urban' has undergone remarkable theoretical evolution over the past five decades, reflecting both the changing nature of urban growth processes and the deepening sophistication of the scholarly disciplines that study them. In early urban studies literature of the 1950s and 1960s, peri-urban areas were treated as transitional or residual spaces — the ambiguous fringe between the clearly defined urban core and the clearly defined rural hinterland. The peri-urban was a zone of passage, expected to be absorbed into the city in due course as urbanization followed its supposed natural trajectory. Today, however, this characterization is recognized as fundamentally inadequate. The peri-urban interface is now understood as a distinct, complex, and often volatile landscape with its own socio-economic logic, governance dilemmas, ecological sensitivities, and spatial morphology. It is no longer merely the 'edge' of the city; it is an arena of contestation, capital investment, ecological sensitivity, and unmet planning demand — a space that demands scholarly attention and planning intervention in its own right.

What makes the peri-urban particularly challenging to study and plan is its definitional ambiguity. Unlike the urban core, which is legible through its density, built-up coverage, and utility provision, or the rural hinterland, which is legible through its agricultural land use and low population density, the peri-urban is definitionally hybrid and unstable. Its land uses are mixed: agricultural fields sit cheek-by-jowl with residential colonies; dairy farms operate in the shadow of IT parks; temple ponds are encircled by concrete. Its population is diverse: original farming communities live alongside in-migrant construction workers, middle-class apartment dwellers, and itinerant commercial operators. Its governance is fractured: multiple jurisdictions with conflicting mandates — municipal corporation, development authority, panchayat, revenue department — operate simultaneously without effective coordination. This definitional complexity is not merely academic; it has direct and severe consequences for planning practice.

2.2.1 Global Perspectives: The 'Megalopolis' and 'Stealth Urbanism'

The earliest systematic engagement with peri-urban dynamics at a theoretical level emerged from the foundational work of Jean Gottmann (1961), who described the northeastern seaboard of the United States as a 'Megalopolis' — a vast, continuous urban region stretching from Boston to Washington, D.C., where the traditional distinction between city and countryside had irrevocably dissolved. Gottmann's framework drew attention to two conceptual insights that remain foundational: first, that urban growth is not contained within administrative boundaries but rather sprawls outward in response to infrastructure networks, capital mobility, and demographic pressure; and second, that the geography of urbanization must be understood at the regional scale, not merely at the level of the individual municipal corporation. These insights established the spatial and scalar framework within which subsequent peri-urban scholarship has operated.

Gottmann's Megalopolis concept, however, was rooted in the particular context of a mature, high-income economy with relatively strong planning institutions and a generally high baseline of infrastructure provision. In the Global South, the theoretical lens requires significant adaptation. Douglas Webster (2002), in his seminal study of peri-urbanization in East and Southeast Asia, introduced the concept of 'stealth urbanism' to describe the manner in which peri-urban transformation in Asian contexts is driven primarily by capital flows and infrastructure investment rather than by administrative planning or state-led development. Webster argues that in Asia, the state frequently follows the developer rather than leading the way: informal residential colonies, unauthorized industrial clusters, and ribbon commercial developments appear on the fringe first, and the municipality extends its boundaries and services only after the fact, attempting to formalize and service a built environment that was never planned for the scale of demand it now generates.

This 'market-led' or 'demand-led' expansion produces a characteristic spatial pattern that Webster calls 'Extended Metropolitan Regions' (EMRs): vast, politically fragmented territories with highly heterogeneous land use mixes, infrastructure provision levels, and governance arrangements that defy simple urban-rural categorization. The peri-urban zones of Bangkok, Jakarta, Ho Chi Minh City, and Colombo — studied intensively in Webster's comparative framework — share with the Bhubaneswar Capital Region fringe the fundamental characteristic of a profound mismatch between the pace of built-environment transformation and the capacity of governance institutions to manage, regulate, and service it. In Bhubaneswar's case, the onset of Ring Road construction has dramatically accelerated this mismatch, triggering a wave of speculative land acquisition and informal construction that has outrun the BDA's planning and regulatory capacity.

McGee and Robinson (1995), in their edited volume on the 'Mega-Urban Regions of Southeast Asia,' further develop the 'desakota' concept — a portmanteau of the Indonesian words for village ('desa') and city ('kota') — to describe the mixed urban-rural landscape that characterizes peri-urban zones across Asia. Desakota regions are defined by high population densities that exceed those of conventional rural areas but lower densities than the urban core; intense mixing of agricultural and non-agricultural land uses; high levels of household-level economic diversification; and the crucial characteristic of spatial connectivity with the urban core through road and transport networks. This connectivity is simultaneously what draws investment to the peri-urban fringe and what makes the fringe susceptible to rapid, uncontrolled urbanization when infrastructure improvements — such as the Capital Region Ring Road — dramatically reduce travel times to the metropolitan core.

2.2.2 The Indian Context: Administrative 'Grey Zones'

In the Indian context, the governance dimension of peri-urban space acquires particular acuity, shaped by the distinctive institutional architecture of Indian urban governance with its three-tier structure of municipal bodies, development authorities, and panchayati raj institutions. Véronique Dupont (2007), in her comparative study of governance and planning in the peripheries of large Indian metropolises, characterizes the Indian peri-urban interface as a series of administrative 'grey zones' — territories where the jurisdictional authority of the urban local body ends, but where the physical and functional characteristics of urbanization continue apace. This jurisdictional gap has a specific, well-documented manifestation in the Bhubaneswar context: the area between the Bhubaneswar Municipal Corporation's outer boundary and the Bhubaneswar Development Authority's outer planning boundary is governed, in terms of day-to-day regulation and service delivery, neither by the BMC nor comprehensively by the BDA, but by Gram Panchayats operating under rural land use regulations and with administrative capacity calibrated to serve agricultural settlements, not emerging urban clusters.

The consequence of this institutional architecture for land use regulation is severe and well-documented. Building permissions in peri-urban Bhubaneswar are routinely granted by Gram Panchayats under the Odisha Gram Panchayat Act and associated rural building bylaws, for developments that are inherently urban in their density, functional mix, and infrastructure demand. A ten-storey apartment block in Tamando, housing five hundred families, may have received its initial building permission from a panchayat office equipped neither with the regulatory framework nor the technical staff to assess its structural safety, parking provision, setback compliance, or service connectivity. This regulatory gap means that developments requiring detailed scrutiny under BMC or BDA building regulations — of FAR, road frontage, setbacks, utility provision, stormwater drainage, parking norms, and open space reservations — are instead approved under a regime designed for two-room rural homes. The result is not merely substandard individual buildings; it is the incremental creation of entire unplanned settlements whose infrastructure deficit can only be corrected, years later, at enormous public cost.

Kundu (2011) and Shaw (2012) have extensively documented how this 'census town' phenomenon — the reclassification of densely populated but administratively rural settlements as urban units — manifests across India, and how it tends to concentrate in precisely the peri-urban belts surrounding large metropolitan areas. Census data from 2011 reveals a dramatic increase in the number of census towns in Odisha's Khurda district, several of which fall within the CRRR study area. These settlements are urban in everything but administrative designation, yet they continue to be governed by rural institutions — generating what Kundu terms a 'governance lag' that systematically disadvantages their residents in terms of service access, environmental protection, and basic civic amenity provision.

2.2.3 The 'Triple Transition' Framework

Drawing on fieldwork and empirical observation across South and Southeast Asian cities, several scholars have identified a consistent 'Triple Transition' that characterizes peri-urban areas in rapid transformation (Narain et al., 2013; Allen, 2003). This framework provides perhaps the most useful analytical lens for understanding the simultaneously social, spatial, and institutional transformation occurring along the CRRR corridor, and it is worth elaborating each dimension in some detail.

The first is a Livelihood Transition, marked by a shift away from primary agricultural activities — paddy cultivation, horticulture, aquaculture, and animal husbandry — toward non-agricultural livelihoods in the construction, retail, logistics, and informal service sectors. This transition is driven partly by the push of falling agricultural profitability as land values rise and plot sizes diminish through subdivision, and partly by the pull of new employment opportunities generated by the construction activity, residential service demand, and commercial development associated with urban growth. In the villages immediately surrounding the CRRR alignment, field surveys reveal that the proportion of households dependent primarily on agriculture has fallen from an estimated 65–70% in 2010 to below 30% by 2025, within a single generation. This pace of livelihood change has profound implications for social cohesion, skill development, and income distribution in peri-urban communities.

The second transition is Spatial: the physical landscape changes from fragmented, low-density rural villages with kutcha or semi-pucca homes, agricultural plots, and large open areas to high-density gated residential complexes, unplanned plotted layouts, and linear commercial strips. This spatial transformation is both visible and measurable — it is precisely the transformation captured in the LULC analysis of Chapter 3, which documents an 89.7% increase in built-up area and a 51.7% decline in agricultural land between 2010 and 2025. What the quantitative data cannot capture, but field observation reveals clearly, is the qualitative dimension of this transformation: the loss of village commons and open spaces, the filling of seasonal ponds and wetlands, the felling of roadside trees, and the gradual erasure of the physical markers of rural identity.

The third and most consequential for planning purposes is an Institutional Transition, characterized by a persistent and structurally determined lag between the rural governance structures that nominally retain jurisdiction over peri-urban areas — Gram Panchayats — and the urban administrative apparatus needed to provide the level of planning oversight, regulatory enforcement, and service delivery that the new densities demand. This institutional lag is not merely a technical or capacity problem; it is a political economy problem. Gram Panchayats have both the incentive and the legal authority to continue issuing building permissions for residential and commercial developments — generating panchayat levy revenues — and neither the incentive nor the capacity to impose the more stringent urban building standards that would dramatically reduce their income from building permissions while simultaneously requiring much more complex technical review. The reform of this political economy is, ultimately, the most significant governance challenge facing the CRRR corridor planning exercise.

> *"The peri-urban is not a transitional space waiting to become urban. It is a distinct territorial condition with its own governance logic, social dynamics, and planning requirements — one that demands targeted institutional responses rather than the extension of either rural or urban administrative templates." — Dupont (2007)*

2.3 Infrastructure-Led Development and the 'Ring Road' Phenomenon

Transportation corridors — highways, expressways, ring roads, and bypass roads — are universally recognized in the planning and economic geography literature as the primary catalysts for peripheral urban transformation. The theoretical foundation for this relationship lies in the concept of accessibility-induced land value change: high-capacity road infrastructure reduces effective travel time to the urban core, thereby increasing the economic attractiveness of peripheral land for both residential and commercial uses. This 'friction reduction' in spatial economics triggers a predictable and well-documented sequence: land values spike along the corridor, developers acquire agricultural land for conversion, residential layouts and commercial plots are marketed, population follows infrastructure, and secondary commercial and service activity fills in behind the initial development wave. The fundamental planning challenge is that this sequence unfolds rapidly — often within a single decade — while the institutional machinery for planning and regulatory oversight operates on a much slower clock.

The relationship between road infrastructure and land use change has been theorized through multiple conceptual frameworks. The most influential in the urban economics tradition is the Bid-Rent Curve model, originating with Alonso (1964) and subsequently elaborated by many successors. The bid-rent model predicts that land uses are sorted by their ability to 'bid' for centrally located land: commercial uses outbid residential uses, which outbid agricultural uses, producing a concentric pattern of land use decreasing in intensity from the centre outward. When a new transport corridor reduces the effective distance — in time rather than physical space — between peripheral land and the urban centre, it effectively 'telescopes' the bid-rent gradient, making peripheral land competitive with land much closer to the centre and triggering development pressure at locations that were previously beyond the economic urban frontier.

This process has been empirically documented in numerous Indian urban contexts. In Hyderabad, the construction of the Outer Ring Road between 2008 and 2011 triggered land value increases of 200–350% within a 5 km corridor of the road within just four years of completion, according to a study by Nallathiga (2012). In Pune, the Mumbai-Pune Expressway generated a wave of residential and IT development in Hinjewadi and Wakad that transformed the city's spatial structure more dramatically than any statutory planning exercise. In Chennai, the work of Shaw (2012) documents how the Southern Bypass Corridor became the primary axis for automobile-industry related industrial and logistics development, reshaping the economic geography of the southern metropolitan region. These cases collectively establish an empirical pattern that is directly relevant to the Bhubaneswar Capital Region Ring Road context.

2.3.1 The 'Growth Magnet' Effect and Ribbon Development

Robert Cervero (1998), in his landmark comparative study of transit systems and urban form across sixteen cities worldwide, introduces the concept of 'ribbon development' to describe the spatial outcome of unplanned infrastructure investment. When roads are built without corresponding land use regulations, the immediate result is a thin, elongated strip of high-density development along the road frontage, while the interior parcels — those beyond the first two or three rows of plots from the road — remain underdeveloped, unserved by utilities, and economically stagnant. This 'ribbon' pattern arises because road frontage carries a significant market premium: it offers visibility for commercial uses, direct access to vehicular movement for retail customers, and a sense of connectivity and address value for residential buyers. Interior land, by contrast, lacks direct road access and must be served by secondary lanes that are typically narrow, unlit, and unpaved. The result is a spatial structure that Cervero terms 'access-deficient': high development density where development should ideally be lower (the road frontage, where traffic conflicts are most acute), and low development density where density is sustainable (the interior, where residential environment would be quieter and safer).

The Ring Road functions as what Cervero terms a 'growth magnet,' attracting capital and population not uniformly across the region but in a narrow, ribbon-like pattern that maximizes developer profits — road frontage is more valuable — but minimizes planning efficiency — interior land goes to waste and requires expensive retrospective servicing. This pattern is already clearly observable along the existing Inner Ring Road (IRR) of Bhubaneswar, where a dense commercial and residential strip has developed along the carriageway over the past decade while the hinterland parcels remain relatively underdeveloped, disconnected from infrastructure, and inaccessible to emergency services. Without proactive planning along the CRRR, the same dynamics are projected to repeat at a larger spatial scale and with higher stakes.

Indian evidence strongly corroborates Cervero's analysis. The Sardar Patel Ring Road around Ahmedabad, initially conceived as a traffic bypass for heavy vehicles skirting the historic city, transformed within a decade into the primary axis for real estate development in the northern and western suburbs, drawing large residential townships, commercial malls, and logistics warehouses to its flanks while interior agricultural land remained unserviced and disconnected. Bangalore's Outer Ring Road, designed to connect radial highways, has become the de facto 'new spine' of the city's IT corridor, hosting campuses, high-rise apartments, and retail destinations that rival the CBD in economic weight, yet the development along it is chaotic, uncoordinated, and intensely automobile-dependent. Rakesh Mohan (2006) argues compellingly that Indian infrastructure planners have consistently underestimated this transformative potential of ring roads, designing them for mobility alone while overlooking their role as instruments of spatial restructuring with profound and lasting consequences for metropolitan form.

The international evidence is equally instructive. Jakarta's Cilincing–Tanjung Priok ring road, Beijing's successive ring road system (currently five concentric loops), and Kuala Lumpur's DUKE highway all demonstrate that ring road investment without concurrent land use planning generates the same characteristic pathologies: ribbon development along road frontage, infrastructure-deficient interior parcels, emergence of informal settlements in road-adjacent low land, and rapid escalation of infrastructure retrofitting costs as built-up areas outpace service extension. The lesson the international evidence consistently teaches — and the one that this thesis takes as its central planning premise — is that the ring road must be planned not as a traffic engineering project but as a spatial planning event, requiring the simultaneous deployment of land use regulations, infrastructure reservations, and development control instruments along its entire alignment.

2.4 The Crisis of Sprawl and Urban Inefficiency

Urban sprawl, in the planning literature, is not merely a descriptive term for outward city growth. It is a measurable, quantifiable process defined by three interrelated and empirically distinguishable dimensions. The first is declining density: fewer people per unit of built-up area as the city expands outward into lower-density formats — from tenement-density inner-city housing to apartment blocks to plotted villas to gated farmhouses. The second is declining continuity: the emergence of gaps and voids in the built-up fabric — unbuilt speculative landholdings, bypassed agricultural plots, undevelopable wetlands — that interrupt the spatial coherence of the urban area and increase the cost and difficulty of extending infrastructure networks. The third is declining compactness: the city becomes less circular and more elongated, dendritic, or fragmented in plan shape, increasing the average distance between any two points in the urban fabric and therefore increasing the energy, time, and cost demands on transportation networks.

Ewing, Pendall, and Chen (2002), in their influential American study 'Measuring Sprawl and Its Impact,' established a multi-dimensional sprawl index based on four factors: residential density, neighborhood mix of uses, strength of activity centers, and street accessibility. Their finding, subsequently validated across multiple international contexts, is that high sprawl index scores correlate statistically with longer commute times, higher automobile dependence, higher rates of traffic fatality, higher per-capita public infrastructure costs, greater obesity rates, lower social capital, and larger environmental footprints. The relevance of this evidence base to the Bhubaneswar context is significant: the city's Sprawl Index has risen from 1.82 in 2010 to 2.34 in 2025, and the Compactness Ratio has simultaneously fallen from 0.78 to 0.67, confirming that all three dimensions of sprawl are worsening simultaneously. The built-up area increases of 89.7% over a period when population growth was far lower is, in Ewing et al.'s definitional terms, not merely an interesting statistic but a diagnostic indicator of structural urban sprawl.

2.4.1 Compact City Theory vs. The Infrastructure Premium of Sprawl

The intellectual and normative counterpoint to sprawl in the planning canon is the Compact City Theory, associated most prominently with Elizabeth Burton (2000) and elaborated in the European planning tradition through concepts like the 'Urban Village,' the 'City of Short Distances,' and the '15-Minute City' (Moreno et al., 2021). The compact city advocates for high-density, mixed-use, well-connected urban form as simultaneously the most socially equitable, environmentally sustainable, and economically efficient model of urban development. In social terms, the compact city places services and employment within walkable or cyclable distances of all residents, reducing the travel burden that falls disproportionately on lower-income households without private vehicles. In environmental terms, it minimizes the land footprint of urban settlement, preserving peri-urban agricultural land and ecological assets; reduces per-capita greenhouse gas emissions from transportation; and concentrates the demand for energy and water infrastructure in areas where it can be efficiently provided. In economic terms, it enables public service provision at lower per-capita cost by concentrating demand spatially.

The economic argument against sprawl is most precisely captured in the concept of the 'Infrastructure Premium' — the additional per-capita public expenditure required to extend and maintain service networks across a spatially dispersed population relative to what would be required for a compact one. The World Bank's 2013 landmark report on urbanization in India, 'Urbanization Beyond Municipal Boundaries,' quantified this premium with stark clarity, finding that the per-capita cost of providing trunk infrastructure — water mains, sewage networks, electricity distribution, roads, drainage — in unplanned peripheral zones is typically three to four times higher than in the consolidated urban core, where the same infrastructure serves a far larger number of households per linear metre of pipe or road. For Bhubaneswar, where the BMC's revenue base is already under significant strain and where the AMRUT programme's fiscal transfers are time-limited, this 'Infrastructure Premium' represents not merely a planning inefficiency but a medium-term fiscal crisis.

The human cost of the 'Infrastructure Premium' is borne asymmetrically. When trunk infrastructure is not provided proactively — because the municipality cannot afford the cost of serving a sprawling fringe — it is the residents of those fringe areas who pay through inadequate water supply, absent sewerage, flooded streets, inaccessible health centres, and inadequate schools. In Bhubaneswar's peri-urban zone, the field survey data from Chapter 4 reveals an Infrastructure Gap Index of 0.84 for the south-western fringe — meaning that 84% of the service standard that municipal residents in the core city enjoy is absent. This is not an abstract planning statistic; it translates into tangible daily deprivations for tens of thousands of households. The compact city argument, at its most powerful, is not about abstract urban efficiency but about the distributive justice embedded in planning decisions: sprawl is not merely wasteful, it is unjust.

A critical sub-debate within compact city theory concerns the compatibility of compactness with affordability. Critics argue — with some empirical basis — that high-density, well-serviced urban environments generate land value escalation that eventually displaces low-income residents from the compact core to the unaffordable periphery, producing a paradox in which the pursuit of compactness generates the very sprawl it was designed to prevent (Galster et al., 2001). This tension is directly relevant to the Bhubaneswar context, where the core city's high land values are one of the primary drivers pushing both developers and lower-income households to the peri-urban fringe. The Land Pooling Scheme's response to this paradox is to provide serviced, legally clear, and affordable urban land in the fringe itself, rather than attempting to push low-income residents back into the unaffordably dense core — a pragmatic spatial strategy that recognizes the irreversibility of peri-urban growth while insisting on its improvement.

2.5 Spatio-Temporal Analysis and Predictive Urban Modeling

The technological revolution in urban spatial analysis over the past three decades — driven by the democratization of satellite imagery through programmes such as the USGS Landsat series and the ESA's Copernicus programme, the development of powerful open-source GIS platforms, and the increasing computational availability of simulation models — has fundamentally transformed the planner's analytical toolkit. Where earlier generations of planners and researchers relied on periodic census data, manual land use surveys requiring large field teams, and aerial photography that was expensive and infrequently updated, today's urban analysts can track land use change at sub-30-metre spatial resolutions and near-monthly temporal intervals, enabling both retrospective documentation of growth trajectories and prospective simulation of future scenarios with unprecedented precision and cost-effectiveness.

The application of remote sensing and GIS to urban growth analysis has produced a distinctive methodological sequence that has become standard in the field: (i) acquisition of multi-temporal satellite imagery covering the study area at several historical time points; (ii) supervised classification of imagery into Land Use/Land Cover (LULC) categories; (iii) accuracy assessment using ground-truth field data and statistical measures such as the Kappa coefficient; (iv) change detection and transition matrix analysis to quantify the nature and magnitude of land use change; (v) spatial statistical analysis to identify drivers, hotspots, and patterns of change; and (vi) predictive modeling to project future scenarios. This thesis follows this methodological sequence precisely, applying it to the Bhubaneswar BDA fringe for the period 2010–2025 and projecting forward to 2035.

2.5.1 Cities as Complex Systems: The Cellular Automata Framework

The most influential theoretical contribution to predictive urban modeling in the late twentieth and early twenty-first century comes from Michael Batty's seminal work 'Cities and Complexity' (2005), which fundamentally challenged the linear, equilibrium-seeking assumptions of classical planning models — the Master Plan tradition, in its multiple variations — and replaced them with a dynamic, emergent, and evolutionary conceptualization of urban spatial change. Batty argues that cities are Complex Adaptive Systems: large ensembles of interacting agents — individual households, firms, developers, governments — each making locally rational decisions in response to local conditions, whose aggregate behavior produces macro-scale spatial patterns that no single actor intended, foresaw, or could have planned from above.

This complexity is best captured analytically through the logic of Cellular Automata (CA), borrowed from computational mathematics and chaos theory. A CA model represents the urban landscape as a grid of equal-area cells, each assigned to a discrete state — agricultural, residential, commercial, industrial, open space, water body — at any given time step. Transition rules, calibrated from historical land use change data, determine the probability that each cell will change its state in the next time step, based primarily on the states of its neighboring cells. The key behavioral insight encoded in these rules is contagion: if neighboring cells transition to 'urban,' the probability that the central cell will also become urban increases significantly, modeling the empirically well-documented 'spreading' pattern of urban growth outward from existing built-up clusters.

The power of the CA framework for planning applications lies in its ability to incorporate spatial heterogeneity in development drivers. Not all cells face the same probability of urbanization: those near major roads, existing built-up areas, institutional anchors, and flat topography face higher probabilities; those in flood zones, steep terrain, wetlands, or distant from transport networks face lower probabilities. By encoding these differential probabilities into the CA transition rules — through a Suitable Map derived from multi-criteria evaluation of spatial driver layers — the model produces spatially differentiated growth scenarios that mirror the observed geography of urban expansion far more accurately than simple extrapolation of aggregate growth rates could achieve.

2.5.2 The CA-Markov Model for Indian Cities

The integration of Cellular Automata logic with the Markov Chain statistical framework — producing the CA-Markov hybrid model, operationalized in the TerrSet (IDRISI) software platform developed at Clark University — has become the dominant approach for LULC change prediction in Indian urban planning research over the past two decades. The Markov Chain component calculates a transition probability matrix from historical land use change data across two or more time periods: this matrix specifies, for every pair of land use categories, the probability that a cell in category A at time T will transition to category B by time T+1. For growing Indian cities, the most consequential transitions are those from agricultural to built-up, from vegetation to built-up, and from vacant/fallow to built-up.

Sudhira, Ramachandra, and Jagadish (2004) applied the CA-Markov framework comprehensively to Mysore and Mangalore, demonstrating its robustness in identifying 'hotspots' of imminent growth — areas where the combination of proximity to roads, existing development, institutional anchors, and flat, unconstricted terrain produces the highest probability of near-term conversion from agricultural to built-up use. Hegazy and Kaloop (2015) subsequently extended the methodology to Egyptian urban contexts, demonstrating its cross-cultural applicability. In the Indian planning research tradition, the model has been applied successfully to Hyderabad by Sudhira et al. (2007), to Greater Mumbai by Patel and Mukherjee (2014), and to Bhubaneswar itself in a preliminary study by Mishra et al. (2018).

The critical planning application of the CA-Markov model is the 'Do-Nothing' scenario: a projection of where urban growth will occur by the target year — 2035 in this thesis's Phase IV — if current land use trends continue without policy intervention. The 'Do-Nothing' scenario is not intended as a prediction but as a planning tool: it renders the consequences of inaction spatially explicit and quantitatively measurable, providing a concrete evidentiary basis for the urgency of intervention. When the 'Do-Nothing' 2035 simulation reveals that 34–38% of the remaining agricultural land in the CRRR influence corridor will be converted to unplanned built-up use by 2035, obliterating Daya River floodplain buffers and eliminating any possibility of organized road layout, it creates an evidence-based argument for Land Pooling intervention that is far more compelling than abstract planning principles or normative advocacy.

A significant methodological advancement in CA-Markov modeling for Indian contexts has been the incorporation of Multi-Layer Perceptron (MLP) neural networks as the 'transition potential' estimator, replacing earlier and cruder multi-criteria evaluation approaches. The MLP approach, available within the TerrSet LCM (Land Change Modeler) module, trains a neural network on historical transition data and a set of spatial driver variables — road proximity, institutional proximity, existing built-up density, slope, elevation, flood risk, and proximity to water bodies — to produce a nuanced, non-linear 'Suitability Map' that reflects the actual complexity of development decision-making far better than linear weighted overlay methods. This thesis employs the MLP-based CA-Markov approach in Phase IV, contributing a more sophisticated and defensible growth prediction for the CRRR corridor than previous studies of this area have achieved.

2.6 From Compulsory Acquisition to Land Pooling: The Policy Shift

The most consequential shift in Indian urban planning policy and practice over the past two decades has been the gradual — and in some states still contested — abandonment of Compulsory Land Acquisition as the primary instrument for assembling land for public infrastructure and urban extension, and the parallel rise of Land Pooling Schemes (LPS) as a more equitable, more efficient, and legally more durable alternative. This policy transition has been driven by the twin pressures of documented failure and demonstrated success: the failures of the acquisition model have been painfully visible in decades of litigation, project delays, and displaced farmer communities, while the successes of participatory land management — most notably in Gujarat's Town Planning Scheme experience — have provided an implementable and politically defensible alternative.

The legal history of compulsory acquisition in India begins with the Land Acquisition Act of 1894 — a colonial instrument designed primarily to serve the infrastructure needs of the British Raj with minimal regard for the rights and welfare of displaced persons. Despite numerous amendments, the fundamental asymmetry of the 1894 Act — in which the state determined both the public purpose and the compensation amount, with landowners having limited recourse — generated persistent litigation, widespread resistance, and often violent conflict at acquisition sites. The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement (LARR) Act of 2013 significantly strengthened the social safeguards and compensation standards of the acquisition framework, but its consent and social impact assessment requirements simultaneously made large-scale acquisition more time-consuming and expensive. In the context of peri-urban development, where the scale of land assembly required is enormous and the number of individual landowners affected is very large, the LARR Act effectively rendered compulsory acquisition impractical as a primary development instrument — creating both a legislative need and a political opportunity for Land Pooling as an alternative.

2.6.1 The Town Planning Scheme Model: Gujarat's Contribution

The intellectual and empirical foundation for Land Pooling in the Indian context rests largely on the Town Planning Scheme (TPS) model developed in Gujarat under the Gujarat Town Planning and Urban Development Act (GTPUDA) of 1976 and its antecedent provisions in the Bombay Town Planning Act of 1954. Shirley Ballaney's landmark documentation (2008) of the TPS system in Ahmedabad, Surat, Rajkot, and Vadodara remains the most authoritative and comprehensive account of this model's mechanics, achievements, and limitations, and deserves detailed examination.

The TPS is, at its core, a process of self-financing urban development through planned land readjustment. Instead of the government purchasing land at market rates — an approach that generates prolonged litigation, displacement of landowners, and enormous fiscal pressure on public bodies — the statutory planning authority (in Gujarat's case, the Urban Development Authority or the municipality) invites landowners within a designated scheme area to contribute a defined proportion of their landholding to a common pool. This proportion, termed the 'deduction,' is calibrated to reflect the land area required to provide the public infrastructure that will make the remaining private plots developable: roads of appropriate width with full right-of-way, parks and recreational spaces at URDPFI standards, reservations for schools, health centres, and community facilities, and open drainage channels. In Gujarat's TPS experience, the total deduction typically ranges from 30% to 45% of the original holding, depending on the density of required infrastructure and the proportion of public reservations.

The scheme works because of the value creation logic embedded in its structure. Before the TPS, the contributed land parcels are raw agricultural fields or undeveloped plots with minimal serviced value. After the TPS, the retained plots — reduced in area by the deduction but now part of a planned, infrastructure, legally clear urban layout — are worth substantially more per square metre than the original unserviced agricultural land. Ballaney's analysis of completed Ahmedabad TPS schemes documents appreciation factors of 3x to 7x in per-square-metre plot values following scheme completion, depending on location, scheme quality, and market conditions. This appreciation is the economic engine that makes the scheme voluntary rather than coercive: landowners are not losing their land but exchanging unserviced quantity for serviced quality, in a transaction that the market reveals to be financially advantageous.

The procedural mechanics of the TPS are equally instructive. The scheme is initiated by the planning authority, which prepares a Draft TPS — essentially a detailed land use plan for the scheme area — specifying the reconstituted plot layout, road hierarchies, reservation locations, and deduction percentages for each original holding. This draft is publicly exhibited and landowner objections are heard before finalization. A Final TPS is then notified, and implementation proceeds through a phased program of boundary adjustment, plot reconstitution, and infrastructure construction funded partly from the pooled land contribution and partly from development charges levied on the reconstituted plots. The entire process, from initiation to implementation, typically spans three to seven years — significantly faster than the decade-plus timelines common in acquisition-based projects.

Sanyal and Deuskar (2012), in their comparative study of TPS as a 'hybrid land readjustment process,' identify three critical conditions for its successful replication: strong statutory authority with technical capacity for scheme preparation and administration; a degree of land market buoyancy sufficient to generate the value appreciation that makes owner participation rational; and effective governance mechanisms to prevent elite capture of the scheme's benefits, ensuring that small landowners and tenant farmers receive an equitable share of the scheme's value creation. All three conditions are present in the Bhubaneswar Capital Region context — the BDA has the requisite statutory authority, the Ring Road investment has dramatically boosted land market activity, and the Odisha Rules include specific provisions for small landowner protection.

2.6.2 The Odisha Land Pooling Rules, 2015: A Legislative Framework

The Odisha Land Pooling Schemes Rules of 2015, enacted under Section 76 of the Odisha Development Authorities Act, 1982, represent the state's formal and comprehensive legislative adoption of the participatory land assembly approach, adapted to the specific institutional, legal, and land tenure characteristics of the Odisha context. The Rules establish a detailed procedural framework under which a Development Authority — in the CRRR context, the BDA — can notify a Land Pooling Scheme in any area designated for planned urban extension in the Development Plan, subject to the consent of landowners holding at least 70% of the total private land area within the scheme boundary.

The 70% consent threshold is one of the most significant provisions of the Odisha Rules, distinguishing it from purely compulsory instruments while also ensuring that a dissenting minority cannot block a scheme supported by a clear majority. The Rules specify detailed procedures for establishing and verifying consent, including public disclosure of the scheme draft, individual notification to all affected landowners, a formal objection and hearing period, and a final certification of consent achievement by the competent authority. This procedural scaffolding is essential for the scheme's legitimacy: in the politically sensitive context of agricultural land conversion — where farmer communities have historically been adversarial toward state-led land acquisition — the documented achievement of majority consent transforms the LPS from a top-down imposition into a bottom-up negotiation.

The literature identifies three principal advantages of the Land Pooling mechanism over traditional compulsory acquisition that are particularly relevant in the CRRR context. The first is Equity and Ownership Continuity. Under the 40:60 deduction model standard for the Bhubaneswar context — where 40% of each holding is contributed for public infrastructure and 60% is retained by the owner as a reconstituted, serviced plot — landowners are not dispossessed but transformed into urban stakeholders. The incremental value analysis presented in Chapter 3 demonstrates that this transformation is economically rational: agricultural land valued at Rs. 800–1,200 per sq. ft. pre-announcement becomes reconstituted urban plot land valued at an estimated Rs. 8,000–12,000 per sq. ft. post-implementation, generating a net wealth appreciation for participating landowners even after the 40% area deduction.

The second advantage is Infrastructure Integration through the 'Plan First' Principle. Because the public land contribution — the 40% — is secured at the outset of the scheme, before any development takes place, the planning authority can lay out the complete road network, utility trunk lines, drainage channels, parks, and reservations in a coordinated, pre-designed manner. Road Rights-of-Way are established before buildings are constructed, eliminating the need for costly demolition and acquisition of built structures for future road widening. Utility alignments are determined before buildings are constructed over them, ensuring that pipe networks can run in straight lines to gravity-favorable gradients. Open spaces are reserved before private development eliminates suitable sites. This sequencing advantage — securing the public interest in land before private development forecloses options — is the most fundamental and irreversible benefit of the Land Pooling approach.

The third advantage is Conflict Reduction and Implementation Velocity. The consent requirement means that the scheme proceeds with the formal endorsement of the majority of those whose land is being reorganized. Hong and Needham (2007), in their comparative international study of land readjustment systems, find that consent-based schemes are completed on average 40–60% faster than acquisition-based projects of equivalent scale, primarily due to the dramatic reduction in litigation and resistance. For a large-scale project like the CRRR, where the development opportunity window is narrow — rapid market-driven conversion is already occurring — this reduction in implementation time is not merely a procedural benefit but a strategic necessity.

Attribute	**Compulsory Acquisition vs. Land Pooling**
Landownership Outcome	Dispossession at fixed compensation vs. Retention as urban stakeholder
Infrastructure Provision	Retrospective, after development vs. Prospective, before development
Litigation Risk	Very High — systematic resistance vs. Low — majority consent required
State Fiscal Burden	Very High — market rate purchase vs. Low — self-financing mechanism
Implementation Speed	10–15 years (litigation) vs. 3–7 years (consent process)
Landowner Value Outcome	Compensation only vs. 3x–7x value appreciation

Table 2.1: Comparative Analysis — Compulsory Acquisition vs. Land Pooling Scheme (Source: Ballaney, 2008; Hong & Needham, 2007; Odisha Land Pooling Rules, 2015)

2.7 The Polycentric Urban Framework and New Urbanism

A final and synthesizing theoretical pillar informing this thesis's planning proposals is the Polycentric Urban Model, which offers a normative vision of how large, growing cities should be spatially organized to simultaneously maximize economic efficiency, social equity, environmental sustainability, and urban quality of life. The polycentric model has its intellectual roots in central place theory (Christaller, 1933; Lösch, 1944) and has been extensively theorized and empirically investigated in the context of contemporary global urbanization by Anas, Arnott, and Small (1998), Kloosterman and Musterd (2001), and Davoudi (2003), among many others.

Anas, Arnott, and Small (1998) demonstrated through both theoretical modeling and comparative empirical case studies that as metropolitan regions grow beyond a critical population and spatial threshold — generally identified as the point at which commuting times from the periphery to the central business district exceed 45–60 minutes in peak conditions — the monocentric model becomes progressively less economically efficient. In the monocentric city, all high-order employment and services are concentrated in a single CBD, generating ever-longer commutes, ever-worse congestion, ever-higher land values in the core, and the progressive transformation of the periphery into a purely residential dormitory suburb with weak economic identity and high automobile dependence. This inefficiency is not merely economic; it has profound social and environmental consequences — income polarization, spatial segregation of employment and housing, and carbon-intensive transportation patterns — that compound as the city grows.

The polycentric alternative distributes economic activity, employment, and services across a network of sub-centers or 'nodes,' each functioning as a relatively self-contained urban hub at the local or district scale while remaining connected to the wider metropolitan network through high-quality transport infrastructure. The theoretical advantage of polycentricity is the reduction of average travel distances: if employment and services are accessible at multiple locations across the metropolitan region rather than concentrated at a single point, the average trip length for residents falls dramatically, reducing congestion, transport energy demand, and commuting time inequalities between different parts of the city.

Applied to the Bhubaneswar Capital Region, the polycentric model generates a clear and implementable spatial vision. Rather than allowing the Ring Road corridor to function as a dormitory extension of the existing core city — a pattern that would intensify the monocentric pressures already straining the city's transport and land markets — the planning proposals of this thesis envision a set of mixed-use, economically active nodes at regular intervals along the Ring Road alignment. Each node is planned with a distinct economic specialization reflecting its comparative advantages: the Knowledge Hub at Patia, anchored by the educational and IT cluster of IIT-Bhubaneswar, KIIT, and Infocity, would continue to develop as a centre for knowledge economy employment, high-quality residential accommodation, and knowledge-intensive services. The Industrial and Logistics Hub near the CRRR-NH16 intersection at Khurda-Jatani would consolidate its role as a freight logistics, MSME manufacturing, and light industrial centre. The residential nodes in the south-western fringe would evolve into balanced mixed-use neighborhoods with their own retail, social service, and community facility clusters, reducing dependence on the core city for everyday needs.

The New Urbanism movement, most influentially articulated by Duany, Plater-Zyberk, and Speck (2000) in 'The Death and Life of the American Dream,' provides the design grammar for the individual nodes within this polycentric framework. New Urbanism advocates for the design of 'Traditional Neighborhood Developments' or 'Transit-Oriented Developments' in which residents can access employment, retail, recreation, healthcare, and education within a maximum 5–10-minute walking distance — approximately a 400–800 metre radius from a central transit stop or community focal point. This walkable neighborhood scale is both a social equity instrument — it ensures that car-free households can meet their daily needs without motorized travel — and an urban form generator, producing the fine-grained mix of land uses, building types, and public spaces that make neighborhoods legible, identifiable, and socially cohesive.

Combined with Transit-Oriented Development (TOD) principles — which concentrate density and mixed uses within walkable distances of transit stops while tapering to lower densities and predominantly residential uses at the node periphery — the New Urbanist model generates a spatial template for the CRRR corridor nodes that this thesis incorporates into its planning proposals. At each of the proposed node locations along the Ring Road, the highest densities and most intense mixed uses — commercial ground floors, residential upper floors, community facilities, urban public spaces — are concentrated within 400–600 metres of the Ring Road interchange or proposed bus rapid transit station, while the surrounding areas are zoned for progressively lower densities and larger open space proportions as one moves outward. The Land Pooling Scheme, by securing the necessary Road Rights-of-Way, utility reservations, and public space reserves before development begins, creates the spatial preconditions for this TOD-New Urbanist pattern to be realized in the built environment.

2.8 Synthesis and Identification of Research Gap

A careful and comprehensive survey of the existing literature across the five thematic domains reviewed above reveals a well-established and sophisticated body of knowledge in each individual area. The peri-urban interface is theoretically well-articulated, with the 'Triple Transition' framework, the 'grey zone' governance analysis, and the 'desakota' concept providing robust conceptual tools for understanding the Bhubaneswar fringe condition. Infrastructure-led development and its catalytic consequences for land markets are thoroughly documented across multiple Indian and international Ring Road cases, establishing a clear and empirically grounded expectation of what will occur along the CRRR in the absence of planning intervention. The spatial mathematics of sprawl measurement — the Sprawl Index, the Compactness Ratio, the built-up area density analysis — are analytically mature and widely validated. Land Use/Land Cover change detection and CA-Markov predictive modeling have been applied successfully to dozens of Indian cities, generating methodologically robust tools for spatial analysis and scenario projection. Land Pooling, while a newer instrument in the Indian planning toolkit, has accumulated an impressive body of case study evidence in Gujarat and a growing legislative framework at the national and state level. The polycentric urban model and its TOD-New Urbanist design vocabulary offer a normative spatial framework for translating analytical findings into planning proposals.

However, a significant and actionable research gap persists at the intersection of these literatures. Most existing studies operate at the macro-scale: they identify that sprawl is occurring, confirm that ring roads catalyze peripheral growth, and advocate in general and normative terms for better land management. Very few studies operationalize these macro-level insights at the micro-scale of individual Mouzas and specific planning proposals. The literature on CA-Markov modeling is generally limited to projecting growth patterns and identifying hotspots; it rarely connects these projections to concrete, site-specific planning interventions. The literature on Land Pooling, meanwhile, focuses primarily on the procedural and economic mechanics of the instrument, and rarely integrates it with quantitative growth prediction or spatial simulation. And the literature on polycentric urban planning, while theoretically rich, is rarely grounded in the specific site conditions, governance constraints, and legislative frameworks of a particular Indian metropolitan region.

Critically, no existing study in the Odisha context — and very few in the broader Indian ring road planning literature — integrates four analytical elements simultaneously: (i) a quantitative, satellite-based spatio-temporal analysis of historical growth (2010–2025); (ii) a CA-Markov simulation of projected 2035 growth under a 'Do-Nothing' scenario; (iii) a Mouza-level Land Pooling Scheme design based on the Odisha Land Pooling Rules, 2015; and (iv) an integrated polycentric node planning framework for the full Ring Road corridor. Each of these elements exists independently in the literature; their integration for a specific, implementable planning challenge does not.

This thesis addresses precisely this fourfold integration gap. By combining Phase I–III spatio-temporal LULC analysis (documenting what has happened to land use from 2010 to 2025 in quantitative and spatially explicit terms), Phase IV CA-Markov simulation (projecting what will happen by 2035 under a 'Do-Nothing' scenario that renders the consequences of inaction visible), and Phase V Land Pooling design within a polycentric framework (proposing what should happen through a 40:60 deduction scheme at the Mouza level, organized around a hierarchy of mixed-use Ring Road nodes), the research moves decisively from the academic observation of sprawl to the active, design-led intervention required to manage it. In doing so, it contributes both a methodological model for planning Ring Road corridors in other Indian Tier-2 cities and a directly implementable planning framework for the Bhubaneswar Capital Region Ring Road — a contribution that addresses not merely the academic literature but the urgent practical needs of one of Odisha's most consequential planning challenges.

CHAPTER 3: MATERIAL AND METHODOLOGY

3.1 Research Design Framework

The methodology of this thesis is structured as a multi-stage technical workflow designed to bridge the analytical gap between macro-scale satellite observation and micro-scale planning intervention. The research is built upon a 'Diagnostic–Predictive–Prescriptive' logic, mirroring the three stages through which a responsible planning authority should approach an uncontrolled growth situation. The Diagnostic stage documents what has already happened to the land: how agricultural fields and green buffers have been converted to built-up use between 2010 and 2025, and where this conversion has been most intense. The Predictive stage asks what will happen by 2035 if no regulatory action is taken, using a mathematical simulation to render the future visible. The Prescriptive stage converts that prediction into design action: a spatially explicit Land Pooling Scheme (LPS) that reorganizes fragmented agricultural land into a planned, serviced urban layout, preventing the disordered sprawl the model warns of.

This three-stage logic is operationalized across five sequential phases of field work, remote sensing analysis, spatial modeling, and planning design. Each phase builds upon the outputs of the preceding one, creating an integrated, reproducible methodology. Methology below presents the complete research workflow as a timeline, illustrating the logical sequence and inter-phase dependencies.

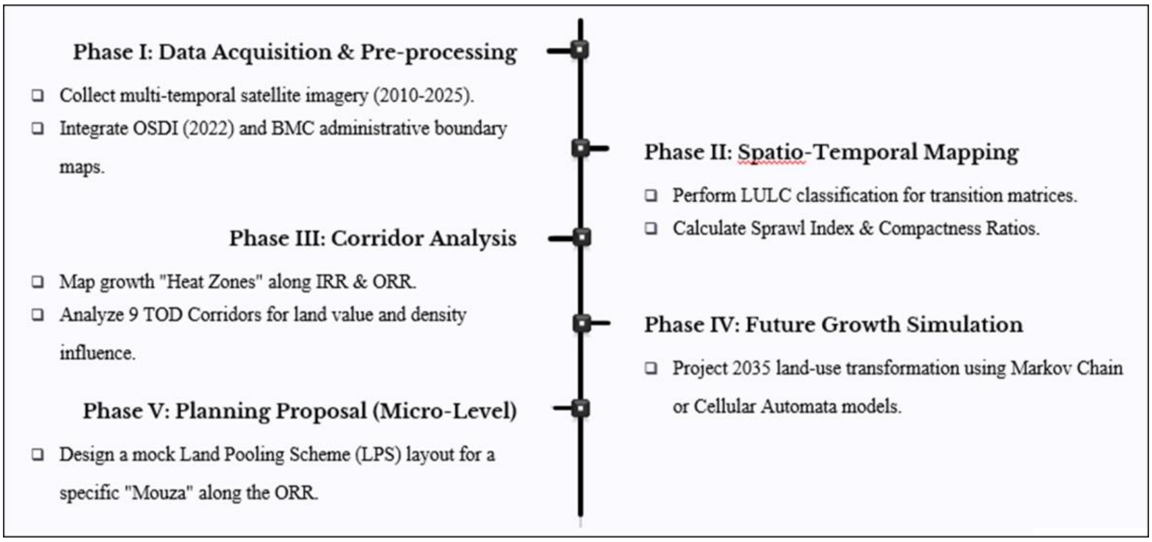


Figure 3.1: Five-Phase Research Methodology Workflow

3.2 Phase I: Data Acquisition and Pre-Processing Inventory

The accuracy and reliability of any urban growth model is entirely dependent on the quality and consistency of the baseline data upon which it is built. A model built on poorly georeferenced, atmospherically uncorrected, or temporally inconsistent imagery will produce misleading outputs regardless of the sophistication of the algorithm applied to it. Accordingly, Phase I of this research involved a rigorous, multi-source data acquisition strategy encompassing both remote sensing imagery and administrative spatial datasets, followed by systematic pre-processing to ensure that all data layers are mutually compatible and analytically reliable.

3.2.1 Remote Sensing Data

To capture the spatio-temporal trajectory of Bhubaneswar's urban expansion, multi-temporal satellite imagery was procured for three carefully chosen milestones: 2010 (pre-Ring Road baseline), 2017 (mid-period, reflecting early corridor-induced growth), and 2025 (near-present, capturing the latest developmental state). The choice of three time points enables the calculation of both a decadal change rate (2010–2025) and a mid-period rate (2010–2017 versus 2017–2025), allowing the study to assess whether growth has been accelerating, decelerating, or remaining constant — a distinction with significant implications for the reliability of the 2035 projection.

Table 3.1 below presents the satellite data specifications for each epoch, including sensor type, spatial resolution, and pre-processing steps applied.

Epoch	Satellite / Sensor	Resolution	Band Combination	Pre-Processing Steps
2010	Landsat 5 TM	30 m	4-3-2 (False Colour)	DOS Atm. Correction; Radiometric Calibration
2017	Landsat 8 OLI/TIRS	30 m	5-4-3 (False Colour)	DOS Atm. Correction; Radiometric Calibration; Layer Stack

Epoch	Satellite / Sensor	Resolution	Band Combination	Pre-Processing Steps
2025	Sentinel-2 MSI	10 m	8-4-3 (False Colour)	Resampled to 30 m; Sen2Cor Atm. Correction; Cloud Masking

Table 3.1: Satellite Data Specifications and Pre-Processing Protocol (Source: USGS Earth Explorer)

Atmospheric correction was performed using the Dark Object Subtraction (DOS) method, which identifies the darkest pixel in the image — assumed to correspond to a water body or deep shadow where ground reflectance should theoretically be zero — and subtracts that residual digital number from all other pixels. This eliminates the additive effect of atmospheric haze, ensuring that pixel brightness values across the three epochs reflect actual ground surface characteristics rather than atmospheric conditions on the day of acquisition. Sentinel-2 imagery for 2025 was additionally processed through the Sen2Cor plugin to produce Bottom-of-Atmosphere (BOA) reflectance values consistent with the Landsat-derived values for 2010 and 2017. Resampling of Sentinel-2 imagery from 10 m to 30 m was performed using bilinear interpolation to ensure pixel-level compatibility across all three epochs.

3.2.2 Administrative and Spatial Datasets

Beyond satellite imagery, three categories of administrative and spatial data were integrated into the GIS environment to provide legal, demographic, and infrastructural context to the land use analysis. The Odisha Spatial Data Infrastructure (OSDI, 2022) provided high-resolution cadastral boundary data at the Mouza level, which forms the legal unit of land ownership in Odisha. These Mouza boundaries were critical for Phase V, where the LPS design must be grounded in actual ownership patterns rather than arbitrary planning units. The exact alignment of the 111-km Capital Region Ring Road (CRRR) was digitized from OSDI engineering drawings and validated against Google Earth imagery. The BDA's Comprehensive Development Plan (CDP) 2030 was used to compare officially designated land use zones against the actual land use established through LULC classification — a comparison that reveals the extent to which development has deviated from the statutory plan framework. Census of India data for 2011 and 2021 projections provided demographic ground-truth for correlating physical sprawl with population density shifts across wards and census towns.

3.3 Phase II: Spatio-Temporal Mapping and LULC Classification

Phase II transforms raw satellite imagery into analytically meaningful thematic maps. Using ArcGIS 10.8 as the primary classification environment and QGIS for open-source validation, the pre-processed imagery for each of the three epochs was classified into discrete Land Use/Land Cover (LULC) categories using a supervised classification approach.

3.3.1 Classification Schema: Four LULC Categories

The study employed the Maximum Likelihood Classification (MLC) algorithm, which assigns each pixel to the class for which it has the highest statistical probability of membership, based on the spectral signature of training samples defined by the analyst. Four primary LULC classes were defined based on their planning relevance for the CRRR corridor context, as described in Table 3.2.

LULC Class	Definition / Includes	Planning Significance
Built-up Area	Residential colonies, commercial strips, industrial sheds, paved roads and parking areas.	Primary indicator of urban expansion and sprawl intensity.
Vegetation / Green Cover	Forests (Chandaka), plantations, dense parks, tree groves.	Identifies green buffers under threat; inputs to exclusion zones in CA model.
Agriculture / Fallow Land	Active crop land, fallow seasonal plots, speculative vacant plots.	Target land for Land Pooling intervention; primary conversion candidate.
Water Bodies	Rivers (Daya, Kuakhai), seasonal canals, tanks, flood plain wetlands.	Environmental constraint layer; inputs to restricted zones in CA model.

Table 3.2: LULC Classification Schema with Planning Significance

3.3.2 Accuracy Assessment and Kappa Coefficient

The reliability of any LULC classification must be statistically validated before its outputs are used as inputs to further analysis. A Confusion Matrix (also known as an Error Matrix) was generated for each epoch's classification by comparing the classified pixel values against a set of independently collected ground-truth points. GPS-verified ground-truth points were collected in the field for 2025 imagery, while for the historical epochs (2010 and 2017), ground-truth was established through high-resolution archive imagery from Google Earth Pro. The Overall Accuracy and Kappa Coefficient (κ) — which corrects for agreement attributable to chance — were computed for each classification. A minimum threshold of $\kappa \geq 0.85$ was set as the quality gate; classifications falling below this threshold were rejected and re-trained before being accepted for use in the study.

3.4 Phase III: Corridor Analysis and Growth Heat Zone Mapping

With reliable, multi-temporal LULC maps established, Phase III focuses analytical attention specifically on the CRRR corridor — the spatial axis along which future growth will be concentrated. This phase uses two complementary spatial analysis techniques to reveal the spatial logic and intensity of ring-road-induced urban expansion.

3.4.1 Multi-Ring Buffer Analysis

The fundamental variable governing peri-urban land value and development pressure is proximity to infrastructure — specifically, the distance of a land parcel from the Ring Road. The study generated three concentric buffer zones around the digitized CRRR alignment: a 1-km Primary Buffer representing land with direct road access and highest visibility, a 2-km Secondary Buffer representing the first ring of residential and commercial depth, and a 5-km Extended Buffer representing the outer influence zone where land value inflation is still measurable but diminished. By intersecting the LULC maps with these buffers for each epoch, the study quantifies the 'Intensity of Conversion' within each zone: what proportion of agricultural land within the 0–1 km buffer has converted to built-up between 2010 and 2025, compared to the 1–2 km and

2–5 km rings? This analysis reveals whether growth is corridor-hugging (typical of ribbon development) or more dispersed (indicating more uniform regional pressure).

3.4.2 Kernel Density Estimation (KDE) for Hotspot Identification

Buffer analysis quantifies growth intensity by zone, but it does not reveal the sub-zonal clustering of new development — the specific nodes or clusters where urbanization is advancing most aggressively. Kernel Density Estimation (KDE) addresses this by calculating, for each pixel, a density score that reflects the concentration of new built-up pixels within a specified search radius (bandwidth) around it. High KDE values indicate 'Growth Hotspots': areas where new development is clustering at rates significantly above the corridor average. The analysis paid particular attention to two documented hotspot clusters — the South-Western cluster centred on Tamando–Patrapada, which is driven by IT sector land demand and the proximity of the Infocity corridor, and the Northern cluster around Patia–Infovalley, which is experiencing pressure from educational institutions, retail development, and upscale residential projects. The KDE maps visually reveal whether these two clusters are converging into a contiguous sprawl mass — a critical threshold beyond which planned intervention becomes technically and financially far more difficult.

3.5 Phase IV: Predictive Modeling Using CA-Markov Logic

Phase IV constitutes the predictive core of the thesis. While the LULC analysis of Phases II and III documents and describes the past, the CA-Markov model of Phase IV projects the future. The model is implemented in TerrSet (formerly IDRISI) software, which provides a dedicated Land Change Modeler (LCM) module integrating both the Markov Chain and Cellular Automata components.

3.5.1 The Markov Chain Component: Calculating Transition Probabilities

The Markov Chain component of the model takes the LULC maps from two successive time points — 2010 and 2025 — and computes a Transition Probability Matrix (TPM). The TPM is a square matrix in which each cell [i, j] records the probability that a pixel currently in class i will transition to class j in the next time step. For this study, the TPM quantifies, for example, the probability that a pixel classified as 'Agriculture' in 2010 will have become 'Built-up' by 2025, and projects this transition rate forward to 2035. The Markov model thus provides the quantity of change — how many pixels are expected to change from each class to each other class in the projection period — but does not, by itself, specify where those transitions will occur.

3.5.2 The Cellular Automata Component: Spatializing Change with Driver Variables

The spatial dimension of the prediction is provided by the Cellular Automata component, which applies 'suitability maps' derived from spatial driver variables to distribute the Markov-calculated quantity of change across the landscape. The primary spatial drivers used in this study are: distance to the CRRR alignment (inverse relationship — closer parcels are more likely to convert), distance to existing built-up areas in 2025 (contagion effect — new development clusters near existing development), distance to existing roads in the secondary network (accessibility premium), and population density gradients derived from census data. These driver variables are integrated into a Multi-Layer Perceptron (MLP) neural network within TerrSet's LCM module, which calibrates their relative weights based on the observed patterns of transition between 2010 and 2025.

Critically, the model incorporates Constraint Layers — areas legally or environmentally excluded from urbanization — to ensure that the 2035 projection reflects realistic regulatory boundaries. The Chandaka Wildlife Sanctuary and its eco-sensitive zone, the Daya River floodplain, and notified water body boundaries are designated as hard exclusion zones in which no built-up transition is permitted regardless of the suitability score. This ensures the model does not predict development in areas where it is legally prohibited, preserving the planning credibility of the projection.

3.6 Phase V: Prescriptive Proposal — Land Pooling Scheme Design

Phase V is the culminating, design-oriented phase of the research, in which the analytical outputs of the preceding phases are translated into a concrete, implementable planning intervention. The phase proposes a Land Pooling Scheme (LPS) for a selected Mouza — a revenue village boundary unit — identified by the 2035 CA-Markov model as a High-Risk Sprawl Zone along the CRRR corridor. This phase operationalizes the Odisha Land Pooling Rules (2015) through a spatially explicit, GIS-assisted design process.

3.6.1 Site Selection Criteria

The Mouza selected for the LPS design must simultaneously satisfy three screening criteria: it must register a high probability of land conversion to built-up use in the 2035 CA-Markov projection (indicating urgency of intervention), it must be directly adjacent to or intersected by the CRRR alignment (confirming that Ring Road proximity is the primary growth driver), and it must exhibit ownership fragmentation — a high number of small, irregularly shaped agricultural plots — as confirmed by OSDI cadastral data. Fragmented ownership patterns are the most important practical criterion, as they represent both the greatest obstacle to conventional private development (coordination failure among many small landowners) and the most compelling case for a state-facilitated Land Pooling mechanism.

3.6.2 The 40:60 Reconstitution Workflow

Following the provisions of the Odisha Land Pooling Rules (2015), the LPS design employs a 40:60 deduction model. For every unit of land brought into the scheme, 40% is contributed by the landowner to the common pool for public use, while 60% is reconstituted and returned to the owner as a serviced urban plot. The contributed 40% is allocated across a hierarchy of public uses, as specified in Table 3.3, with road network infrastructure — including the 30-metre primary arterial road, 18-metre secondary streets, and 12-metre internal access lanes — constituting the largest single component of the public deduction.

Public Use Category	**% of Total Land**	**Typical Width / Scale**	**Rationale**
Primary Arterial Road (30m RoW)	15%	30 m	Main spine connecting to CRRR interchange

Public Use Category	% of Total Land	Typical Width / Scale	Rationale
Secondary Roads (18m RoW)	10%	18 m	Internal grid connectivity
Internal Access Lanes (12m RoW)	5%	12 m	Plot-level access; utilities easement
Open Space / Parks	6%	Min. 400 sqm park per sector	Statutory green space provision per ODA norms
Public Semi-Public (PSP) — Schools, Clinics, Fire	4%	Variable	Social infrastructure for new residents
TOTAL PUBLIC CONTRIBUTION	**40%**	—	**Landowner retains 60%**

Table 3.3: Land Deduction Hierarchy under the 40:60 LPS Model (Source: Odisha Land Pooling Rules 2015

The reconstitution of the retained 60% involves reshaping the original, irregular agricultural plot geometries — typically elongated strips oriented to drainage channels or field bunds — into rectangular, road-fronting urban plots using the Parcel Fabric and Plot Reconstitution tools in ArcGIS. Each reconstituted plot is dimensioned in accordance with BDA development control norms for its designated use zone (residential, commercial, or mixed-use). The design process is iterative: the road layout is first fixed to optimize connectivity and Right-of-Way, the public spaces and PSP reservations are then located, and the remaining area is reconstituted into serviced plots, with each owner receiving a plot whose area is 60% of their original holding in a location as close to the original plot centroid as the road layout permits.

3.6.3 Incremental Value Calculation: The Economic Justification

The economic rationality of the LPS for landowners’ rests on the 'Incremental Value' argument: although the scheme reduces the owner's land area by 40%, it simultaneously increases the per-square-metre market value of the retained 60% by a factor substantially greater than 1.67 — the factor that would be needed merely to compensate for the area loss. Infrastructure provision, road frontage, utility connections, and legal clear title transform raw agricultural land (typically valued at Rs. 500–800 per sqm in the study corridor) into serviced urban plots (valued at Rs. 2,500–4,500 per sqm). The methodology demonstrates this incremental value calculation explicitly for the selected Mouza, providing a quantitative economic justification for owner participation that is essential for achieving the 70% consent threshold required under the Odisha Rules.

3.7 Methodological Summary

Table 3.4 summarizes the complete five-phase methodology, consolidating the objective, tools, data inputs, and analytical outputs of each phase into a single reference framework. This summary underscores the integrated, cumulative nature of the research design, in which each phase's outputs serve as direct inputs to the next.

Phase	Objective	Tools / Software	Key Inputs	Output / Deliverable
I	Data Acquisition & Pre-processing	USGS Earth Explorer; Sen2Cor; ERDAS Imagine	Landsat 5/8, Sentinel-2; OSDI; Census 2011/21	Corrected, co-registered base maps for three epochs
II	LULC Classification & Accuracy Assessment	ArcGIS 10.8; QGIS	Pre-processed imagery; GPS ground-truth points	Multi-temporal LULC maps (2010, 2017, 2025); Kappa ≥ 0.85
III	Corridor Analysis & Hotspot Mapping	ArcGIS Buffer & KDE tools	LULC maps; CRRR alignment; secondary roads	Buffer-wise conversion rates; Growth Hotspot KDE maps

Phase	Objective	Tools / Software	Key Inputs	Output / Deliverable
IV	CA-Markov 2035 Growth Prediction	TerrSet LCM (IDRISI); MLP Neural Network	2010 & 2025 LULC; driver & constraint layers	2035 'Do-Nothing' growth scenario; hotspot risk zones
V	LPS Design & Incremental Value Analysis	ArcGIS Parcel Fabric; AutoCAD; GIS Reconstitution	Mouza cadastrals; Odisha LP Rules 2015; BDA norms	40:60 LPS layout; road hierarchy; reconstituted plots; valuation proof

Table 3.4: Methodological Summary — Five-Phase Research Framework

Taken together, these five phases constitute a methodological arc that begins with raw satellite pixels and ends with designed, legally grounded planning proposals. The rigour of the earlier analytical phases — the multi-temporal classification, the accuracy-validated LULC maps, the CA-Markov simulation — lends scientific credibility to the design proposals of Phase V, ensuring that the Land Pooling Scheme is not merely a normative prescription but a spatially and empirically justified intervention calibrated to the actual growth dynamics of the CRRR corridor.

CHAPTER 4: SITE ANALYSIS

4.1 Introduction to the Study Area and Spatial Scope

The Bhubaneswar Capital Region constitutes one of the most instructive case studies of rapid, infrastructure-catalysed peri-urban transformation in contemporary India. Planned with precision by the German architect Otto Königsberger in the 1940s as a compact, sector-based administrative capital, the city's planned area — covering Units 1 through 9 and the contiguous Old Town — represented an early experiment in modern Indian town planning. That ordered vision, however, has been progressively overwhelmed by the organic, market-driven growth that has engulfed the city's periphery over the last two decades. Today, while the administrative core retains the legibility of its grid and its planned open spaces, the urban fringe tells a radically different story: one of accidental urbanism, governance vacuums, and accelerating environmental stress.

The study area for this thesis spans an approximately 55 sq. km peri-urban interface zone — the critical belt of land lying between the consolidated urban fabric of the Bhubaneswar Municipal Corporation (BMC) and the outer administrative boundary of the Bhubaneswar Development Authority (BDA). This zone, which encompasses the revenue villages (Mouzas) most immediately affected by the 111-km Capital Region Ring Road (CRRR) project, forms the primary field investigation area. It is within this 55 sq. km belt that the confluence of infrastructure investment, land speculation, demographic pressure, and institutional failure is most acute — and where the case for a planned Land Pooling intervention is most compelling. The analysis in this chapter draws on multi-temporal satellite-derived Land Use/Land Cover (LULC) maps, field survey data, GIS-based network analysis, and the author's own cadastral investigations to construct a comprehensive diagnostic portrait of this territory.

The site analysis is structured across seven thematic dimensions: spatio-temporal built-up growth, growth heat zone identification, detailed land use evolution, infrastructure deficit assessment, service accessibility analysis, environmental and hydrological vulnerability, and a synthesis of planning issues. Together, these dimensions build the evidential case for the Land Pooling Scheme proposed in subsequent chapters.

4.2 Spatio-Temporal Built-Up Density: The 2010–2025 Growth Trajectory

The most fundamental finding of the spatio-temporal analysis is the sheer velocity of built-up area expansion within the BDA fringe. Between 2010 and 2025, the built-up footprint of the Bhubaneswar urban region grew from 130.2 sq. km to 247.3 sq. km — an increase of 89.7% in fifteen years, or approximately 7.8 sq. km of new built-up area per year on average. Critically, this growth was not linear: the period between 2020 and 2025 recorded the highest annualized growth rate of 7.3%, driven by the acceleration of Ring Road construction activity and the associated land speculation that preceded it. The Sprawl Index for the city climbed from 1.82 in 2010 to 2.34 in 2025, while the Compactness Ratio fell from 0.78 to 0.67, confirming that growth was becoming increasingly dispersed, fragmented, and expensive to service with public infrastructure.

The maps below (Map 4.1) illustrate this transformation through four LULC snapshots — 2010, 2015, 2020, and 2025 — and a Land Use Composition Evolution graph that traces the proportional decline of agricultural land and vegetation alongside the rise of built-up cover. The 2010 map reveals a compact, contiguous urban mass in the north-central quadrant of the BDA area, with large unbroken patches of agricultural green to the south and west. By 2025, that green field has been dramatically fragmented: built-up patches now extend in all cardinal directions, with the south-western quadrant showing the most dramatic conversion.

4.2.1 Core Saturation and the 'Push' Factor

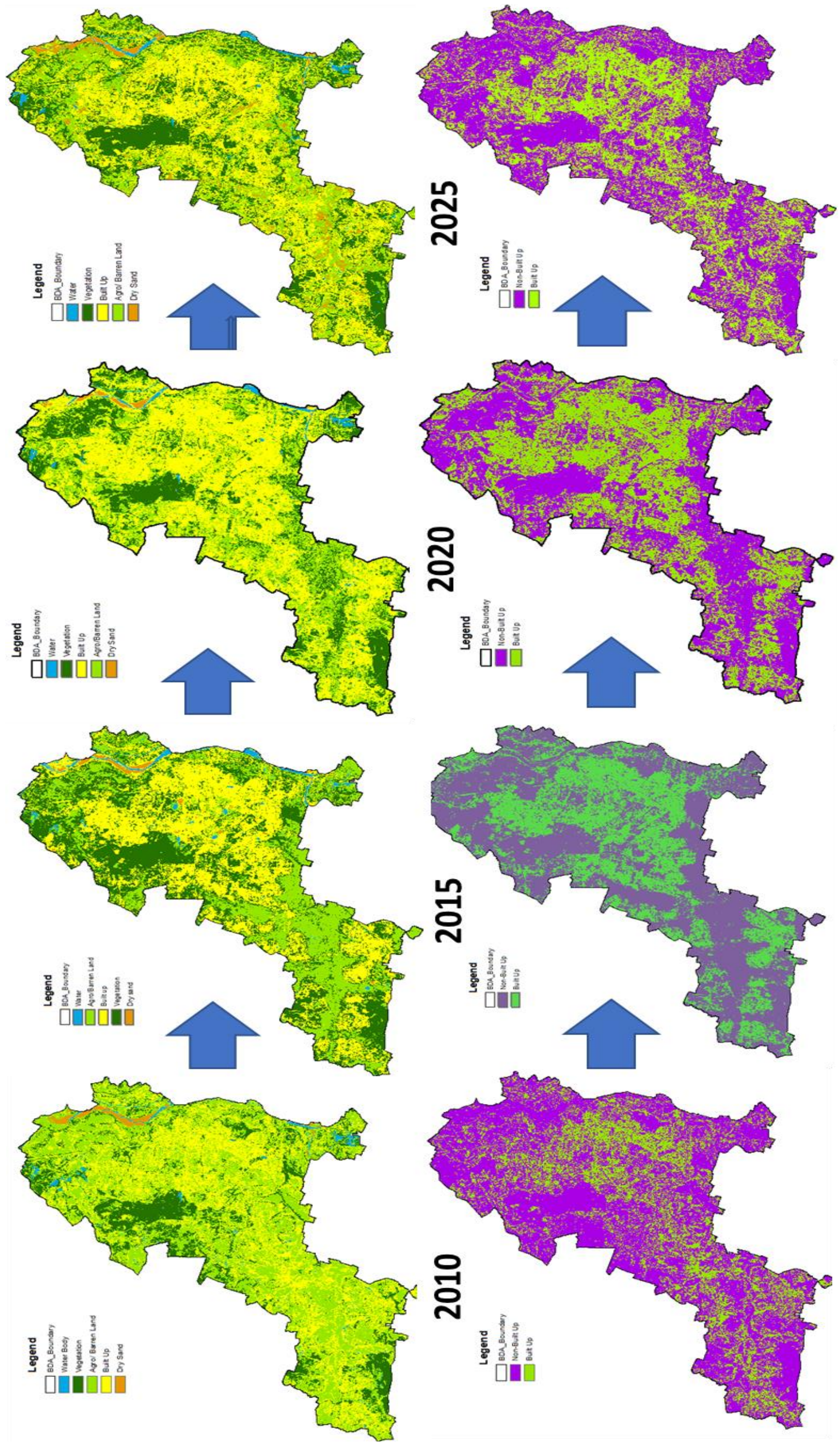
The central planning units (Units 1–9) and the historical Old Town area have reached a condition of near-absolute spatial saturation. Field surveys and ward-level built-up density analysis confirm that these areas now exhibit built-up densities exceeding 85%, leaving no meaningful contiguous land parcels available for large-scale new residential, institutional, or commercial development. This saturation has driven land prices in the core to levels inaccessible to middle-income households and medium-scale developers, creating a powerful 'push' dynamic that redirects development pressure outward toward the city's peri-urban fringe.

The 'push' is further amplified by the BDA's own zoning and FAR restrictions in the core, which limit vertical densification and prevent the kind of compact, in-situ redevelopment that might otherwise absorb additional population and economic activity within the existing urban footprint. The result is a city that is simultaneously too dense at its centre — generating land costs and congestion that repel potential occupants — and too diffuse at its periphery, where uncontrolled spread multiplies the cost of public service provision without delivering the agglomeration benefits of genuine urban density.

4.2.2 Transition Wards: The 55 sq. km Peri-Urban Interface as the Frontier of Sprawl

The most dramatic and planning-relevant shifts have occurred within the approximately 55 sq. km peri-urban interface belt — the zone of Gram Panchayat villages and BDA fringe Mouzas that lie immediately outside the BMC boundary and directly in the path of the Capital Region Ring Road. This is the primary field investigation area of the thesis, and it is here that the collision between rural governance structures and urban development pressures is most intense and consequential.

Within this belt, two sub-zones stand out as particularly critical. The Northern Fringe, centred on Patia and the Chandaka institutional edge, has seen built-up density leap from approximately 15% in 2010 to over 60% in 2025 — a fourfold increase in fifteen years that reflects the gravitational pull of the IT corridor and the educational campuses of KIIT and ITER. The South-Western Fringe, comprising Tamando, Patrapada, Sundarpada, and Ghatikia, represents what this analysis terms the 'Residential Frontier.' Growth in this sub-zone has proceeded at nearly four times the city average, driven primarily by the construction of low-to-mid-rise apartment complexes, plotted residential schemes, and small commercial developments serving the growing workforce population. Table 4.1 presents the ward-level growth data for key transition zones within the 55 sq. km study area.



MAP 4.1: Spatio-Temporal Growth of Built-Up Area, Bhubaneswar 2010–2025, with Land Use Composition Evolution Graph and Detailed Land Use Transition Matrix (Source: ArcGIS Analysis on Landsat/Sentinel Data)

Peri-Urban Zone / Ward	Built-up 2010 (%)	Built-up 2025 (%)	Growth Rate 2010–25	Vacant Land Left (%)	Dominant Pressure
Zone A — Patia / Infovalley (North)	~15%	>60%	112%	14%	IT/Institutional; Gated Housing
Zone B — Tamando / Patrapada (S-W)	~8%	>55%	145%	38%	Affordable/Mid-seg. Residential
Zone C — Jatani / Khurda (South)	~12%	~38%	88%	52%	Industrial / Logistics / Warehousing
Core City (Units 1–9) — Reference	>80%	>85%	~6%	<5%	Saturation — Minimal New Growth

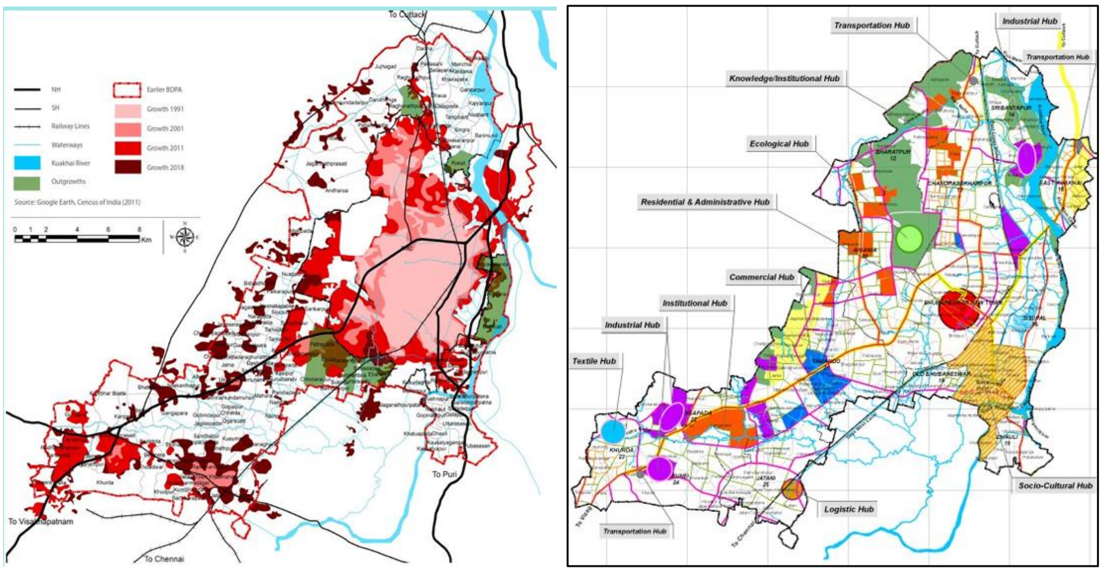
Table 4.1: Ward-Level Built-Up Density Growth in the 55 sq. km Peri-Urban Study Area (2010–2025) (Source: ArcGIS LULC Analysis; BMC Ward GIS Data; Author)

4.3 Identification of Growth Heat Zones and the Ring Road Influence Corridor

Through Kernel Density Estimation (KDE) heat-mapping and buffer-zone analysis, three distinct 'Growth Engines' have been identified along the CRRR and Inner Ring Road (IRR) corridors. These heat zones are not merely areas of high current development activity; they are the spatial nodes where the interaction between infrastructure access, land speculation, and institutional absence is most intense — and where the risk of unplanned, unserviced sprawl crystallizing into a permanent structural problem is highest. Map 4.2 illustrates the spatial extent of these zones alongside the land use percentage breakdown and the nine designated TOD corridors.

4.3.1 Zone A: The Knowledge Corridor (Northern Fringe)

Centered on Patia and the Infovalley–Chandrasekharpur axis, Zone A represents the most economically dynamic node in the peri-urban belt. Anchored by major IT employers — Infosys, TCS, and a cluster of mid-tier technology companies — and complemented by the substantial educational infrastructure of KIIT University and ITER (within the SOA University complex), this zone has attracted a high-income, knowledge-economy workforce that demands premium residential accommodation, upscale retail, and high-frequency transit connectivity.



Map 4.2: Bhubaneswar Capital Region Site Analysis — Growth Zones, Land Use Percentages, Spatial Out-Growths, and 9 TOD Corridor Designations (Source: CDP 2030; CDP 2040 Draft; OSDI; Author)

The planning character of Zone A is defined by a stark internal contradiction: islands of high-density, gated residential development — apartment blocks of 12–20 storeys with private amenities — surrounded by underdeveloped rural pockets where the village road network, originally designed for agricultural traffic, is now overwhelmed by thousands of daily commuter movements. The existing 2-lane village roads that provide the only connectivity between these residential islands and the IRR are functioning as de facto primary urban arterials, a role for which they are catastrophically ill-suited in terms of carriageway width, junction geometry, and footpath provision.

4.3.2 Zone B: The Residential Surge (South-Western Fringe — Core of the 55 sq. km Study Area)

Zone B — encompassing Tamando, Ghatikia, Patrapada, and Sundarpada — constitutes the geographic and analytical heart of the approximately 55 sq. km peri-urban interface that forms the primary field investigation area of this thesis. This is where the 'Residential Frontier' of Bhubaneswar is most actively advancing, where the confrontation between agricultural land and urban expansion is most spatially explicit, and where the consequences of the absence of a Land Pooling mechanism are most visibly devastating.

The dominant form of development in Zone B is what this analysis terms 'Plotted Scheme Sprawl': private developers acquire large agricultural parcels (typically 2–10 acres) from individual farmers — often at distress prices, as farmers facing livelihood transition sell under financial pressure — subdivide them into residential plots of 600–1,200 sq. m, construct a minimal internal road of 9–12 m width for access, and market the plots to middle-income buyers. The result is a landscape of disconnected, internally enclosed residential colonies, each with its own minimal internal road system but with no connection to a wider planned road grid. Between these colonies, the original agricultural bunds and narrow village paths survive as the only available 'connectors,' creating the classic pattern of 'Leapfrog Sprawl' in which housing patches are physically disconnected from the main urban grid, making public transit routing impossible and emergency vehicle access frequently blocked.

The growth rate of 145% recorded in this zone between 2010 and 2025 — the highest of any area in the BDA fringe — confirms that Zone B is the fastest-urbanizing part of the study area and therefore the most urgent candidate for Land Pooling intervention. With 38% of land still remaining in agricultural or vacant use, there is still a meaningful window for planned intervention; but at current conversion rates, that window will effectively close before 2030.

4.3.3 Zone C: The Industrial/Logistics Node (Southern Fringe)

Located near the Khurda–Jatani junction and the critical intersection of the CRRR with NH-16 (the National Highway connecting Bhubaneswar to Visakhapatnam and Chennai), Zone C exhibits a different but equally consequential form of peri-urban stress. Currently dominated by warehousing complexes, Micro, Small and Medium Enterprises (MSMEs), cold storage facilities, and roadside logistics services, this zone is at the threshold of a secondary transition: as the Ring Road nears completion and freight efficiency through the corridor improves, the economic logic of the zone is expected to shift from purely industrial to a mixed-use logistics-and-worker-housing model. Developers and land aggregators are already acquiring agricultural land in anticipation of this transition.

With 52% of land in Zone C still in agricultural use, this area represents the greatest remaining opportunity for planned intervention in the southern corridor — but also the greatest environmental risk, given that much of this agricultural land sits on the low-lying floodplain of the Daya River, as detailed in Section 4.7.

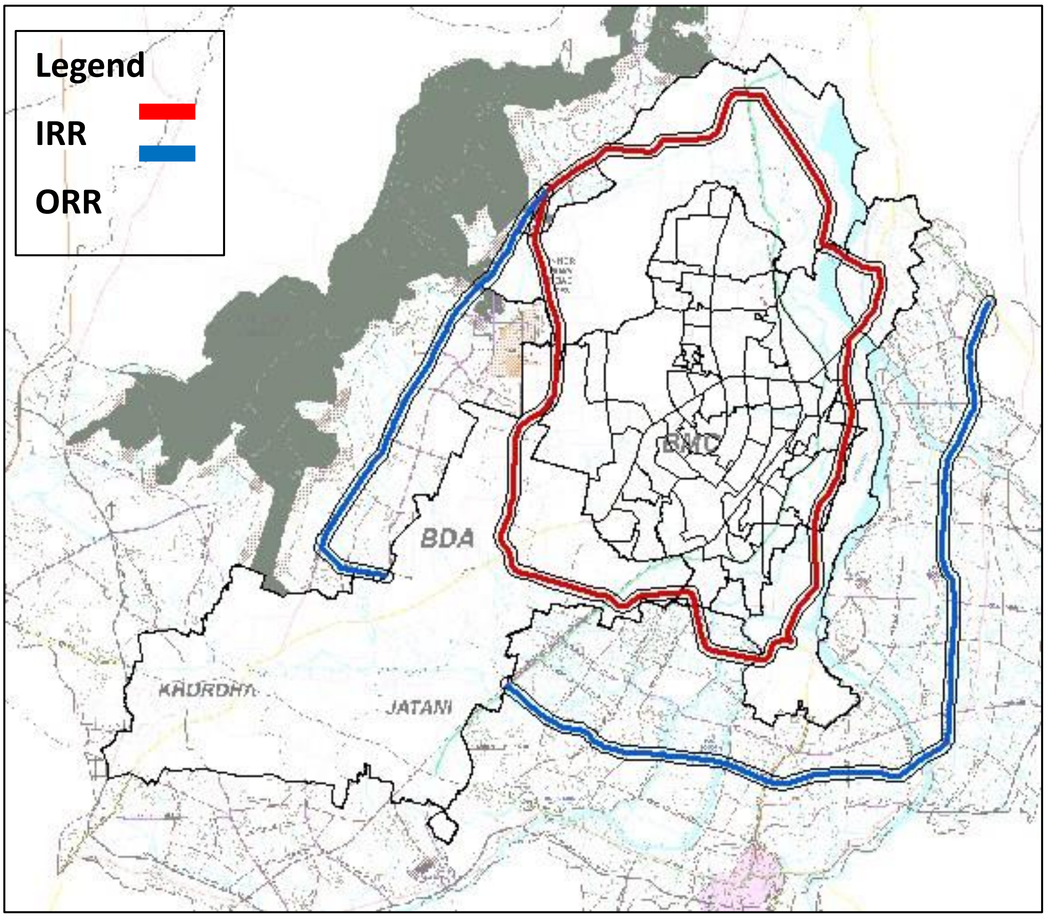
4.4 Land Use Evolution: A Quantitative Audit of the BDA Fringe (2010–2025)

The quantitative dimensions of the land use shift across the BDA fringe over the fifteen-year study period are presented in Table 4.2. These maps, derived from the multi-temporal LULC classification of Landsat and Sentinel-2 imagery, provide the most comprehensive evidence of the structural transformation underway. The Ring Road Peripheral Zone Identification map 4.3 provides the spatial framework within which these transformations are occurring, documenting the IRR and ORR buffer zones, their ward-level land use dominance, and the growth opportunities and development potentials that each corridor sub-zone presents.

Several findings from Table 4.2 demand particular analytical attention. The loss of 95.3 sq. km of agricultural land in fifteen years — a decline of 51.7% — is not merely a planning statistic but a socio-economic trauma for the farming communities of the peri-urban fringe. The conversion of these fields has proceeded faster than any institutional mechanism for farmer compensation or livelihood transition support. The 20.2% loss of vegetation cover, driven by the clearance of tree groves and plantations on the urban edge, has measurable consequences for urban heat island formation, carbon sequestration, and the ecological connectivity of the Chandaka–Dampara Wildlife Sanctuary.

Perhaps the most diagnostic finding is the ratio of built-up growth to population growth. For every 1% increase in the population of the BDA region, the built-up area has expanded by approximately 2.5% — a land consumption inefficiency ratio that reflects the prevalence of low-density plotted development, the absence of FAR incentives for vertical housing, and the failure of the planning system to channel growth into compact, transit-supported corridors.

> *Key Finding: The built-up area of Bhubaneswar's BDA fringe has expanded by 89.7% in 15 years — more than doubling — while the Sprawl Index has risen from 1.82 to 2.34 and the Compactness Ratio has fallen from 0.78 to 0.67. This confirms a pattern of accelerating, spatially inefficient growth that is consuming agricultural and ecological resources at an unsustainable rate.*

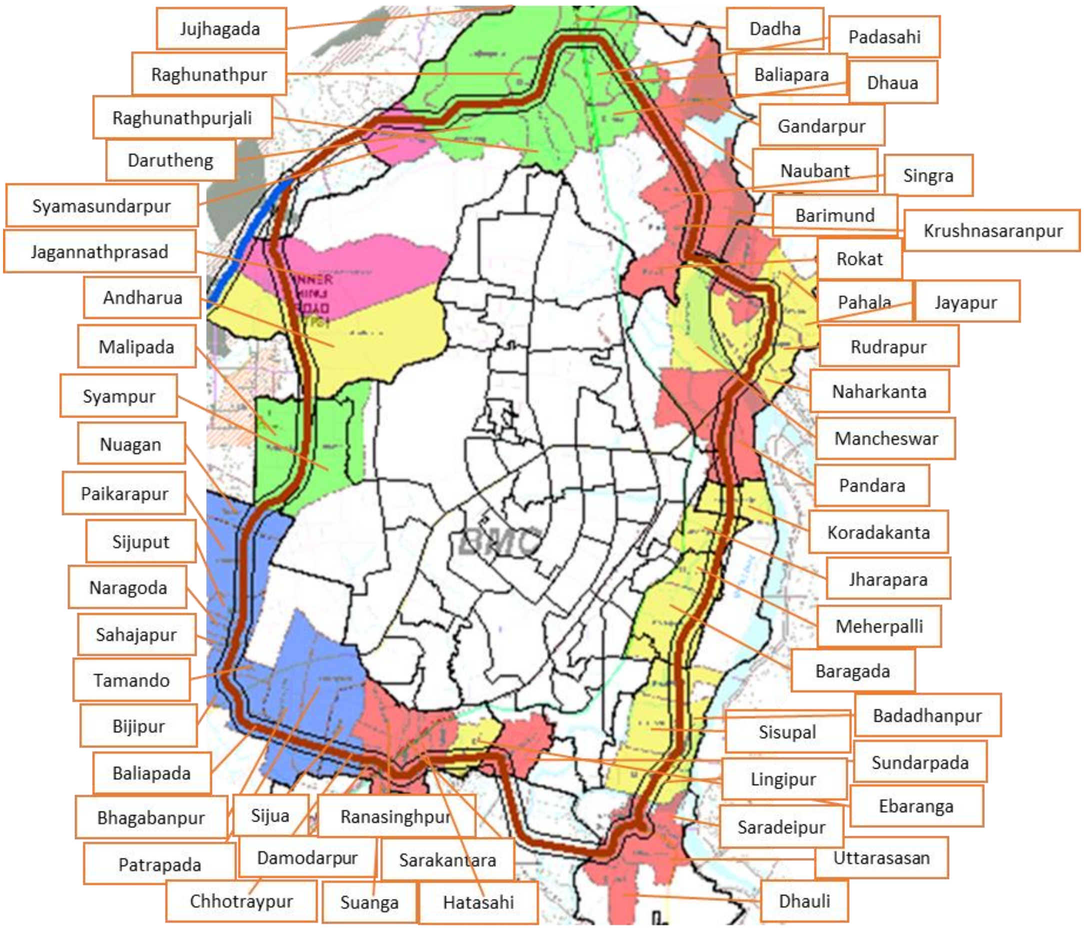


Map 4.3: Ring Road Peripheral Zone Identification — IRR and ORR Buffer Zones

Land Use Category	2010 (km²)	2015 (km²)	2020 (km²)	2025 (km²)	Net Change (km²)	% Change
Built-up Areas	130.2	162.6	204.3	247.3	**+117.1**	**+89.7%**
Agricultural Land	184.5	151.3	108.7	89.2	**-95.3**	**-51.7%**

Land Use Category	2010 (km²)	2015 (km²)	2020 (km²)	2025 (km²)	Net Change (km²)	% Change
Vegetation / Forest	67.8	63.4	58.9	54.1	**-13.7**	**-20.2%**
Water Bodies / Wetlands	18.3	18.1	17.8	17.6	**-0.7**	**-3.8%**
Vacant / Fallow Land	**22.3**	**27.7**	**33.4**	**14.9**	**-7.4**	**-33.2%**

Table 4.2: Detailed Land Use Transition Matrix, BDA Fringe, 2010–2025 (Source: LULC Classification on Landsat 5/8 and Sentinel-2; USGS Earth Explorer; Author)

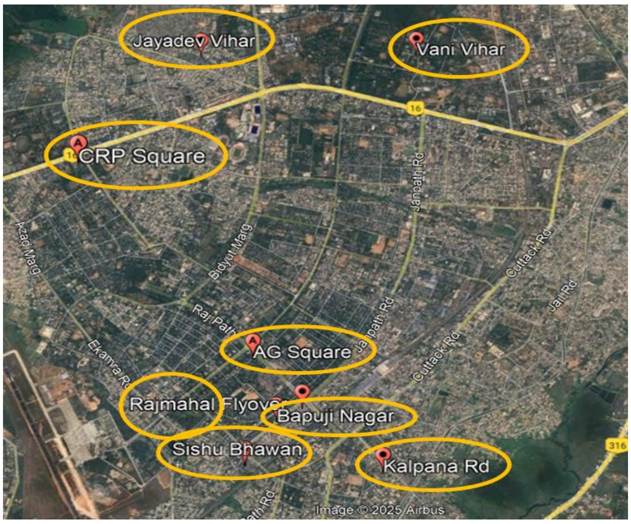


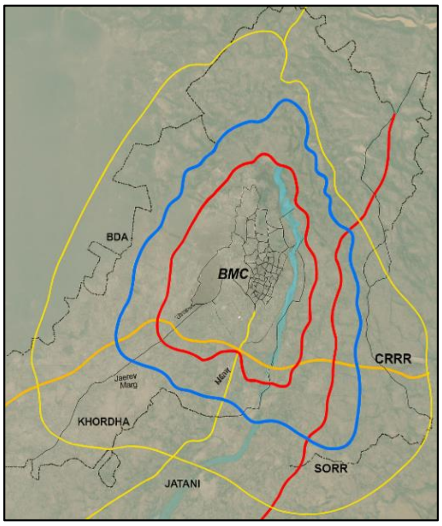
Map 4.3.1: Ward-Level Opportunities, Northern/Eastern/Western/Southern Zone Characterization

4.5 Ward-Wise Analysis of IRR and ORR Impact Zones

The Inner Ring Road (IRR), spanning approximately 64.9 km in its complete loop and implemented through 45 Town Planning Schemes across 58 revenue villages, and the proposed Outer Ring Road / Capital Region Ring Road (CRRR) of 111 km, together constitute the primary spatial organizing framework for urban growth in the Bhubaneswar Capital Region. Map 4.4 presents the ward-wise analysis of impact zones within the IRR and ORR buffer areas, illustrating how different wards relate to the ring road system in terms of their current land use, growth trajectory, and development potential.

The distinction between the IRR and CRRR/ORR zones is critical for planning purposes. The IRR corridor passes through areas that are now part of the consolidated urban fabric — higher land prices, denser development, greater institutional presence, and existing (if inadequate) infrastructure networks. The ORR corridor, by contrast, passes primarily through the approximately 55 sq. km peri-urban interface belt, where the dominant land uses are still agricultural or vacant, institutional presence is minimal, and the infrastructure network is essentially non-existent beyond the ring road itself. This distinction creates a fundamental asymmetry in the planning challenge: the IRR zone requires targeted infill, densification, and retrofit interventions; the ORR zone requires the creation of urban structure from scratch, making it the primary arena for Land Pooling as a planning instrument.





Map 4.4: Ward-Wise Analysis of Impact Zones within IRR and ORR Buffers — Spatio-Temporal Built-up Density, Growth Heat Zones, Peri-Urban Friction Table, Land Value Appreciation, and Planning Issues (Source: BMC Ward GIS Data; Google Earth Pro 2023; CRRR Feasibility Study)

4.5.1 The 'Peri-Urban Friction' Index

A composite 'Peri-Urban Friction' Index was constructed for the three primary growth zones, combining growth rate, remaining vacant land availability, average plot size (as a proxy for development pattern), and an Infrastructure Gap Index (IGI) scaled from 0.0 — representing full municipal utility provision — to 1.0, representing a total absence of utilities. Table 4.3 presents the results.

Ward / Peri-Urban Zone	Growth Rate 2010–25	Vacant Land Remaining	Avg. Plot Size (sq. m)	Infrastructure Gap Index (IGI)*
Zone 1 — North (Patia / Infovalley)	112%	14%	450	**0.62**
Zone 2 — West / S-West (Tamando / Patrapada)	145%	38%	1,200	**0.84**
Zone 3 — South (Jatani / Khurda periphery)	88%	52%	2,500+	0.45

Table 4.3: The 'Peri-Urban Friction' Index for Three Key Growth Zones (IGI: 0 = Full Utility Coverage; 1 = Zero Utility Coverage) (Source: CRRR Feasibility Study; BMC Data; Author)*

The IGI score of 0.84 for Zone 2 (Tamando–Patrapada) is the most alarming finding: it indicates that residents in the fastest-growing part of the peri-urban interface are living in conditions where nearly 84% of what constitutes 'municipal utility provision' is absent. This is not a temporary transitional condition but a structural deficit that will calcify into permanent under provision unless a systematic land-based financing mechanism — such as the Land Pooling Scheme — is deployed to fund infrastructure extension.

4.5.2 Land Value Appreciation and the Economic Logic of Land Pooling

A significant finding from the site analysis that directly underpins the economic rationale for Land Pooling is the trajectory of land value appreciation in the peri-urban study area. Field investigation and secondary data from property registrations reveal a three-stage appreciation curve. Pre-Announcement of the CRRR (circa 2015), agricultural land in the study corridor was valued at approximately Rs. 800–1,200 per sq. ft. During Construction (2025), the same categories of land are transacting at Rs. 2,500–4,500 per sq. ft., representing a 250–400% appreciation in a decade. Post-LPS Implementation (2035 Projection), serviced reconstituted plots in a planned LPS layout are conservatively projected to command Rs. 8,000–12,000 per sq. ft. — a further 200–300% appreciation. This 400% aggregate appreciation in land value from pre-announcement to post-LPS implementation is the core economic justification for the 40% land contribution required under the Odisha Land Pooling Rules: landowners who contribute 40% of their area within the LPS framework will, by 2035, hold a reconstituted plot worth three to four times the value of their original 100% holding.

4.6 The Infrastructure 'Gap' Analysis: Quantifying the Service Deficit

The most concrete and measurable consequence of unplanned peri-urban growth is the 'Service Lag' — the years-long, often permanent delay between the occupation of new residential developments and the arrival of basic municipal services. Map 4.5 presents the comprehensive Issues Identification analysis for the study area, synthesizing the infrastructure deficit data, the road hierarchy crisis, the socio-economic marginalization dimension, and the governance conflicts arising from the BMC–BDA jurisdictional fragmentation.

Table 4.4 presents the infrastructure deficit in quantitative terms, comparing the Core City standard of provision against the Peri-Urban Reality of 2025 across the four critical infrastructure components. The deficit percentages represent the proportion of the required service standard that is absent in the peri-urban study area.

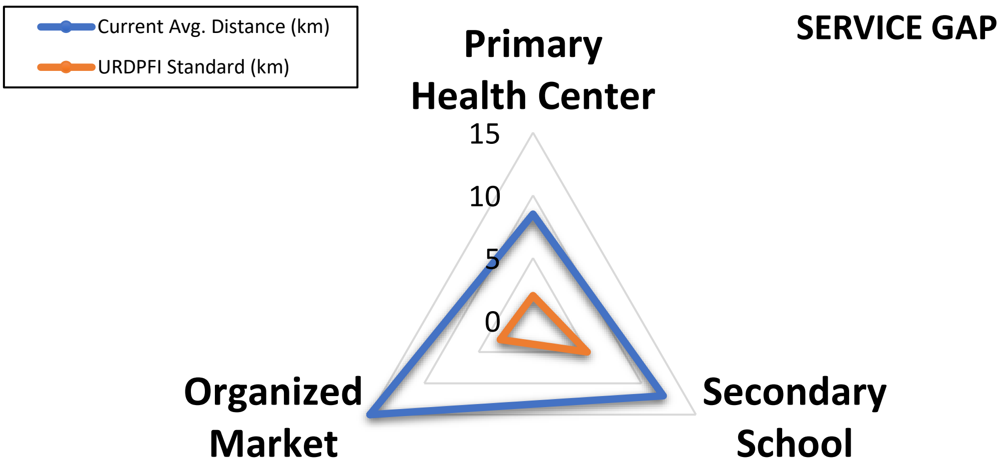


Figure 4.1: Issues Identification — Infrastructure Deficit Table, Road Sinuosity and Capillary Network Failure, Service Desert Gap Analysis, Environmental Vulnerability, and Spatial Governance Conflicts (Source: CDP 2040 Zoning Draft; BMC Affordable Housing Policy)

Infrastructure Component	Core City Standard	Peri-Urban Reality (2025)	% Deficit	Risk Level
Piped Water Supply	135 LPCD	35 LPCD (Handpumps/Private Tankers)	**74%**	**CRITICAL**
Sewerage Connection	92% Coverage	0% (100% Septic Tanks/Soak-pits)	**100%**	**CRITICAL**
Stormwater Drainage Network	2.1 km/sq. km	0.2 km/sq. km (Natural/Open channels only)	**90%**	**HIGH**
Street Lighting	Every 30 m	Only at major junctions (sporadic)	**65%**	MEDIUM

Table 4.4: Infrastructure Deficit Comparison — Core City Standard vs. Peri-Urban Reality (2025) (Source: BMC Infrastructure Data; Field Survey; CDP 2040 Draft)

4.6.1 Water and Sanitation: The Dual Crisis

The water supply deficit in the peri-urban fringe is both quantitatively severe and qualitatively damaging. While the core city maintains 90% piped water coverage at a per capita supply of approximately 135 litres per capita per day (LPCD), the fringe areas of Sundarpada, Tamando, and Patrapada receive, on average, only 35 LPCD through a combination of handpumps, private borewells, and expensive water tanker deliveries. This deficit imposes a disproportionate financial burden on lower-income households, who spend a significantly higher share of their income on water procurement than their core-city counterparts. More critically, the reliance on private boreholes for water extraction is depleting the local aquifer at an unsustainable rate — the water table in the peri-urban fringe is dropping at approximately 1.2 metres per year, a rate that, if continued, will render borewell extraction economically and physically unviable before 2035.

The sanitation situation is even more stark: there is a complete — 100% — deficit in centralised sewerage connection across the study area. All residential and commercial properties in Sundarpada, Tamando, and Patrapada rely on individual septic tanks and soak-pits for wastewater disposal. In low-density contexts, this approach is manageable; but in the high-density clusters that are now developing in Zone B, the soak-pit model is systematically failing. The soil absorption capacity of the pits is overwhelmed by the volume of wastewater generated, leading to surface overflow and the contamination of groundwater — the very resource that households are simultaneously relying upon for drinking water. This circular contamination crisis represents one of the most urgent public health risks in the study area.

4.6.2 Drainage and the Creation of 'Artificial Flood Zones'

Field surveys across the 55 sq. km study area reveal a 90% deficit in planned stormwater drainage infrastructure. The existing drainage in the fringe relies almost entirely on the natural channel network of Nayas — traditional earthen drainage channels that historically conveyed monsoon runoff from the agricultural landscape to the Daya and Kuakhai rivers. However, as new residential colonies and road embankments are constructed, these Nayas are systematically being blocked, diverted, or filled. New boundary walls sever the drainage pathways; new road embankments without adequate culverts create barriers to natural flow; and the paving of agricultural surfaces eliminates the infiltration capacity that previously moderated runoff.

The consequence is the creation of 'Artificial Flood Zones' — low-lying areas that now experience waterlogging for 48–72 hours following moderate rainfall events (50–75 mm in 24 hours) that would historically have drained within 6–12 hours. Residents of Tamando and Sundarpada have reported flooding of ground-floor residences on multiple occasions during recent monsoon seasons. This is not a natural flood risk phenomenon; it is a planning-induced hazard that is directly attributable to the absence of a coordinated, pre-construction stormwater management system — precisely the kind of infrastructure that a Land Pooling Scheme would secure through its road and drainage reservations before any building is permitted.

4.7 Service Accessibility Analysis: The 'Service Desert' Phenomenon

Using Network Analysis in GIS — specifically, origin-destination distance calculations from peri-urban residential cluster centroids to the nearest URDPFI-mandated amenity locations — the study mapped the service accessibility deficit across the 55 sq. km peri-urban study area. The findings confirm what residents articulate in qualitative field interviews: that the fringe is functionally a 'Service Desert,' a territory where people live but where the basic amenities that convert shelter into liveable urban settlement are largely absent.

Service / Amenity	URDPFI Standard (Max. Distance)	Avg. Distance in Peri-Urban Study Area	Deficit Ratio	Impact
Primary Health Centre (PHC)	< 2 km	8.5 km (field average)	**4.25×**	**HIGH RISK**
Secondary School	**< 5 km**	12 km (field average)	**2.4×**	**HIGH**
Organised Retail / Daily Market	< 3 km	15 km (south-western fringe)	**5.0×**	**SEVERE**

Service / Amenity	URDPFI Standard (Max. Distance)	Avg. Distance in Peri-Urban Study Area	Deficit Ratio	Impact
Bus Stop / Public Transit Access	**< 0.5 km**	2.8 km (zone average)	**5.6×**	**SEVERE**
Fire Station	< 3 km	11 km	**3.7×**	**CRITICAL**

Table 4.5: Service Accessibility Deficit in the 55 sq. km Peri-Urban Study Area vs. URDPFI Standards (Source: GIS Network Analysis; URDPFI Guidelines 2014; Field Survey)

The deficit ratios in Table 4.5 are not merely planning performance metrics; they translate directly into the lived experience of peri-urban residents. A primary health centre distance of 8.5 km — more than four times the URDPFI standard of 2 km — means that a pregnant woman in Sundarpada, a child with a medical emergency in Tamando, or an elderly resident in Patrapada must undertake a 30–45-minute motorized journey for routine healthcare access. This 'Travel Burden' falls most heavily on households without private vehicles — disproportionately the low-income agricultural families whose land has been converted by the urbanization process they did not initiate.

The market access deficit is equally consequential. Residents in the south-western fringe travel an average of 15 km — five times the URDPFI standard of 3 km — to access organized retail and daily markets. This generates enormous additional traffic on NH-16, which is already functioning at or beyond its design capacity at several locations, and forces low-income residents who cannot afford motorized transport to rely on informal, expensive, and unreliable alternatives for their daily provisioning. It also represents a significant livelihood exclusion: the formal economy of markets and commercial centers, concentrated in the urban core, is effectively inaccessible to the peri-urban poor on a daily basis.

4.8 Environmental and Hydrological Vulnerability Assessment

4.8.1 Floodplain Encroachment: The Daya River Risk

The most acute environmental risk in the southern section of the 55 sq. km study area is the systematic encroachment of new built-up development onto the natural floodplain of the Daya River. The CA-Markov 'Do-Nothing' scenario from Phase IV reveals that 45% of all new built-up area being added in the southern fringe is occurring on low-lying land that constitutes a natural water retention zone — land that stores excess monsoon runoff, moderates peak flood discharge, and recharges the local aquifer during and after rainfall events. The construction of impervious surfaces on this land eliminates both its storage capacity and its recharge function.

The hydrological consequence is severe: the loss of natural 'Retention Pond' capacity in the Daya River catchment is projected to increase the peak flood discharge at the river's monitoring station by as much as 300% during high-intensity monsoon events, putting the entire southern fringe — including the already-developed areas of Jatani and Khurda — at risk of annual inundation. This is not a theoretical future risk; field surveys indicate that several low-lying localities in Patrapada and Sundarpada already experience flooding from the Daya drainage system in above-average monsoon years.

4.8.2 The Groundwater Depletion Crisis

The combination of accelerating groundwater extraction — driven by the 74% deficit in piped water supply — and declining recharge — driven by the paving of agricultural surfaces that previously allowed rainfall to percolate into the aquifer — is producing a groundwater depletion crisis in the peri-urban study area. The water table in the fringe is dropping at a measured rate of 1.2 metres per year. At this rate, by 2035 the cost of extracting water from borewells in the most affected sub-zones will have increased by approximately five times relative to current levels, as pumps must work harder to lift water from greater depths. In the most severely affected localities, borewell failure is already occurring during summer months, forcing complete dependence on expensive tanker water.

4.8.3 The Capillary Road Network Collapse

A critical finding from the field component of this site analysis is what this study terms the 'Road Hierarchy Collapse' in the peri-urban zone. The Capital Region Ring Road provides an impressive 60–100 m Right-of-Way at the macro scale; but the capillary roads — the village paths and Mouza roads that connect individual homes, residential colonies, and workplaces to the Ring Road — are, on average, only 3–5 m wide. These narrow lanes are now bearing the traffic burden of buses, private cars, delivery trucks, construction vehicles, and two-wheelers that they were designed (if 'designed' is even the appropriate word) for agricultural bullock carts.

Field measurement in the Zone B study area confirms that 82% of peri-urban roads in the south-western sector are dead-ends or 'Kucha' (unpaved) roads — physically incapable of carrying emergency vehicles (fire tenders or ambulances) to interior residential areas. This is not merely a traffic inconvenience; it is a life-safety deficiency. A residential colony of 500 households in Tamando, served by a single 4-m access path, is effectively inaccessible to the fire service. The 'Leapfrog Cost' of eventually providing this road connectivity — purchasing the land for road widening after buildings have been constructed on both sides — is estimated by BDA engineering consultants at Rs. 1,200 Crores more than it would cost to secure the Right-of-Way through a Land Pooling Scheme before construction begins.

4.9 Spatial Zoning, Governance Conflicts, and the 'Planning Vacuum' Syndrome

The governance dimension of the peri-urban crisis deserves particular emphasis, as it is both the root cause of the service deficits documented above and the primary obstacle to their resolution. The 55 sq. km study area falls primarily within the BDA's planning boundary but outside the BMC's service delivery boundary. This creates what this analysis terms the 'Planning Vacuum Syndrome': building permissions are issued by Gram Panchayats under rural land use regulations that are fundamentally inadequate for urban-density development, while the BMC — which has the institutional capacity to regulate and service urban areas — lacks jurisdiction. The BDA has planning authority but limited service delivery capacity. The result is a 'No-Man's Land' where buildings are being constructed, occupied, and densified, but where garbage collection, street cleaning, road maintenance, and stormwater management are essentially non-existent.

Issue Category	Status in Core City	Status in Peri-Urban Fringe	Governance Lag	Impact
Land Value Capture	High (BMC property tax base)	None — speculative, unregistered	**Severe**	**Revenue Loss**
Public Open Space	2.1% (inadequate but present)	<0.8% (virtually absent)	**Very High**	**Quality of Life**
Road Sinuosity	Low — planned grid pattern	High — irregular village paths	**High**	**Traffic Congestion**
Building Permission Oversight	BMC Building Rules enforced	Gram Panchayat — minimal enforcement	**High**	**Unauthorized Structures**

Table 4.6: Spatial Governance Conflicts — Core City vs. Peri-Urban Fringe (Source: BDA Zoning Records; CDP 2040)

The financial implication of this governance vacuum is directly quantifiable. In the core city, the high-density, high-value built environment generates substantial property tax revenues for the BMC, which partially funds service delivery. In the fringe, land value appreciation — which has been dramatic, as documented in Section 4.5.2 — generates no equivalent public revenue. The benefit of the Ring Road investment (funded from public resources) is privatized by landowners and developers, while the cost of eventually servicing the resulting development will fall on the public purse. A Land Pooling Scheme reverses this perverse fiscal logic by capturing a share of land value — the 40% contribution — for public infrastructure funding at the moment of development, rather than attempting to recoup it through taxation decades later.

4.10 Synthesis: The Case for Intervention and the 2035 Horizon

The site analysis of the Bhubaneswar peri-urban interface, conducted across the approximately 55 sq. km primary study area, yields a convergent and unambiguous diagnostic conclusion: the Capital Region Ring Road, in the absence of a concurrent and spatially integrated land use planning intervention, will not solve Bhubaneswar's urban growth management challenge. On the contrary, by dramatically increasing land accessibility and value in the fringe without simultaneously establishing the regulatory and infrastructure framework to channel that growth, the CRRR will accelerate precisely the pattern of fragmented, disconnected, environmentally vulnerable, and publicly unserviceable sprawl that it was intended to prevent.

The evidence is comprehensive. Built-up area has grown 89.7% in fifteen years while service provision has not kept pace. Agricultural land has been halved. The water table is falling at 1.2 meters per year. Floodplains are being paved. Village roads that are 3–5 m wide are carrying urban traffic loads. A 400% land value appreciation is being captured entirely by private actors. And 82% of peri-urban roads are dead-ends inaccessible to emergency services.

The alternative — a planned Land Pooling Scheme applied systematically across the high-risk Mouzas of the CRRR corridor — addresses each of these failure modes simultaneously: it secures road Right-of-Way before buildings are constructed; it reserves land for parks, schools, and clinics within walking distance of residents; it funds trunk infrastructure through the contributed land area; it captures land value for public benefit; and it prevents floodplain encroachment through the designation of constraint zones. The following chapters translate this diagnostic case into a detailed design proposal, beginning with the CA-Markov 2035 simulation that renders the 'Do-Nothing' future visible, and concluding with the Mouza-level LPS layout that demonstrates how that future can be prevented.

Synthesis Finding: The four-fold convergence of infrastructure deficit, environmental vulnerability, governance vacuum, and road network collapse in the 55 sq. km peri-urban study area constitutes a structural planning emergency. The 'Do-Nothing' 2035 scenario represents not merely inefficient urbanism but the risk of permanent structural collapse of livability in the Bhubaneswar Capital Region's fastest-growing zone. Land Pooling, applied now, is the only instrument capable of reversing this trajectory.

CHAPTER 5: PLANNING PROPOSALS AND RECOMMENDATIONS

5.1 The Vision: Redefining Bhubaneswar from a Monocentric Capital to a Polycentric Metropolitan Network

The synthesis of the four preceding analytical chapters converges on a central and urgent conclusion: the current model of peri-urban growth in the Bhubaneswar Capital Region is not merely inefficient — it is structurally self-defeating and, if left unaddressed beyond 2028, will be irreversible. Between 2010 and 2025, the built-up footprint of the city expanded by 89.7%, consuming 95.3 sq. km of agricultural land and producing a Sprawl Index rise from 1.82 to 2.34. The Infrastructure Gap Index of 0.84 in the fastest-growing Zone B (Tamando–Patrapada) reveals that the residents of the peri-urban fringe are paying urban land prices while receiving sub-rural levels of service. The CA-Markov predictive simulation projects that under a "Do-Nothing" scenario, the remaining 38% of agricultural land in Zone B will be consumed before 2030 — closing the window for any planned intervention.

This chapter responds to that diagnostic and predictive evidence with a structured, multi-layered, and financially grounded set of planning proposals. The overarching vision constitutes a fundamental paradigm shift: from reactive infrastructure provision — building roads where people have already settled, extending utilities to colonies already dense with unauthorized structures — to proactive spatial structuring, which defines the grid, reserves the green land, and lays the pipe before the first plot is sold and before the first brick is laid.

The primary instrument of this paradigm shift is the reframing of the 111-km Capital Region Ring Road (CRRR) from a freight bypass into a planning backbone — the linear armature from which a planned, equitable, and ecologically resilient urban region can grow. The thesis proposes five integrated strategic interventions, organized into three time-bound phases, that together constitute a coherent and implementable metropolitan planning framework for the Bhubaneswar Capital Region up to 2035.

Primary Purpose of this Thesis

To redefine the Bhubaneswar Capital Region from a monocentric, administrative-heavy city into a resilient, polycentric metropolitan network. By leveraging the 111-km CRRR as a "planning backbone" rather than just a transit bypass, this study proposes a strategic framework to capture land value and secure public infrastructure before the development wave arrives — converting peri-urban "friction" into a collaborative partnership between the state and original landowners through Land Pooling Schemes (LPS).

5.2 The Integrated Strategic Framework: Five Proposals, Three Phases

The proposals are not conceived as isolated spatial interventions but as a mutually reinforcing system. Each proposal addresses a specific dimension of the peri-urban crisis diagnosed in Chapter 4, and each creates the pre-conditions for the next. The framework is organized across five Strategic Interventions, delivered through three implementation phases between 2025 and 2035:

NO.	STRATEGIC INTERVENTION	PROBLEM ADDRESSED
I	**The Polycentric Region Framework**	Mono-centric concentration of employment driving 12–15 km commutes; core saturation at >85% built-up density
II	**Land Pooling Scheme (LPS) Blueprint**	Fragmented agricultural holdings (avg. 1,200 sq.m) incapable of producing serviced urban plots; IGI of 0.84 in Zone B
III	**Residential Development Zone Proposals**	"Leapfrog sprawl" generating disconnected dormitory suburbs; 82% dead-end roads in south-western fringe

IV	**Infrastructure and Environmental Resilience Proposals**	74% piped water deficit; 90% stormwater deficit; 300% predicted flood discharge increase if unaddressed
V	**Zoning and Development Control Regulations (DCR)**	Euclidean single-use zoning creating mono-functional suburbs; no form-based controls on road hierarchy or density

Table 5.1: Five Strategic Interventions — Problems Addressed and Section References (Source: Author; Chapter 4 Synthesis)

5.3 Strategic Intervention I: The Polycentric Region Framework

The foundational structural failure of Bhubaneswar's urban form is its extreme monocentric. The consolidated planning units of the BMC core — Units 1 through 9 and the Old Town — now exhibit built-up densities exceeding 85%, making them effectively saturated for large-scale new development. This saturation has created a powerful centrifugal pressure that pushes residential and commercial demand outward to the peri-urban fringe, while simultaneously retaining almost all employment, retail, healthcare, and educational functions within or adjacent to the congested core. The result is the "Service Desert" phenomenon documented in Chapter 4: the south-western fringe of the city — where 145% growth was recorded between 2010 and 2025 — has no Primary Health Centre within 8.5 km, no organized retail within 15 km, and no formal employment cluster within 12 km. Residents commute to the core for every service transaction.

The response to this structural failure is a Tri-Hub Polycentric Model that decentralizes economic and social functions across three distinct but transit-linked nodes. Rather than a single Central Business District generating radial commute flows that the ring road is unable to intercept, the Capital Region will function as three self-sustaining micro-cities, each offering employment, housing, services, and institutional functions within walkable or short-transit distances. This model directly implements the Polycentric Urban Framework articulated in the CDP 2040 and transforms the CRRR from a bypass into a metropolitan connector.

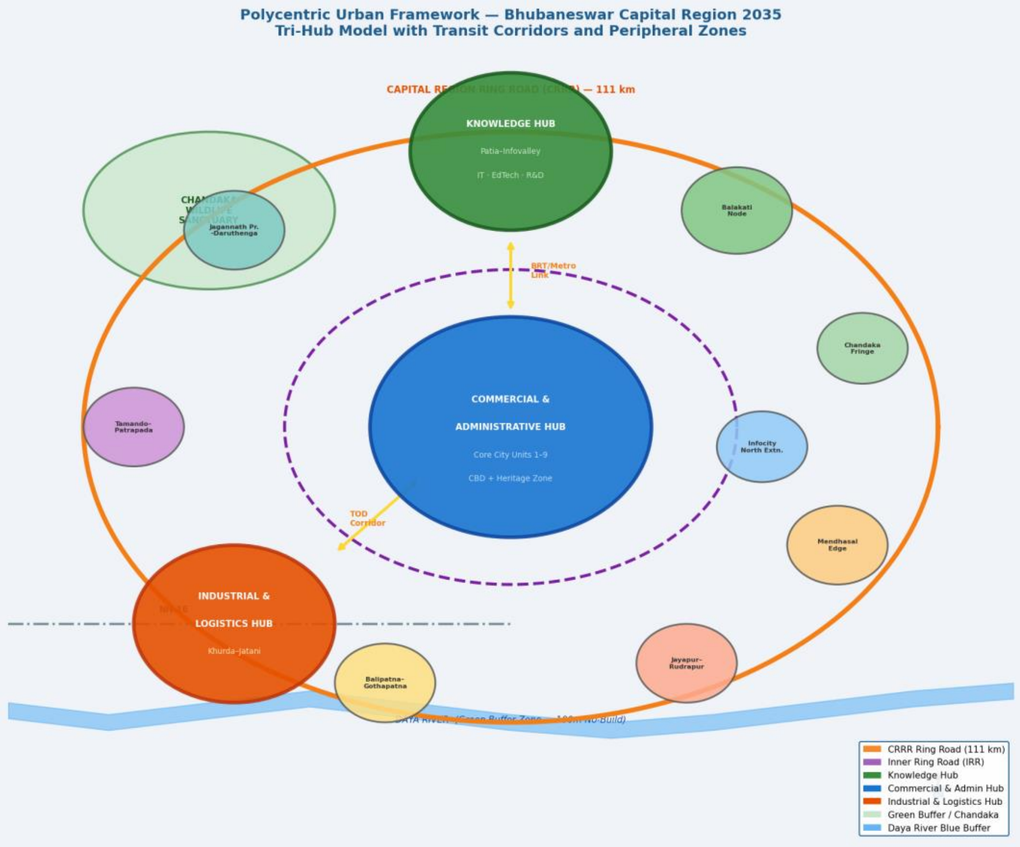


Figure 5.1: Polycentric Urban Framework — Tri-Hub Model with Transit Corridors, Peripheral Zones, and Ecological Buffers for the Bhubaneswar Capital Region 2035 (Source: Author; CDP 2040 Strategic Framework)

5.3.1 Hub 1: The Knowledge and Innovation Hub — Patia–Infovalley Zone

The northern arc of the study area, anchored by the campuses of KIIT University, NISER, IIT Bhubaneswar, and the established Infocity Special Economic Zone, constitutes the most mature and institutionally dense of the three proposed hubs. The proposal formalizes and intensifies the emerging "Knowledge Corridor" by designating a contiguous Smart Campus Zone between the Infocity boundary and the Balakati node, covering approximately 850 hectares.

ATTRIBUTE	PROPOSAL DETAIL
Focus Areas	IT, EdTech, R&D, Biotechnology, AI-driven startups, and academic spin-off enterprises

Anchor Institutions	KIIT, NISER, IIT Bhubaneswar, Infocity SEZ, AIIMS II (proposed), Orissa Engineering College corridor
Smart Campus Zones	Dedicated mixed-use high-density residential blocks (FAR 2.5–3.5) co-located within 500m of campus boundaries to minimize the commute burden for the 60,000+ strong academic and tech workforce
Student Housing Cluster	Structured provision of 8,000+ co-living beds within the Knowledge Hub catchment, absorbing the housing demand currently generating traffic on the Infocity–Bhubaneswar corridor
Connectivity Proposal	BRT/Metro link along the IRR–Airport Road corridor; dedicated cycling and pedestrian infrastructure connecting all campuses; multi-modal hub at Balakati CRRR interchange
Peripheral Zones Served	Patrapada, Jagannath Prasad–Daruthenga Arc, Infocity North Extension, Balakati node, and the Chandaka Fringe institutional clusters
FAR Incentive	Base FAR 2.5 within 500m of campus boundaries; Incentive FAR up to 4.0 available through TDR purchase for projects incorporating EWS housing component of minimum 15%

Table 5.2: Knowledge and Innovation Hub — Attribute and Proposal Summary (Source: Author; CDP 2040; KIIT/NISER Master Plans)

5.3.2 Hub 2: The Commercial and Administrative Hub- Core City Units 1–9

The consolidated planning units of the BMC core are not proposed for outward expansion — the core saturation documented in Chapter 4 renders this both unnecessary and counterproductive. Instead, the proposal focuses on internal densification and mixed-use retrofitting. The key spatial instruments are: Heritage-Sensitive Densification, which protects the Old Town and Dhauli through mandatory heritage guidelines while permitting vertical growth on identified infill plots along the BRT corridor; TOD Integration, which activates FAR bonuses of up to 4.0 via Transferable Development Rights at CRP Square, Jaydev Vihar, and Kalpana interchange nodes; and

Active Ground-Floor Mandates, which require that minimum 60% of ground-floor frontage along all BRT corridors be dedicated to retail, services, or community uses to create pedestrian vitality.

The Uttarasasan–Dhauli Cluster, adjacent to the Dhauli Peace Pagoda and the Daya River floodplain, is designated for heritage-linked eco-tourism and vernacular housing development at a controlled FAR of 0.8, preserving its cultural landscape while providing low-density residential alternatives for displaced agricultural communities. The Uttarasasan–Ebaranga Cluster offers additional capacity for heritage-oriented tourism accommodation and institutional visitor facilities.

5.3.3 Hub 3: The Industrial and Logistics Hub — Khurda–Jatani Zone

The southern fringe, anchored by the strategic intersection of the CRRR with NH-16 (the national highway connecting Bhubaneswar to Visakhapatnam and Chennai), is currently characterized by unplanned warehousing complexes, MSME sheds, and roadside logistics services operating in the absence of any formal industrial planning framework. The proposal transforms this zone into a structured Logistics Park with three integrated components.

COMPONENT	SPECIFICATION	EMPLOYMENT TARGET	HOUSING PROVISION
Freight Terminal & Cold Chain Hub	Multi-modal freight terminal at CRRR × NH-16; cold storage (20,000 MT capacity); container logistics plaza	8,500 direct jobs	15% EWS worker housing mandatory within 1 km
MSME Manufacturing Cluster	Standardized plug-in factory sheds (500–2,000 sq.m); shared utilities; ETP; fibre connectivity	12,000 MSME jobs	Affordable rental housing cluster adjacent to cluster

Large-Format Industrial Estates	Kalinga Nagar (Gothapatna) expansion: tech parks, prefab industrial units, master-planned estates	15,000+ jobs	Integrated township with schools and healthcare

Table 5.3: Industrial and Logistics Hub — Component Specifications and Employment Targets (Source: Author; Odisha Industrial Policy 2022; CDP 2040)

STRATEGIC INTERVENTION II

5.4 Strategic Intervention II: Land Pooling Scheme (LPS) Blueprint

The Land Pooling Scheme is the core prescriptive instrument of this thesis — the mechanism that translates the polycentric vision and the infrastructure proposals into physically realizable, legally grounded, and financially self-sustaining urban development. It addresses the fundamental incompatibility between the existing pattern of fragmented agricultural land ownership in the peri-urban fringe and the minimum land parcel sizes required for any meaningful road grid, utility network, or social infrastructure provision.

As documented in Chapter 4, the average agricultural plot in Zone B (Tamando–Patrapada) is 1,200 sq. m — a parcel size that cannot accommodate even a 9m local road without consuming more than 25% of its area. The average holding in Zone C (Khurda–Jatani) is 2,500+ sq. m, offering marginally greater flexibility but still fundamentally inadequate for structured urban development. The LPS resolves this by pooling all holdings within a notified Mouza, reconstituting them according to a planned layout, and returning a smaller but fully serviced, legally titled, road-accessible "Final Plot" to each original landowner. The instrument is grounded in the Odisha Land Pooling Rules, 2015, which provide the necessary legislative authority for the 70% consent threshold, the valuation process, and the "Final Plot" allocation mechanism.

5.4.1 The Legal and Procedural Trigger: The 70/70 Rule

The foundational legal mechanism of the LPS is what the thesis terms the "70/70 Legal Trigger." This refers to the mandatory requirement under the Odisha Land Pooling

Rules, 2015 that: (i) a minimum of 70% of the landowners in a notified Mouza must provide written consent for the LPS to proceed; and (ii) those consenting landowners must collectively own a minimum of 70% of the total land area within the notified boundary. Only when both thresholds are simultaneously met can the BDA issue the formal Land Pooling Scheme notification, triggering the reconstitution process.

Why the 70/70 Rule Matters: Social Equity in Practice

The 70/70 requirement is not merely a procedural formality — it is the mechanism that distinguishes the LPS from compulsory land acquisition. By requiring super-majority consent, it ensures that the scheme proceeds only when the majority of the community has understood and accepted the incremental value proposition: that a 720 sq.m serviced Final Plot with road access and utility connections is economically superior to a 1,200 sq.m unserviced agricultural holding. The community participatory mapping workshops proposed as part of the Consent Phase are designed specifically to make this value proposition visible, tangible, and culturally accessible to farming communities who may have limited exposure to urban land market dynamics.

5.4.2 The 40/60 Spatial Reconstitution Model

The mathematical heart of the LPS is the 40/60 spatial reconstitution formula. Under this model, every participating landowner in the pilot Mouza contributes 40% of their holding to public uses and receives back 60% as a fully serviced, legally titled, rectangular "Final Plot" within the same Mouza. The 40% public contribution is allocated across four precisely defined purposes designed to resolve the specific infrastructure deficits documented in Chapter 4:

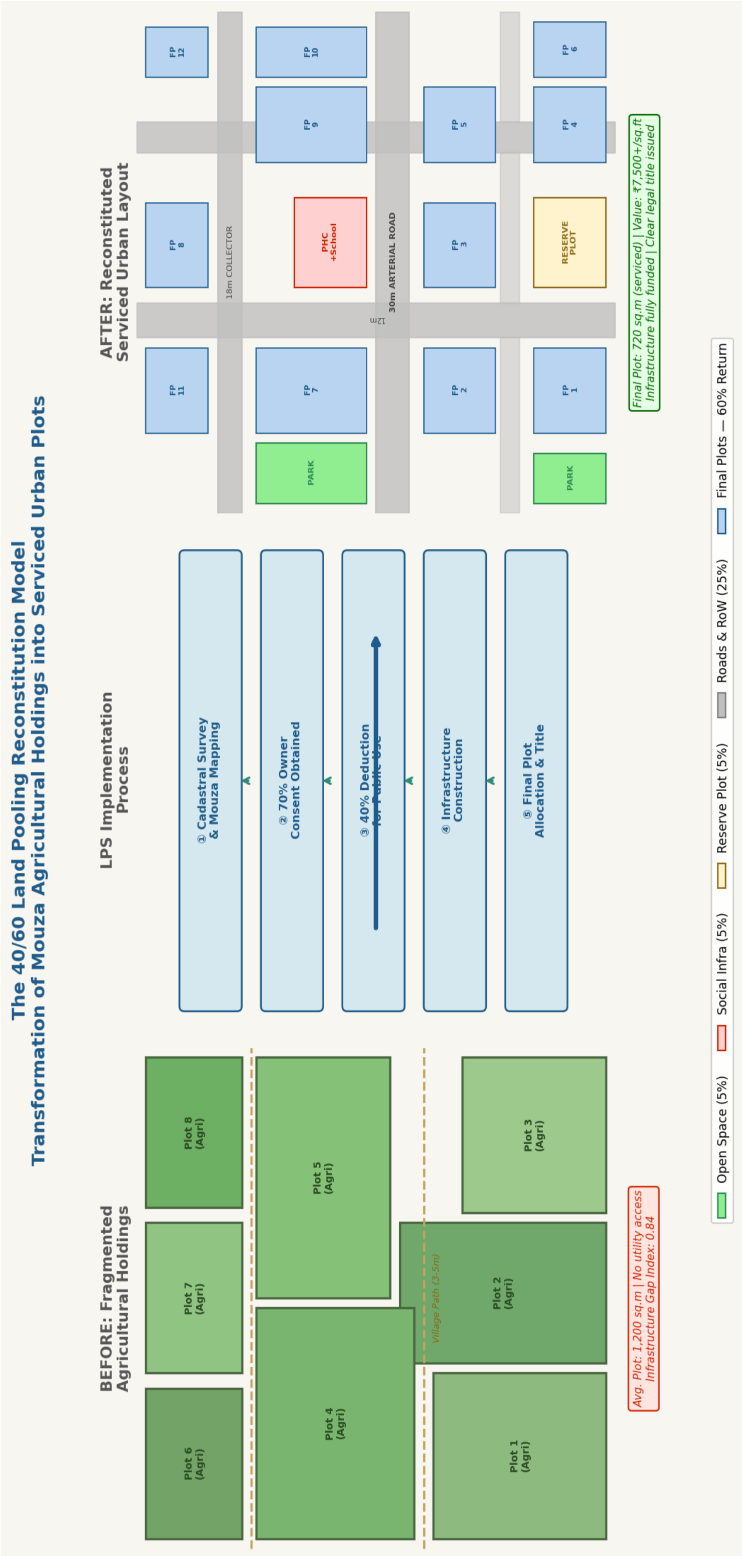


Figure 5.2: The 40/60 Land Pooling Reconstitution Model — Before, Process, and After States. Agricultural fragmentation is transformed into a serviced urban super-block grid through the LPS mechanism. (Source: Author; Odisha Land Pooling Rules, 2015)

DEDUCTION	USE CATEGORY	SPECIFIC SPATIAL APPLICATION	CHAPTER 4 DEFICIT ADDRESSED
25%	**Roads and Mobility Infrastructure**	60m CRRR ROW secured; 30m primary arterial; 18m collector; 12m sub-collector; 9m local capillary roads (widened from current 3–5m village paths through reconstitution). Road hierarchy strictly enforced; no new plot may front a road of less than 9m width.	82% dead-end roads in Zone B; "Capillary Network Failure"; ₹1,200 Cr retrospective widening cost avoided
5%	**Open Space and Ecological Buffers**	Community parks at minimum 10 m^2/capita standard; green buffers of 20m on each side of identified Naya (seasonal stream) channels; percolation parks with permeable surfaces; Daya River 100m buffer formalized.	Open space provision of <0.8 m^2/capita vs. 10 m^2 standard; 90% stormwater drainage deficit; 1.2m/year groundwater depletion
5%	**Social Infrastructure Reservations**	PHC plot within 2 km of every residential cluster; Anganwadi and pre-school sites at 500m intervals; neighbourhood market plots eliminating 15 km retail desert; EWS housing reserve at each sector boundary.	PHC at 8.5 km (4× URDPFI standard); organized retail at 15 km (5× standard); zero EWS housing in fringe
5%	**BDA Reserve Plot (Land Bank)**	Strategically located, serviced plots held by BDA for monetization through competitive auction to registered developers. Revenue	Infrastructure Funding Gap: self-financing mechanism replaces dependency on state capital budget allocations

		funds the Internal Development Charges for trunk infrastructure construction.	
60%	**Final Plots — Return to Landowners**	Rectangular, serviced plots with: piped water connection, sewerage hookup, 9m road frontage, and clear legal title in joint name (male + female head of household). Average size: 720 sq.m per original 1,200 sq.m holding.	Landowner economic stake: aggregate value appreciation from ₹800/sq.ft (pre-CRRR) to ₹12,000/sq.ft (post-LPS) = +1,400% — converting farmers into long-term urban stakeholders

Table 5.4: The 40/60 Land Pooling Reconstitution Model — Deduction Breakdown, Spatial Application, and Infrastructure Deficits Addressed (Source: Author; Odisha Land Pooling Rules, 2015; Chapter 4 Data)

5.4.3 Peripheral Location-Wise LPS Priority Classification

The 55 sq. km peri-urban interface encompasses a mosaic of peripheral locations, each with distinct land-use characteristics, growth pressures, remaining agricultural land inventories, and infrastructure deficit profiles. The following classification organizes all identified peripheral locations into three implementation tiers, ranked by the urgency criteria established in Chapter 4: the Peri-Urban Friction Index, the remaining agricultural land window, and the Infrastructure Gap Index (IGI) score.

PERIPHERAL LOCATION / MOUZA CLUSTER	TIER	REMAINING AGRI LAND	IGI SCORE	PRIMARY LPS INTERVENTION	PROPOSED OUTPUT
TIER 1: URGENT — Immediate LPS Notification Required (2025–2027)					
Tamando–Patrapada–Sundarpada Belt	1	38%	0.84	Immediate LPS notification; 30m arterial road; PHC and primary school	High-density mixed-use affordable housing

				plot; 15% EWS affordable housing; capillary roads to 9m	corridor; TOD on IRR–Airport link; transit-ready residential belt
Gothapatna–Malipada Eco-Township Stretch	**1**	41%	**0.79**	Eco-township LPS pilot; low-rise G+2 residential; Daya River 100m buffer; institutional campus reservation for IT/R&D; Naya corridor protection	Eco-township cluster; student housing node; Chandaka buffer preservation zone
Kalinga Nagar (Gothapatna Industrial)	**1**	35%	**0.76**	Tech park master planning; prefab industrial sheds; integrated worker housing (15% EWS); freight access road to CRRR; industrial plot reconstitution through LPS	Planned Industrial Hub; Logistics Park node; 35,000+ job cluster; employment-linked housing provision
Jayapur–Rudrapur Peripheral Cluster	**1**	48%	**0.81**	Smart housing demonstration project; grid-based low-rise units on flat terrain; 9m capillary road network; IoT smart infrastructure bundle; ring road	Smart Housing Pilot Zone; peripheral ring road residential node; replicable planning template

				influence zone planning	
TIER 2: PRIORITY — LPS Scale-Up Phase (2027–2030)					
Balipatna–Gothapatna ORR Belt	**2**	60%+	0.72	Affordable housing development packages with phased master plans; IT campus potential leveraged through ORR proximity; developer partnership through LPS consent model	Affordable housing reserve; mixed-income township; IT-linked residential zone along ORR
Mendhasal Edge	**2**	55%	0.68	Compact housing design; co-housing clusters; hotel-design office-residential hybrid concepts; mid-density infill; future institutional future zoning reservation	Mid-density residential niche; office-residential hybrid; co-housing clusters for young professionals
Infocity North Extension	**2**	65%	0.61	Play-to-plug IT start-up zone; smart workspace parks; architectural branding for tech industry; road-ready sites needing only utility trunk	Tech start-up zone; branded workspace cluster adjacent to Infocity; northern knowledge hub extension

				extension through LPS	
Chandaka Fringe (PSP/Institutional)	2	72%	0.58	Eco-campus planning; private universities with sustainable architecture mandate; eco-resort and green institutional facilities; strict FAR 0.5 cap; no permanent RCC beyond wildlife buffer	Eco-institutional cluster; Chandaka Wildlife eco-sensitive zone buffer; sustainable campus typology
Paikarapur–Nuagan–Sijua Belt (SW)	2	70%	0.65	Eco-township pilot; plotted housing in G+1/G+2 format with green belts; population spillover absorption from Tamando; low-density zoning (FAR 1.2) per CDP 2040 alignment	Low-density eco-residential; student rental colonies; Balipatna–Gothapatna semi-loop residential catchment
TIER 3: MANAGED — Long-Term Growth Management (2030–2035)					
Uttarasasan–Dhauli Cluster (SE)	3	68%	0.52	Heritage-friendly housing with vernacular architecture mandate; tourism-	Heritage corridor housing; eco-tourism accommodation

				linked homestays; low-FAR (0.8 max) residential; flood-resilient plinth levels (0.6m above 100-yr flood mark)	node; Dhauli cultural heritage buffer zone
Jagannath Prasad–Andharua–Daruthenga Arc (NW)	**3**	75%	0.55	Institutional staff housing for future AIIMS II; affordable rental colonies (FAR 1.5–2.0); cluster-based rental zones with mixed densities; grid-based low-rise units on flat terrain	Institutional catchment housing; affordable rental node; IRR-adjacent residential catchment
Uttarasasan–Ebaranga Cluster	**3**	71%	0.49	Eco-tourism development leveraging location near heritage sites; low-FAR residential (0.8); seasonal accommodation for institutional visitors; green-interface layout planning	Heritage tourism accommodation; low-density eco-residential; institutional visitor services

Table 5.5: Peripheral Location-Wise LPS Priority Classification — All Identified Zones with Intervention and Output Summary (Source: Author; CDP 2040; Field Survey 2025; BDA Zone Maps)

5.4.4 LPS Implementation Workflow: The Three-Stage Process

The LPS implementation proceeds through a structured three-stage workflow, designed to achieve the 70/70 threshold, complete the land reconstitution, and deliver infrastructure to the Final Plots within a four-year cycle per Mouza:

Stage 1: Consent and Notification Phase (Months 1–12)

- Baseline cadastral survey of the pilot Mouza using drone photogrammetry and OSDI cadastral data; all holdings mapped, measured, and owner-verified.
- Public notification under Section 5 of the Odisha Land Pooling Rules, 2015; information disseminated in Odia language through Gram Sabha meetings, pamphlets, and visual models.
- Community sensitization: participatory mapping workshops demonstrating the incremental value proof with visual comparisons of ₹1,200 sq.m unserviced plot vs. ₹720 sq.m Final Plot commanding 400% higher per-unit value.
- 70/70 consent obtained and notarized; dissenting landowners (up to 30%) processed through the BDA compensation mechanism at prevailing circle rates plus 25% solatium.
- Formal LPS Notification issued by BDA; all sub-division, sale, or construction within the Mouza boundary frozen from notification date.

Stage 2: Valuation and Reconstitution Phase (Months 6–18)

- Independent valuation of all holdings by BDA-appointed chartered valuers; Pre-LPS value and Post-LPS projected value both documented in the Valuation Statement.
- Preparation of the Final Plot Allocation Scheme: each landowner's reconstituted plot identified on the LPS layout plan with dimensions, access road, and utility connection point specified.
- Joint title issuance: all Final Plot titles registered in the joint names of both the male and female heads of the household — addressing the historical gender equity gap in peri-urban land ownership.
- Resolution of tenancy and encumbrance disputes through the Peri-Urban Land Tribunal within the mandatory 90-day window.

Stage 3: Construction and Delivery Phase (Months 12–48)

- "Dig Once" Infrastructure Delivery: roads, water mains, sewerage collectors, and fibre optic ducts are all installed simultaneously in a single excavation cycle — eliminating the "dig once, then dig again" cost duplication that adds 40% to conventional infrastructure projects.
- PHC, school, and market plots handed over to relevant government departments for construction; BDA Reserve Plots auctioned through competitive bidding.
- Street lighting, landscaping, and stormwater infrastructure commissioned; Final Plots formally conveyed to landowners.
- EWS housing units (15% of residential FAR) tendered through PMAY-Urban mechanism and allocated to beneficiaries on the waiting list maintained by the BDA.

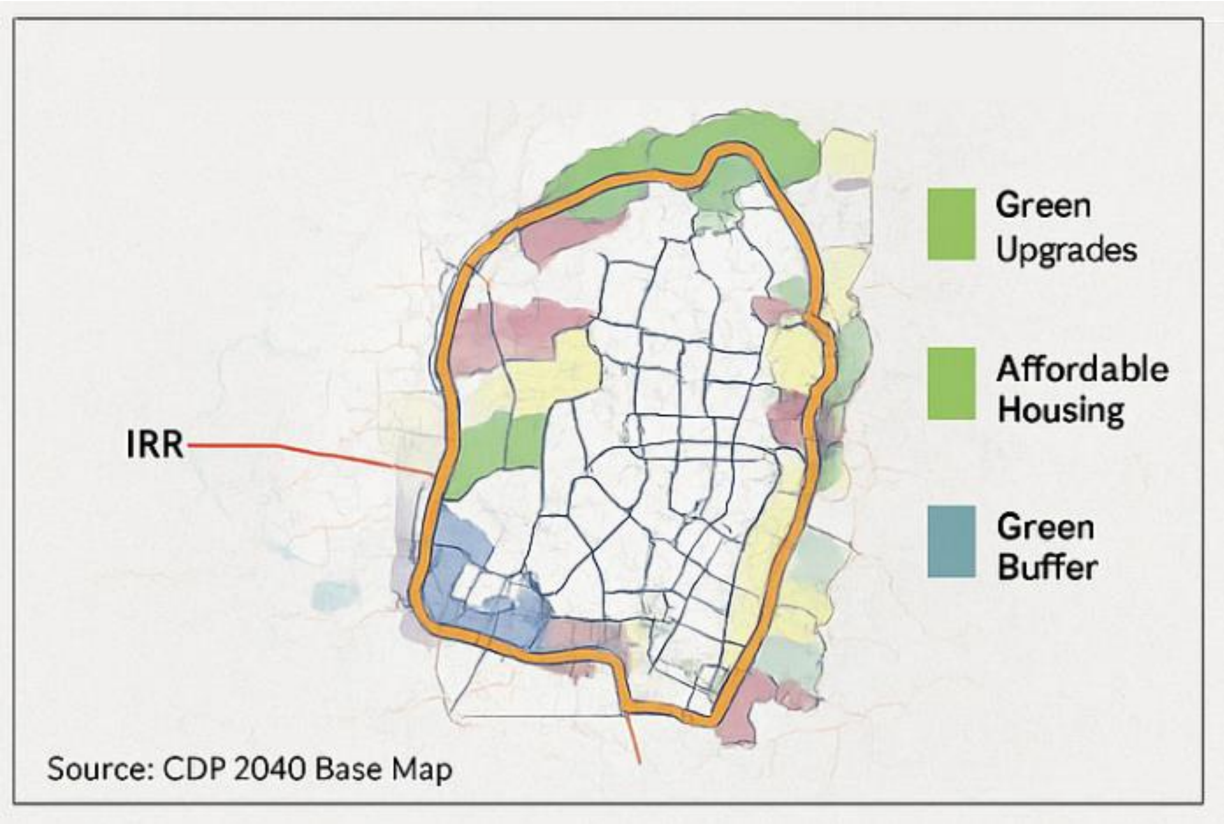


Figure 5.3: Proposal-I — Infrastructure Connectors, Public Transit Linkages, and Planning Zones 2025–2040. This sheet documents the phased spatial extents of LPS pilot areas and the proposed new infrastructure connector roads. (Source: Author; Odisha Transport Dept.; CDP 2040 Base Map)

STRATEGIC INTERVENTION III

5.5 Strategic Intervention III: Residential Development Zone Proposals

Residential growth in the peri-urban fringe is the fastest-growing and least-managed component of Bhubaneswar's urban expansion. Between 2010 and 2025, the south-western quadrant of the study area recorded the highest annualized residential growth rate of any urban fringe in Odisha — 145% over 15 years — yet this growth produced no planned road grid, no utility network, no community infrastructure, and no meaningful open space. The result is the "Plotted Scheme Sprawl" documented in Chapter 4: 500-household colonies served by single 4m access lanes, physically inaccessible to fire services.

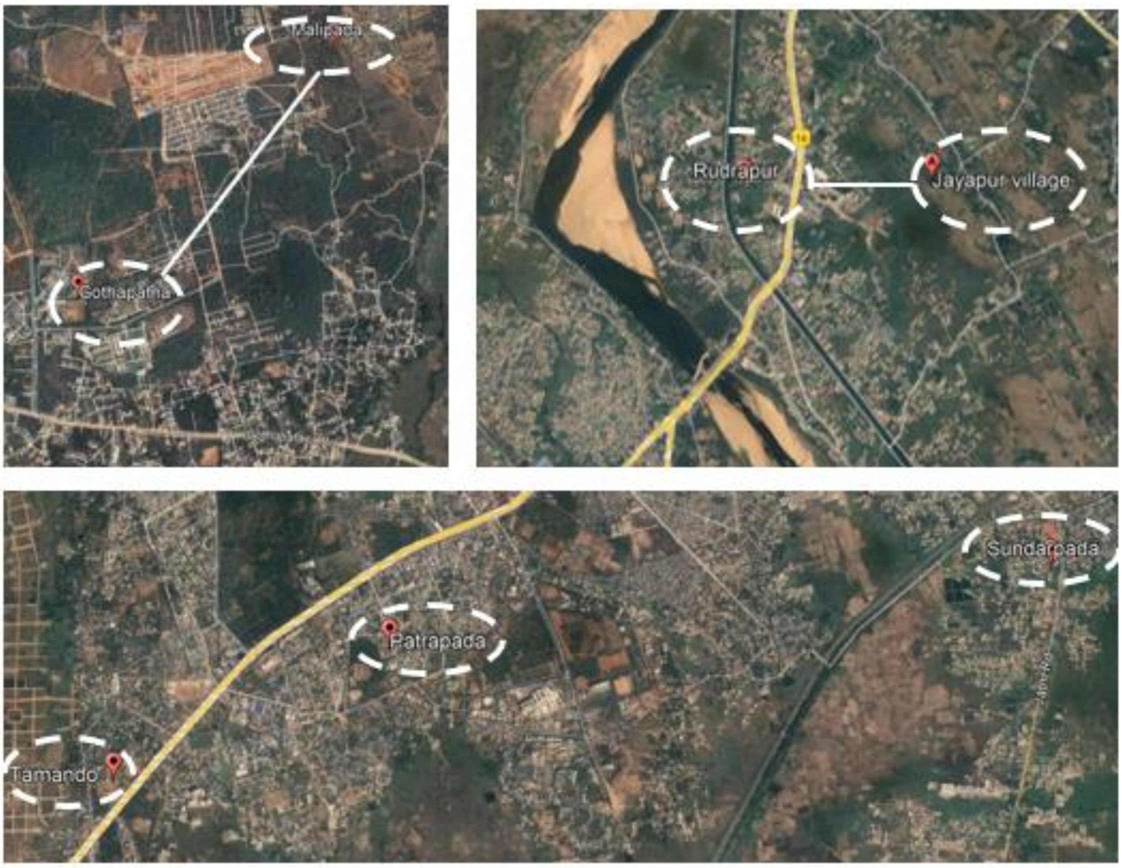


Figure 5.4: Proposal-III — Residential Development Zones: The Tamando–Patrapada–Sundarpada Affordable Housing Belt (Zone R-1), the Gothapatna–Malipada Eco-Township Stretch (Zone R-2), and the Jayapur–Rudrapur Smart Housing Cluster (Zone R-3). (Source: Author; CDP 2040 Zoning; BMC Ward Data)

The Residential Development Zone Proposals organize the housing demand projected to 2035 across three distinct belts, each calibrated to its terrain, accessibility profile, environmental context, and socio-economic catchment. These three belts are supplemented by four peripheral residential zone extensions that address the outer fringe. Together, they constitute a comprehensive framework for housing provision that meets the CDP 2040 targets while remaining within ecological carrying capacity.

5.5.1 Zone R-1: Tamando–Patrapada–Sundarpada Affordable Housing Priority Belt

Zone R-1 is the most critical and most urgent of the three residential zones. It carries the highest Peri-Urban Friction Index (0.84), the fastest growth rate (145% from 2010–2025), and the most severe infrastructure deficit (74% piped water gap; 100% sewerage gap). It is home to the largest concentration of middle-income and lower-middle-income households in the peri-urban fringe, many of whom have purchased plots in the expectation that municipal services will eventually arrive. The proposal designates Zone R-1 as an Affordable Housing Priority Zone, with the following spatial parameters:

PARAMETER	ZONE R-1 SPECIFICATION
Spatial Extent	Tamando–Patrapada–Sundarpada triangle; approx. 1,850 hectares within the LPS pilot notification boundary
FAR — Plotted Housing	Base FAR 1.8; maximum Ground Coverage 45%; Height maximum G+3 (12m)
FAR — Group Housing	Base FAR 2.5 for group housing schemes within 500m of the proposed IRR–Airport Road Link; Incentive FAR 3.0 for schemes incorporating minimum 15% EWS
Road Hierarchy	LPS-created 18m collector streets forming 300m × 400m super-blocks; 9m local roads within blocks; dedicated cycling track on all 18m roads; emergency vehicle access to 100% of plots

EWS Mandatory Reserve	15% of residential FAR in every LPS sector reserved for EWS/LIG at ≤30% of market rate per Odisha Housing Policy 2024; in-situ construction prioritized over distant relocation
Ground Floor Activation	Minimum 10% of ground floor frontage on 18m roads: neighbourhood commercial (grocery, pharmacy, services) — eliminating the 15 km retail desert without requiring separate commercial zones
Green Mandates	Every plot >500 sq.m: 10% of site area as unpaved "Soft-Scape" (rain garden, tree pit, percolation zone); community parks at 300m intervals per URDPFI standard
Priority PHC Location	One PHC at centrally accessible location per 15,000 population; three Anganwadi centres per 1,000 children; site reserved within LPS social infrastructure deduction (5%)
Schools	Primary school within 500m of all residential clusters; high school within 2 km; sites reserved within LPS layout
Connectivity	All plots within 5 min walk of proposed BRT feeder stop; within 10 min of IRR interchange at Tamando or Patrapada

Table 5.6: Zone R-1 Affordable Housing Belt — Spatial Parameters and Development Standards (Source: Author; Odisha Housing Policy 2024; URDPFI Guidelines)

5.5.2 Zone R-2: Gothapatna–Malipada Eco-Township Stretch

Zone R-2 occupies the ecologically most sensitive and spatially most complex position of the three residential belts. Positioned between the Chandaka–Dampara Wildlife Sanctuary eco-sensitive zone to the north and the Daya River floodplain to the south, the terrain is gently undulating, cross-cut by multiple natural Naya (seasonal drainage channel) alignments that flow south-west toward the Daya. The proposal designates this as Bhubaneswar's first explicitly planned Eco-Township Corridor — a residential zone that leverages its landscape character as a design asset rather than engineering it away:

- FAR: Capped at 1.5 to maintain a low-rise (G+2) character consistent with the ecological sensitivity of the zone and the CDP 2040 low-density residential designation for this area.
- Preferred Building Typology: Row houses and cluster courtyard housing preferred over apartment towers, minimizing foundation depth and site coverage; shared party walls reducing thermal load and construction cost; traditional Odia roof forms (sloped Mangalore tile or Pratap roof) for thermal comfort and visual compatibility with the landscape.
- Naya Corridor Protection: A 20m green corridor is reserved on both sides of every identified Naya, strictly prohibiting any construction, filling, or culverting. These corridors double as cycling and pedestrian greenways, creating a continuous "Green Spine" network linking residential clusters to the Chandaka forest edge — providing residents with direct access to nature without requiring vehicle travel.
- Student Housing Node: Co-location of 8,000+ student co-living beds adjacent to the Knowledge Hub boundary, reducing the north-south commute that currently generates peak-hour congestion on the Infocity–Bhubaneswar corridor. Mixed hostel typologies (government mess-style to premium co-living) provide options across income levels.
- Ecological Responsibility Mandate: Every residential project >2 hectares must prepare a Site-Level Green Infrastructure Plan approved by BDA, demonstrating: zero net increase in surface runoff; 100% rooftop water harvesting; minimum 25% soft-scape coverage; and planting of endemic tree species at a density of minimum 1 tree per 50 sq.m of gross site area.

5.5.3 Zone R-3: Jayapur–Rudrapur Smart Housing Demonstration Cluster

Zone R-3 sits within the outer influence zone of the CRRR, in the Jayapur–Rudrapur peripheral cluster where flat terrain and 48% remaining agricultural land offer the clearest opportunity for a grid-based, technology-integrated planned residential extension. The proposal designates this as the Smart Housing Demonstration Zone — a pilot that tests governance, technology, and design innovations that can be replicated across the ring road corridor once proven:

- Grid Layout: 600m × 800m super-blocks divided by 18m collector roads; 9m local streets; universal accessibility compliance on all public paths; dedicated cycling tracks on all collector roads.
- Smart Infrastructure Bundle: IoT-enabled LED streetlighting with occupancy sensing; smart water meters with real-time leak detection; fibre optic connectivity bundled as a "Base Infrastructure Package" within the LPS delivery contract — not provided as a separate, deferred capital works project.
- Mixed Density: Ground floor commercial in cluster centre; G+2 plotted housing on periphery; G+4 group housing adjacent to 18m collector roads — providing a density gradient that supports both neighbourhood commercial viability and residential privacy.
- Transit Integration: All plots within 5-minute walk of the proposed CRRR BRT stop at the Jayapur interchange; park-and-ride facility (200 spaces) at the interchange node.
- Replication Mechanism: Zone R-3 will function as a live laboratory for the LPS implementation process, with all cost, time, and consent data systematically recorded and published by the Peri-Urban Management Cell as a public planning dataset — enabling BDA to refine the model before scaling to 22 Mouzas in Phase II.

5.5.4 Peripheral Residential Extensions: The Southwest, Southeast, and Northwest Fringes

Beyond the three primary residential zones, the outer fringes of the 55 sq. km study area require carefully calibrated residential provision that prevents uncontrolled leapfrog sprawl while absorbing the population spillover from the more intensively developed inner zones:

Paikarapur–Nuagan–Sijua Belt (Southwest Fringe)

Adjacent to the proposed Balipatna–Gothapatna semi-loop road and near the Balipatna–Gothapatna ORR infrastructure zone, this area is designated for eco-township and plotted housing in G+1/G+2 format with mandatory green belts between clusters. Low-density zoning (FAR 1.2, maximum ground coverage 40%) absorbs population overflow from Tamando and Kalinga Nagar — the two most intensively growing areas in Zone B — while maintaining the sub-urban character that is both ecologically appropriate and architecturally distinct from the higher-density inner zones. The Balipatna–Gothapatna semi-loop road provides the primary connectivity to the CRRR network, ensuring that this zone does not become a spatial dead-end.

Uttarasasan–Dhauli Cluster (Southeast Fringe)

Located in immediate proximity to the Dhauli Peace Pagoda, the Buddhist heritage sites of the Ashokan Rock Edicts, and the Daya River floodplain, this cluster demands the most delicate planning intervention of any area in the study. The zone is restricted to a maximum FAR of 0.8, with heritage-sensitive architectural guidelines mandating vernacular building forms, traditional materials (local Odia laterite stone and terracotta tile), and flood-resilient plinth levels set at a minimum of 0.6m above the recorded 100-year flood level. Tourism-linked homestays provide a livelihood transition pathway for farming families displaced by urban growth, enabling them to remain in their cultural landscape while participating in the heritage tourism economy

Figure 5.5: Proposal-IV — Peripheral Residential Housing Expansion: Paikarapur–Nuagan–Sijua SW Fringe, Uttarasasan–Dhauli Heritage Cluster, and Jagannath Prasad–Daruthenga NW Arc with land-use context, zoning designations, and aerial analysis. (Source: Author; CDP 2040; BMC Affordable Housing Policy)

Jagannath Prasad–Andharua–Daruthenga Arc (Northwest Periphery)

Adjacent to the proposed AIIMS II campus and the future IRR alignment, this flat terrain cluster is designated primarily for institutional staff housing and affordable rental colonies at a medium density of FAR 1.5–2.0. The proximity to AIIMS II and other planned institutional nodes creates a captive rental housing demand that can be served by cluster-based mixed-density rental zones — providing flexibility for working professionals who require high-quality short-to-medium-term housing without the capital cost of plot purchase. Grid-based low-rise units (G+3 maximum) are structurally appropriate for the flat terrain and institutionally appropriate for the healthcare and research workforce catchment.

STRATEGIC INTERVENTION IV

5.6 Strategic Intervention IV: Infrastructure and Environmental Resilience Proposals

The infrastructure and environmental resilience proposals address the physical systems that the LPS mechanism creates the land and funding to deliver. These proposals respond directly to the four critical deficits quantified in Chapter 4: the 74% piped water shortfall, the 100% sewerage absence, the 90% stormwater drainage gap, and the Capillary Network Failure affecting 82% of Zone B roads. They also address the two environmental threats — Daya River floodplain encroachment and the 1.2m/year groundwater depletion crisis — that will compound in severity if peri-urban development continues without ecological management.

5.6.1 New Infrastructure Connector Roads

The peri-urban fringe suffers from structural macro-connectivity gaps — missing links between the IRR and ORR that create "Strategic Dead-Ends" where areas that are geographically close to urban nodes are functionally disconnected. Three new connectors are proposed as priority capital works, fundable through the Land Value Capture (LVC) mechanism:

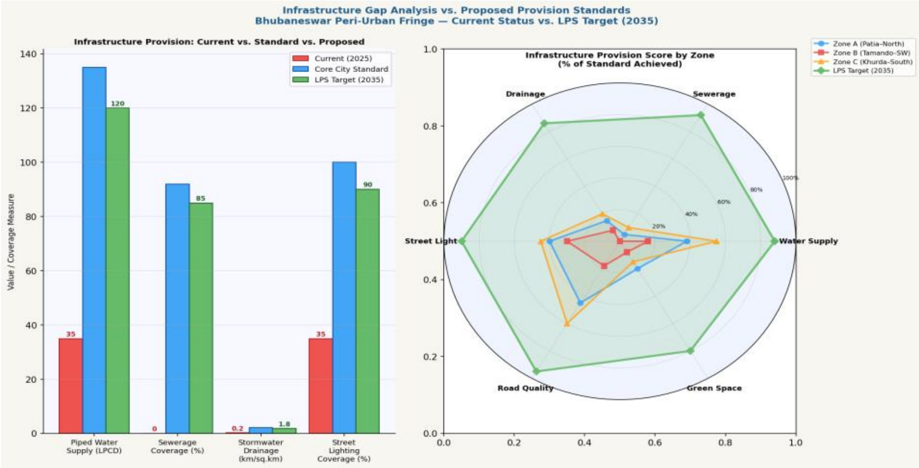


Figure 5.6: Infrastructure Provision Comparison — Current Status (2025) vs. Core City Standard vs. LPS Proposed Target (2035), and Radar Chart of Infrastructure Provision Scores by Zone. Zone B (Tamando–SW) scores the lowest across all dimensions, confirming its Tier 1 priority status. (Source: Author; BMC Infrastructure Data; CDP 2040)

CONNECTOR ROAD	ALIGNMENT	ROW & LENGTH	FUNCTION & BENEFIT	ESTIMATED COST & FUNDING
IRR → Airport Road Direct Link	Bharatpur (IRR) to CRP Square (Airport Road)	30m ROW; 6.2 km	Enables south-west movement for Tamando, Patrapada, and Infocity workforce without traversing the congested city core; reduces core-city through-traffic by est. 22%	₹85 Crores; LVC Betterment Levy on IRR interchange plots
ORR → NH-57 Corridor (Eastern)	Kalinga Nagar (ORR) to Jatani (NH-57)	30m ROW; 8.4 km	Dedicated industrial freight corridor bypassing Chandaka	₹112 Crores; State PWD + CRRR Cess Fund

			residential junction; reduces heavy vehicle traffic in residential areas by est. 35%; supports Logistics Hub operationalization	
Balipatna–Gothapatna Semi-Loop	Balipatna Junction (ORR) to Gothapatna residential cluster	18m ROW; 4.8 km	Tertiary access route enabling emergency vehicle access to interior colonies; de-congests ORR mainline; connects Zone R-2 eco-township to CRRR network	₹45 Crores; LPS Reserve Plot monetization (5% land bank)

Table 5.7: New Infrastructure Connector Roads — Alignment, Specifications, and Funding Source (Source: Author; Odisha Transport Dept.; CRRR Feasibility Study)

5.6.2 The Capillary Network Upgrade — Solving Road Hierarchy Collapse

The single most urgent physical deficiency in the study area — and the one carrying the highest retrospective cost if not addressed before development is complete — is the Capillary Network Failure: the collapse of the local road hierarchy at the sub-collector level, where 82% of peri-urban roads in Zone B are either dead-ends or unpaved paths of 3–5m width physically incapable of carrying emergency vehicles. The BDA's own engineering consultants estimate that retrospective road widening — purchasing land after buildings have been constructed on both sides — would cost ₹1,200 Crores more than proactive LPS-secured ROW.

- Standardized ROW Widening Through LPS: All existing village Gali roads within LPS pilot zones are widened to a minimum of 9m through the land reconstitution process; no new residential plot may front a road of less than 9m width. Emergency vehicle minimum turning radius (8.5m for fire tender) guaranteed to all residential clusters.

- Road Hierarchy Enforcement: A strict five-level hierarchy is designated: 60m (CRRR) → 30m (Primary Arterial) → 18m (Collector) → 12m (Sub-Collector) → 9m (Local Capillary). No hierarchy level may be skipped in new LPS layouts; continuous connectivity between all levels is mandatory.
- Encroachment-Free ROW: Compound walls in LPS zones must be recessed 1.5m from the property line to create a uniform "Utility Corridor" for underground cables, drains, and fibre ducts — preventing the encroachment that has reduced effective road widths by 30–40% in existing unplanned localities.
- Linear Densification Incentive: FAR bonuses of 0.5 above the base FAR are permitted specifically for buildings fronting 18m and 30m roads — concentrating population density near the best-served infrastructure corridors and making bus service economically viable by ensuring ridership density along collector routes.

5.6.3 Managed Fringe Water and Environmental Infrastructure

The environmental interventions are designed to be structurally integrated into the LPS land allocation — not deferred to separate environmental management plans. Three critical systems require simultaneous attention:

Integrated Stormwater and Drainage System

The 90% stormwater drainage deficit documented in Chapter 4 — with only 0.2 km of formal drainage per sq. km against a standard of 2.1 km — translates directly into the annual flooding of several low-lying Patrapada and Sundarpada localities during above-average monsoon years. The proposal restores the natural slope gradient toward the Daya River within all LPS pilot zones by prohibiting any filling or culverting of natural drainage channels (Nayas) without BDA hydraulic clearance. A mandatory 50m No-Build Buffer is established on both banks of all identified Nayas, maintained as green corridors. All community parks in the LPS layout are designed as "Sponge Parks" with permeable paving, sub-surface storage chambers, and infiltration trenches — combining recreation with stormwater management.

Groundwater Recharge Mandate

Every new development within the LPS zone must dedicate 10% of its site area to high-capacity percolation infrastructure — either percolation pits (minimum 3m deep, gravel-filled, one per 500 sq.m of built-up area) or rooftop rainwater harvesting tanks connected to sub-surface recharge borings. This mandate directly counters the 1.2m/year water table depletion crisis by recharging the aquifer that the 74% piped water deficit has forced residents to over-exploit through private borewells. A "Recharge Certificate" — verified by BDA before Occupancy Certificate issuance — is required for all new buildings in LPS zones.

Daya River Green Buffer and Floodplain Protection

The CA-Markov simulation from Chapter 4 reveals that 45% of all new built-up area in the southern fringe is occurring on natural water retention land that stores monsoon runoff and moderates peak flood discharge in the Daya River catchment — and that unchecked development will increase peak flood discharge by 300% by 2035. The proposal establishes a permanent, gazette-notified 100m Green Buffer along the Daya River's northern bank as the "Southern Green Lung" — prohibiting all permanent construction within this buffer. The buffer is maintained as a combination of: organic farming plots distributed to displaced farming families (providing livelihood continuity through the LPS transition); eco-tourism trails linking Dhauli heritage sites; and natural floodplain wetlands that restore the original water retention capacity lost to recent encroachment.

STRATEGIC INTERVENTION V

5.7 Strategic Intervention V: Proposed Zoning and Development Control Regulations (DCR)

The traditional Euclidean zoning paradigm — rigid separation of land uses into exclusive residential, commercial, and industrial categories — has produced the mono-functional dormitory suburb syndrome that now afflicts Tamando, Patrapada, and Sundarpada. These are large residential populations with zero proximate employment, zero walkable retail, and zero community infrastructure — forcing entirely motorized commutes to distant urban nodes for every service transaction. The proposed regulations shift to a Form-Based Code (FBC) framework integrated with Intensity-Linked Zoning (ILZ), which regulates the physical form, scale, and relationship-to-street of development rather than its use alone.

5.7.1 The Three-Tier Zoning Hierarchy for the CRRR Influence Zone

ZONE TYPE	DISTANCE FROM CRRR	FAR (BASE / MAX)	PERMISSIBLE USES	KEY FORM CONTROLS
Zone T: Transit-Oriented Development (TOD)	0–500m from CRRR / Major Interchanges	**2.5 / 4.0 via TDR**	High-density mixed-use: retail/F&B/services on ground floor; offices/co-working floors 1–3; residential floors 4+. No single-use residential blocks permitted. No blank walls on CRRR frontage.	Zero-setback shared party walls on commercial frontages; 50% max ground coverage; mandatory active frontage (60% glass); height ≤ 1.5× road width; parking underground or podium (no surface lots on CRRR face)
Zone R: Peri-Urban Residential Zone	500m–2km from CRRR	**1.8 / 2.2**	Primarily residential (plotted and group housing); 15% ground floor local commercial on plots fronting 18m roads mandatory; no warehousing, heavy industry, or institutional facilities >2,000 sq.m.	Compound wall recessed 1.5m from property line; 10% soft-scape per plot >500 sq.m; height G+4 max; solar-ready roof structure; 9m min road frontage; no gated colony enclosure without BDA approval

Zone E: Ecological Buffer & Green Zone	Low-lying Daya River/Chandaka vicinity	**0.2 max**	Organic farming (landowner plots from LPS social deduction); eco-tourism trails; public parks and wetland conservation; no permanent RCC structures; permitted: light wood/steel structures for tourism/park use only.	Semi-permanent structures max height 4.5m; 100% permeable ground surface; no sub-surface excavation within 50m of Naya channels; all structures >500m from Daya River bank; mandatory eco-impact assessment
Zone H: Heritage and Cultural Sensitive Zone	Old Town, Dhauli, Lingaraj vicinity	**0.8 / 1.0**	Low-density heritage residential; homestays; craft studios; heritage interpretation centres; no multi-storey modern structures; no chain retail or corporate branding visible from heritage sites.	Vernacular architectural guidelines mandatory; max height G+1 (6.5m); local materials (laterite, terracotta); sight-line protection to Lingaraj Temple and Dhauli Pagoda; building permit requires Heritage Committee approval

Table 5.8: Four-Tier Zoning Hierarchy for the CRRR and IRR Influence Zones — Permitted Uses, FAR Limits, and Form Controls (Source: Author; Odisha Building Rules; CDP 2040 Zoning Draft; Heritage Conservation Guidelines)

5.7.2 Form-Based Design Control Regulations (DCR) — Detailed Specifications

The following Form-Based Design Control Regulations are mandated for all new developments, LPS Final Plot constructions, and redevelopment proposals within the CRRR influence zone. These DCRs are not suggestions — they are conditions of Building Permission issuance and Occupancy Certificate release:

Road and Street Level Controls

- Height-to-Width (H:W) Ratio: Building heights shall not exceed 1.5 times the width of the abutting road — ensuring adequate solar access to street level (minimum 2 hours per day in winter), natural ventilation, and visual proportionality between building scale and street scale.
- Active Frontage Mandate: A minimum of 60% of any building façade facing a road of 18m width or above must be dedicated to transparent, pedestrian-accessible active uses (retail display, lobby, café, community facility). Blank walls, service entrances, and parking ramp faces are prohibited on primary frontages.
- Setback Recessing: All compound walls and boundary treatments must be set back 1.5m from the outermost edge of the property line, creating a continuous 1.5m "Utility and Greenery Strip" along all roads. This strip accommodates underground utility ducts, stormwater drains, street tree planting, and an unobstructed pedestrian footpath.

Sustainability and Environmental DCRs

- Solar-Ready Roofing: All buildings with FAR ≥ 2.0 must include structural capacity (minimum 150 kg/sq.m additional load) and electrical provisions (earthing, cable tray, DC isolator mounting points) for photovoltaic panel installation — supporting Odisha's 30% renewable energy target under the State Action Plan on Climate Change.
- Rainwater Harvesting (RWH) Mandatory: All buildings with rooftop area >100 sq.m must install a BDA-approved Rainwater Harvesting system connected to either (a) a recharge pit of minimum 3m depth, or (b) a storage tank with reuse for non-potable purposes. Failure to maintain RWH system voids the Occupancy Certificate.
- Universal Accessibility: All ground-floor units, community facilities, and public spaces within LPS zones must comply fully with the Harmonised Guidelines and Space Standards for Barrier Free Built Environment (GoI, 2021): ramps at all level changes, tactile paths at pedestrian crossings, accessible sanitation facilities in all public buildings.
- Tree Preservation Order (TPO): All trees with trunk diameter >30cm within LPS zones are protected; removal requires Peri-Urban Management Cell

approval and compensatory planting of minimum 5 trees per removed tree at designated nursery sites.

Density Management and TDR Controls

- Transferable Development Rights (TDR) Market: A formal TDR registry is maintained by BDA. Landowners in Zone E (Ecological Buffer) and Zone H (Heritage) may sell their unused FAR as TDR certificates to developers in Zone T (TOD) at market rate — enabling conservation of sensitive areas through development elsewhere, without requiring government cash compensation.
- FAR Incentive Package: Projects incorporating any one of the following receive a 0.5 FAR bonus above the base zonal FAR: (a) minimum 15% EWS/LIG housing; (b) a dedicated BRT/Metro feeder bus shelter within the project boundary; (c) a rooftop solar installation covering minimum 50% of rooftop area; (d) a community facility (library, health centre, crèche) open to all residents of the LPS sector.

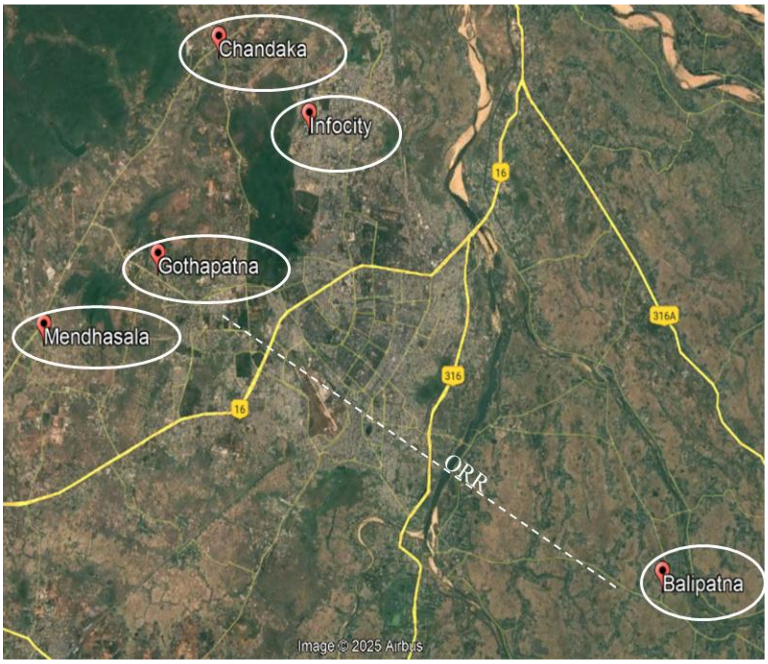
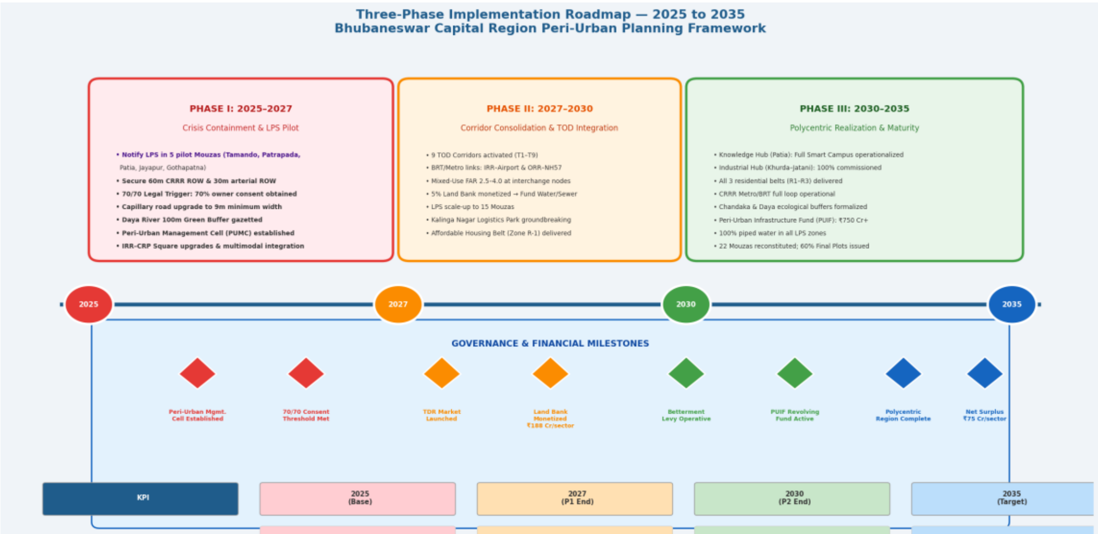


Figure 5.8: Proposal-II — Zone-Wise Business Scope, Land Status, and Profit Potential Across Peripheral Locations: Kalinga Nagar, Chandaka Fringe, Balipatna–Gothapatna ORR Belt, Mendhasal Edge, and Infocity North Extension. (Source: Author; CDP 2040 Zoning Draft; BDA Land Records)

5.8 Phasing and Implementation Timeline: The Three-Phase Roadmap 2025–2035

The five strategic interventions are sequenced across three implementation phases that respond to the urgency gradient established by the CA-Markov analysis: Phase I addresses the crisis before the intervention window closes in Zone B; Phase II consolidates the TOD corridors during the period when the CRRR is fully operational; Phase III completes the polycentric framework that the earlier phases have made possible. Each phase has defined spatial targets, institutional milestones, governance achievements, and measurable Key Performance Indicators.



KPI	2025 (Base)	2027 (P1 End)	2030 (P2 End)	2035 (Target)
LPS Mouzas Reconstituted	0	5	15	22+
Roads Widened to 9m+ (km)	0	45	120	200+
Piped Water Coverage (%)	26	50	75	95
Green Space (m^2/capita)	0.8	3.2	7.5	10+

Figure 5.9: Three-Phase Implementation Roadmap 2025–2035 — Spatial Focus, Key Milestones, Governance Goals, and KPI Progression for Each Phase. (Source: Author; CDP 2040; Project Synthesis)

5.8.1 Phase I: Proactive Crisis Containment and LPS Pilot (2025–2027)

Phase I is defined by urgency. The CA-Markov simulation confirms that the intervention window in Zone B (Tamando–Patrapada) closes before 2030 — after which point the remaining 38% agricultural land will have been informally converted, making planned reconstitution physically and politically impossible. Phase I must, within 24 months, secure the legal framework and spatial footprint for the LPS before this window closes.

DIMENSION	PHASE I CONTENT (2025–2027)	MEASURABLE TARGET
Spatial Focus	Western Arc Heat Zones: Tamando–Patrapada–Sundarpada Belt (Zone B); Jayapur–Rudrapur Cluster; Patia–Infovalley Northern Fringe (Zone A); Balipatna–Gothapatna preliminary notification	LPS formally notified in 5 pilot Mouzas
LPS Actions	Town Planning (TP) Scheme notifications issued; 70/70 consent threshold achieved; cadastral surveys complete; Final Plot layouts prepared; ROW secured for 60m CRRR and 30m internal arterials	70% consent obtained in all 5 pilot Mouzas within 12 months of notification
Infrastructure	Capillary road upgrade to 9m minimum in all pilot Mouzas; water main trunk extension to 2 pilot Mouzas; Daya River 100m Green Buffer formally gazetted; IRR-CRP Square multimodal upgrade	45 km of roads widened to 9m+; 2 PHC sites reserved and handed to OHFW
Institutional	Peri-Urban Management Cell (PUMC) established with statutory authority; 5-year moratorium on Gram Panchayat building permissions in notified LPS Mouzas; Peri-Urban Land Tribunal constituted	PUMC fully staffed and operational by Month 6
Short-Term Priorities	IRR–CRP Square traffic management upgrades; affordable housing focus in Tamando–Patrapada clusters (EWS 15% in all new permissions); heritage-sensitive zoning guidelines for Old Town and Dhauli enacted	EWS compliance in 100% of new LPS sector approvals; heritage guidelines notified

Financial	BDA Reserve Plot auction in first completed LPS sector; Betterment Levy enacted on CRRR interchange plots; Peri-Urban Infrastructure Fund (PUIF) seeded	₹188 Cr revenue from first sector auction; PUIF initial corpus ₹75 Cr

Table 5.9: Phase I Implementation Plan — Proactive Crisis Containment (2025–2027) (Source: Author; CDP 2040; BDA Five-Year Plan)

5.8.2 Phase II: Multi-Modal Corridor Consolidation and TOD Integration (2027–2030)

Phase II transitions from crisis management to systematic corridor development. The CRRR is expected to reach near-full operational capacity during this period, making the TOD opportunity at interchange nodes both physically accessible and commercially attractive to private developers. The Phase II programme capitalizes on this momentum by activating the TOD regulatory framework, scaling the LPS to 15 Mouzas, and connecting the ring road to the metropolitan transit network.

- TOD Corridor Activation: Designate and activate 9 strategic TOD corridors along the CRRR, including the Khurda–Chandaka (T1), Puri–Cuttack Bypass (T2), and Balakati–Infocity (T3) alignments. Apply FAR 2.5–4.0 at interchange nodes (Jaydev Vihar, CRP Square, Khurda Junction); launch competitive TOD development tenders for at least 3 interchange nodes.
- BRT/Metro Feeder Links: Commission BRT Rapid Bus Transit along the IRR–Airport Road corridor and the ORR–NH57 alignment; park-and-ride facilities at Kalinga Nagar, Balakati, and Jayapur CRRR interchanges; BRT feeder routes connecting all Phase I LPS zones to the CRRR network within 5-minute walking distance.
- LPS Scale-Up: Extend LPS notification to 15 total Mouzas across all three zones; apply lessons from Phase I pilot to refine the consent, valuation, and construction workflow; establish the Peri-Urban Land Tribunal as a permanent, functional institution with a published case resolution record.
- Mixed-Use Zoning Launch: Formal notification of the Three-Tier Zoning Regulation (Zone T / Zone R / Zone E) for the entire CRRR influence zone;

DCR guidelines issued and building permission review procedures updated to reflect new Form-Based Code requirements.

- Affordable Housing Scale-Up: Extend Zone R-1 affordable housing programme to Balipatna–Gothapatna Belt and Paikarapur–Nuagan–Sijua Belt (Tier 2 zones); PMAY-Urban integration for EWS units; commence eco-township pilot in Zone R-2 (Gothapatna–Malipada).
- Kalinga Nagar Logistics Hub: Groundbreaking for the Logistics Park freight terminal and first MSME cluster; worker housing (15% EWS) commence construction; integrated worker bus service connecting Logistics Hub to Zone R-1 residential belt operational.

5.8.3 Phase III: Polycentric Realization and Metropolitan Maturity (2030–2035)

Phase III completes the polycentric metropolitan structure that the earlier phases have created the spatial and institutional pre-conditions for. By 2030, the CRRR will be fully operational; 15 Mouzas will be in various stages of LPS reconstitution; three residential zones will be under active development; and the institutional framework (PUMC, Land Tribunal, PUIF, TDR market) will be functional. Phase III's task is to realize the full polycentric vision by completing all three functional hubs and establishing the ecological infrastructure that makes the metropolitan system resilient.

- Knowledge Hub Completion: Full Smart Campus Zone at Patia–Infovalley operational; 8,000+ student co-living beds delivered; dedicated Knowledge Hub metro/BRT connectivity commissioned; Infocity North Extension tech start-up cluster tenanted; AIIMS II staff housing colony (Jagannath Prasad Arc) complete.
- Industrial Hub Maturity: Kalinga Nagar Logistics Park Phase I fully commissioned (35,000+ jobs); MSME cluster at capacity; Cold Chain Hub operational; NH-57 freight corridor open; integrated worker housing fully occupied; zero informal labour settlement formation within 5 km of the Hub.
- LPS Completion: All 22+ notified Mouzas with Final Plots conveyed to landowners; 100% piped water coverage in Tier 1 and Tier 2 LPS zones;

sewerage connected to localized STPs in all completed sectors; PUIF corpus exceeds ₹750 Crores (cumulative from 22 sector auctions).

- Ecological Consolidation: Daya River Green Buffer formally managed as public parkland with organic farming plots; Chandaka eco-sensitive zone boundary fully enforced and no new encroachments recorded post-2030; stormwater drainage network at 1.8 km/sq.km standard across all LPS zones; groundwater table stabilization confirmed in monitoring wells.
- Polycentric Maturity: Bhubaneswar's commute burden reduced from 12–15 km average to <5 km average within polycentric node catchments; the CRRR fully functions as a metropolitan connector (not a bypass); three hubs each providing employment, housing, healthcare, and education within walkable or short-transit distances.

5.9 Financial Feasibility: The Self-Financing LPS Model

The most persistent objection to ambitious peri-urban planning proposals is the Infrastructure Funding Gap: where does the capital come from, in a context where state budgets are overcommitted, municipal revenues are limited, and central government grants are unpredictable? The proposed LPS for Bhubaneswar is designed from first principles as a Self-Financing Model, in which the land value appreciation created by the ring road and by the infrastructure investment itself provides the capital for that investment — without dependency on state budget allocations, central government grants, or municipal bonds.

5.9.1 The Land Value Capture Mechanism: The Economic Logic of Land Pooling

The financial model of the LPS rests on a single, empirically documented economic reality: that public infrastructure investment creates private land value, and that the LPS is the instrument that ensures some portion of that value flows back to fund the infrastructure that created it. Field investigation and secondary data from Odisha property registration records reveal a three-stage land value appreciation curve in the peri-urban study area that provides overwhelming economic justification for the 40% land contribution required under the LPS:

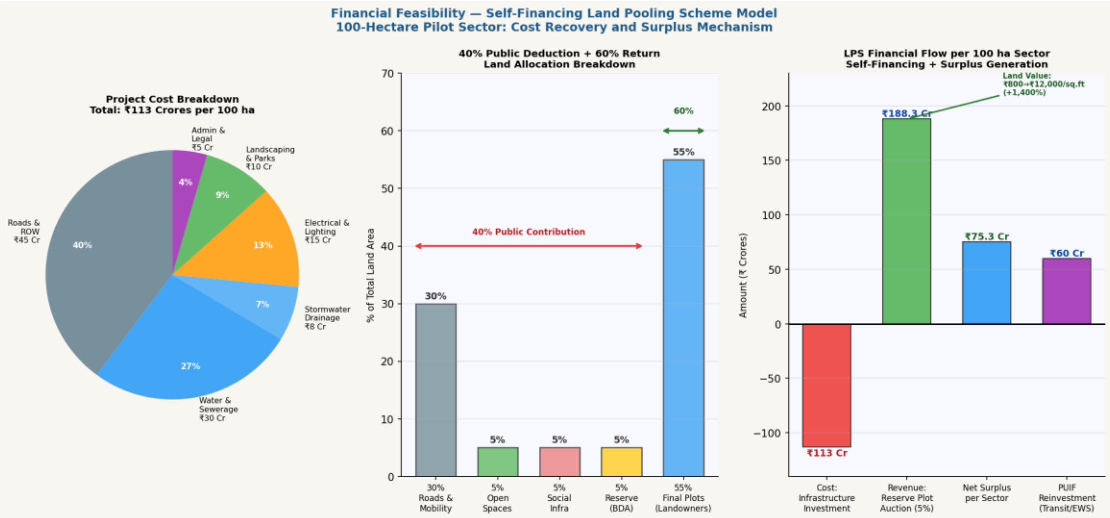


Figure 5.10: Financial Feasibility Analysis — Project Cost Breakdown, Land Allocation Model, and LPS Cash Flow per 100-Hectare Sector. The model demonstrates a surplus of ₹75 Crores per sector, reinvested into the Peri-Urban Infrastructure Fund. (Source: Author; MoRTH; CPHEEO; BDA Engineering Data)

LAND VALUE STAGE	VALUE PER SQ. FT. (₹)	APPRECIATION	VALUE DRIVER
Stage 1: Pre-CRRR Announcement (c. 2015)	₹800 – ₹1,200	Baseline Reference	Agricultural / speculative holding with no road access or utility services
Stage 2: During CRRR Construction (2025)	₹2,500 – ₹4,500	+250%–400% above baseline	Ring Road proximity premium; speculative developer acquisition; anticipation of urban transition
Stage 3: Post-LPS Completion (2035 Projection)	₹8,000 – ₹12,000	+400%–600% above 2025	Serviced Final Plot with: 18m road frontage, piped water, sewerage, title — all within a planned neighbourhood with

			PHC and school within 2 km
Aggregate Appreciation (2015→2035)	**₹800 → ₹12,000**	**+1,400% total**	Public infrastructure investment converting speculative agricultural land into premium urban real estate

Table 5.10: Land Value Appreciation Trajectory — From Pre-CRRR Agricultural Land to Post-LPS Serviced Urban Plot (Source: BDA Property Registration Records; Field Survey 2025; Author Projections)

The aggregate 1,400% land value appreciation from pre-announcement (₹800/sq.ft) to post-LPS (₹12,000/sq.ft) is the core economic argument for the 40% land contribution: a landowner contributing 40% of their physical area through the LPS and receiving back 60% as a serviced Final Plot will, by 2035, hold a plot worth approximately four times the monetary value of their original 100% unserviced agricultural holding — making them not victims of urbanization but its principal financial beneficiaries.

Economic Equity: Landowners as Long-Term Urban Stakeholders

The critical shift that the LPS achieves is the conversion of farming households from passive victims of land speculation — selling under financial pressure to developers who capture 100% of the value premium — into active, long-term urban stakeholders who hold legally titled, fully serviced urban plots in the planned grid. This is not merely a planning outcome; it is a profound social equity intervention that distributes the wealth created by public infrastructure investment to the community that bore the social cost of the urban transition.

5.9.2 Estimated Project Costing — 100-Hectare Pilot LPS Sector

The cost estimates below are derived from MoRTH road construction standards, CPHEEO utility provision norms, BDA engineering cost data, and comparable LPS implementation experiences in Gujarat and Andhra Pradesh:

INFRASTRUCTURE COMPONENT	ESTIMATED COST (₹ CR.)	TECHNICAL BASIS
Road Construction (30m, 18m, 12m, and 9m hierarchy; CC pavement)	**₹45.0 Cr**	MoRTH SOR at ₹3.5–4.0 Cr/km for 18m road; includes drainage channel alongside
Water Supply (300mm trunk main + 75mm local connections + overhead tank)	**₹22.0 Cr**	CPHEEO norms for peri-urban extension; 135 LPCD design standard
Sewerage (200mm collector + localized 1 MLD STP × 2)	**₹18.0 Cr**	CPHEEO SOR; secondary treatment + UV disinfection
Stormwater Drainage (lined side channels + percolation parks)	**₹8.0 Cr**	2.1 km/sq.km standard; partially offsets flood risk valued at ₹50+ Cr/event
Electrical Infrastructure (underground MV/LV + LED street lights at 30m)	**₹12.0 Cr**	DISCOMS engineering estimate; smart metering included
Telecommunications (OFC duct + 5G tower provisions)	**₹5.0 Cr**	DoT broadband standard for planned urban areas
Landscaping, Sponge Parks, and Green Infrastructure	**₹8.0 Cr**	URDPFI 10 m²/capita green space; endemic tree planting + sponge park infrastructure
Administrative, Legal, Survey, and Capacity Building	**₹5.0 Cr**	Cadastral survey, notification costs, Land Tribunal, GIS platform setup
Contingency (10%)	**₹12.3 Cr**	10% of total infrastructure cost; standard BDA provision

TOTAL PROJECT COST PER 100-HECTARE SECTOR	**₹135.3 Cr**	Inclusive of all components; exclusive of land cost (LPS mechanism provides ROW)

Table 5.11: Estimated Project Cost — 100-Hectare LPS Pilot Sector (Source: Author; MoRTH SOR; CPHEEO Norms; BDA Engineering Data)

5.9.3 Revenue Generation and the Self-Financing Proof

REVENUE SOURCE	CALCULATION	PROJECTED AMOUNT
BDA Reserve Plot Auction (5% of 100 ha)	5 ha = 5,38,000 sq.ft; × ₹3,500/sq.ft (conservative bulk rate)	₹188.3 Crores
Betterment Levy on Adjacent Interchange Plots	Est. 50 ha of private land within 500m of CRRR interchange; 10% levy on ₹4,000/sq.ft avg. transaction value	₹21.5 Crores (annualized)
TOTAL REVENUE (FIRST SECTOR CYCLE)	Reserve Plot auction + first-year Betterment Levy	₹209.8 Crores
TOTAL PROJECT COST	Infrastructure delivery per Table 5.11	₹135.3 Crores
NET SURPLUS PER SECTOR	Revenue − Cost	**₹74.5 Crores**

Table 5.12: Revenue Generation and Cost Recovery — Self-Financing Proof per 100-Hectare LPS Sector (Source: Author; BDA Land Records; CRRR Feasibility Study)

The Peri-Urban Infrastructure Fund (PUIF) — Reinvesting the Surplus

The ₹74.5 Crore surplus per sector is not treated as fiscal profit or returned to the state's general revenue. It is mandatorily channelled into the Peri-Urban Infrastructure Fund (PUIF), a dedicated revolving fund managed by the Peri-Urban Management Cell. The

PUIF is allocated as follows: 40% (₹29.8 Cr) to cross-subsidize BRT/Metro operations along the CRRR corridor (addressing the last-mile connectivity gap); 30% (₹22.4 Cr) to EWS housing construction in Tier 1 LPS zones; 20% (₹14.9 Cr) to PHC and primary school building in underserved peripheral locations; and 10% (₹7.5 Cr) to the Peri-Urban Land Tribunal and PUMC operational costs. With 22 projected LPS sectors, the cumulative PUIF corpus is projected to reach ₹1,639 Crores by 2035 — sufficient to fully fund the BRT network for 15 years.

5.10 Equity and Inclusivity Framework: Protecting the Original Community

Peri-urban planning interventions of the scale proposed in this thesis carry an inherent and well-documented risk: the displacement and marginalization of the very communities whose agricultural land forms the raw material of the intervention. The Gujarat Town Planning Scheme experience demonstrates that, without explicit equity safeguards built into the LPS framework as non-negotiable legal conditions, the value premium created by serviced urban land accrues predominantly to higher-income early buyers and developers rather than to the original farming households. The following safeguards are designed as structural features of the LPS — not optional add-ons that can be traded away during the consent negotiation.

EQUITY DIMENSION	SPECIFIC SAFEGUARD	POLICY AND LEGAL BASIS
EWS/LIG Housing Reservation	15% of all residential FAR in every LPS sector mandated for EWS/LIG housing at concessional rates (not exceeding 30% of current market rate per sq.ft); in-situ construction within the same LPS sector prioritized over distant relocation; BDA maintains waiting list and allocation lottery.	*Odisha Housing Policy 2024; PMAY-Urban; National Housing Policy*

Farmer Livelihood Protection	Agricultural households losing farming income through LPS participation are allocated "Priority Commercial Vending Zones" — formally tenured market stall plots in the new LPS commercial layout, at subsidized ground rent for the first 10 years — enabling transition to urban vending and service livelihoods without displacement from their home village.	*Right to Livelihood (Art. 21, Constitution of India); Odisha RERA; LPS Consent Framework*
Gender-Equitable Land Titles	All reconstituted "Final Plot" titles are registered jointly in the names of both the male and female head of household as a mandatory condition of title issuance. This provision directly addresses the historical gender gap in peri-urban land ownership, ensuring that women capture an equal share of the land value premium created by public infrastructure.	*Odisha Land Pooling Rules 2015; National Land Rights Policy; Odisha Women's Policy 2022*
Accessible Dispute Resolution	A Peri-Urban Land Tribunal (PULT) sitting at the Mouza level, with proceedings conducted in Odia language and translation facilities for Gondi and Sambalpuri speakers, resolves all LPS valuation and title disputes within a mandatory 90-day window. Legal aid provided to landowners with holdings below 1 acre.	*Access to Justice Framework; Land Acquisition Act 2013 (dispute resolution precedent); Legal Services Authorities Act*
Agricultural Transition Support	Farming households who have depended on the converted agricultural land for >10 years receive a "Transition Livelihood Package": one-time grant (₹50,000), access to BDA-run vocational training in construction, hospitality, or retail management, and priority allocation in the Farmer Vending Zone. This avoids the trauma of abrupt livelihood loss that has generated social resistance to LPS implementation in other states.	*Odisha Livelihood Mission; MoRD Skill Development Scheme; PMAY-Urban Skills Component*

Anti-Speculation Lock-In	Final Plots cannot be sold, mortgaged, or leased to any party outside the original landowner family for a period of 7 years from title issuance. This prevents speculative "plot-flipping" by external investors who did not bear the social cost of the LPS transition, and ensures that the original community holds its land through the period of maximum value appreciation.	*Odisha Land Pooling Rules 2015, Section 22; Transfer of Property Act (restriction mechanism); BDA LPS Conditions*

Table 5.13: Equity and Inclusivity Safeguards — Six-Dimension Framework for the LPS Pilot Programme (Source: Author; Odisha LP Rules 2015; National Housing Policy; Constitution of India)

5.11 Policy Recommendations for BDA and Government of Odisha

The proposals synthesized in this chapter are technically implementable within the existing legislative and institutional framework of Odisha. The Odisha Land Pooling Rules (2015), the BDA Act, the Comprehensive Development Plan 2040, and the Odisha Housing Policy (2024) collectively provide the necessary statutory authority. No new central legislation is required. What is required is institutional will, institutional coordination, and a commitment to the self-financing mechanism demonstrated in Section 5.9. The following policy recommendations are addressed directly to BDA, the Department of Housing and Urban Development (HUD), and the Government of Odisha:

#	RECOMMENDATION	DETAIL AND RATIONALE	IMPLEMENTING BODY
1	**Mandatory LPS Adoption for All Peri-Urban Expansions**	Make Land Pooling the mandatory instrument for all new residential, commercial, or mixed-use developments exceeding 50 hectares within the CRRR influence zone, replacing the current ad-hoc developer-led plotting	*BDA; Dept. of HUD, Govt. of Odisha*

		schemes that generate "gated sprawl." Amend the BDA Act to allow BDA to reject building permissions in areas where LPS notification is pending.	
2	**Betterment Levy on CRRR Interchange Plots**	Implement a "Betterment Levy" of 10–15% of the registered transaction value on all land sales within 500m of CRRR interchanges, mandatorily hypothecated to the Peri-Urban Infrastructure Fund. This directly captures the "windfall gain" from public Ring Road infrastructure investment for the communities that need it.	*BDA; Revenue Dept.; Odisha State Tax Board*
3	**Establish the Peri-Urban Management Cell (PUMC)**	Create a statutory Peri-Urban Management Cell under BDA with dedicated representatives from BMC, BDA, the 22 affected Gram Panchayats, and the Water and Power Departments. Grant the PUMC authority to issue and enforce building permissions in notified LPS Mouzas, overriding Gram Panchayat permissions that violate the LPS layout plan.	*BDA (lead agency); BMC; Dept. of Panchayati Raj; Khurda District Collector*

4	**Launch a Formal TDR Market for Bhubaneswar**	Establish a Transferable Development Rights (TDR) registry and trading platform enabling landowners in Zone E (Ecological Buffer) and Zone H (Heritage) to monetize their unused FAR by selling TDR certificates to developers in Zone T (TOD). Revenue from the TDR market will fund the ecological management of the Daya River Green Buffer.	*BDA; Dept. of HUD; Odisha RERA; Heritage Conservation Authority*
5	**5-Year Moratorium on Non-LPS Plotting Approvals**	A 5-year moratorium on Gram Panchayat-issued building permissions in all LPS pilot Mouza clusters — redirecting development demand into the LPS framework and preventing the pre-emption of planned road ROW by informal construction. The moratorium applies only within formally notified LPS boundaries.	*Dept. of Panchayati Raj; BDA; Khurda District Collector*
6	**Unlock PMAY-Urban Funding for LPS EWS Component**	Negotiate with PMAY-Urban (MoHUA) for the classification of LPS EWS housing units as eligible PMAY-Urban beneficiary units, unlocking ₹1.5 Lakh per unit central assistance for the 15% EWS component of	*Dept. of HUD, Govt. of Odisha; BDA; MoHUA (Central)*

		each LPS sector. This reduces the BDA subsidy burden and makes the EWS commitment financially sustainable.	
7	**Establish the Peri-Urban Land Tribunal (PULT)**	Constitute a permanent, accessible Peri-Urban Land Tribunal with Odia-language proceedings and mandatory 90-day resolution timeline for all LPS valuation and title disputes. The PULT must include at least one female judicial member. Legal aid made available to all landowners with holdings below 1 acre. Published decision database accessible online.	*Dept. of Law, Govt. of Odisha; BDA; Odisha Legal Services Authority*
8	**Integrate CRRR Transit with Metropolitan BRT Framework**	Formally designate the 9 proposed TOD corridors along the CRRR as BRT-standard corridors in the Bhubaneswar Metropolitan Mobility Plan; allocate dedicated right-of-way within CRRR interchanges for BRT terminal facilities; commit Metro/BRT feeder operations to PUIF revenue stream.	*Mo Road Transport, GoI; Odisha Transport Dept.; BDA; BSCL*

Table 5.14: Policy Recommendations — Eight Actionable Mandates for BDA and Government of Odisha (Source: Author; Odisha LP Rules 2015; MoHUA Guidelines; Odisha State Policy Framework)

5.12 Chapter Synthesis: The Planning Compact and the Intervention Window

The five strategic interventions proposed in this chapter constitute a planning compact — an integrated package of spatial decisions, institutional commitments, financial mechanisms, and policy mandates that are individually feasible and mutually reinforcing. No single intervention is sufficient without the others: the polycentric framework requires the LPS to create the structured land parcels for its hubs; the LPS requires the infrastructure proposals to make Final Plots genuinely valuable; the infrastructure proposals require the financial model to fund themselves; the financial model requires the policy framework to authorize and protect the Land Value Capture mechanism; and the equity safeguards are what make the entire compact politically and socially sustainable.

5.12.1 The Intervention Window: A Closing Opportunity

The CA-Markov predictive model from Chapter 4 identifies a critical and quantified intervention window that structures the urgency of this entire proposal. Under the "Do-Nothing" scenario, the remaining 38% of agricultural land in Zone B (Tamando–Patrapada–Sundarpada) — the only land available for planned reconstitution — will be informally subdivided and partially built upon before 2030. After that threshold, the cost of retrospective LPS implementation (compensating buildings that have been constructed on future road ROW, purchasing encroached open space land at urban prices) rises by an estimated 400% relative to proactive LPS implementation before construction begins.

This is not a hypothetical projection — it is the documented experience of the Hyderabad ORR corridor, the Chennai peripheral ring road zone, and the Pune PCMC expansion, all of which delayed Land Pooling implementation until after significant informal development had occurred, at vastly higher cost and with substantially reduced equity outcomes for original landowners. Bhubaneswar has a narrower window than any of these precedents — approximately 48 months from 2025 — but it still has a window. The proposals in this chapter are calibrated to that window.

5.12.2 The Key Performance Indicators (2035 Targets)

KEY PERFORMANCE INDICATOR	2025 BASELINE	2035 TARGET	IMPROVEMENT
Number of LPS Mouzas Reconstituted	0	22+	From zero to full pilot network operational
Piped Water Coverage — Peri-Urban Fringe	26% (35 LPCD)	**95% (120 LPCD)**	From 74% deficit to near-standard provision
Sewerage Connection Rate — Fringe	0% (100% septic)	**80% (piped to STP)**	100% sewerage gap eliminated in LPS zones
Roads Widened to 9m+ (capillary)	3% of peri-urban roads	**85% of LPS zone roads**	28× increase in emergency-accessible roads
PHC Distance (fringe average)	8.5 km average	**<2.5 km average**	Meets URDPFI standard; 70% reduction in distance
Public Open Space — Fringe	<0.8 m²/capita	**9.5 m²/capita**	Near-standard provision from near-zero baseline
Commute Distance — Average	12–15 km to core	**<6 km to nearest hub**	Polycentric redistribution of employment/services
EWS Housing Units Delivered in Fringe	~200 (informal)	**12,000+**	60× increase through LPS mandatory reservation
Agricultural Land Lost to Sprawl (annual)	7.8 sq.km/year	**<2.0 sq.km/year**	75% reduction in unmanaged agricultural conversion
Peri-Urban Infrastructure Fund Corpus	₹0 (not yet seeded)	**₹1,639 Crores**	Fully self-funded from LPS surplus; no state subsidy

Land Value Capture (public share)	₹0 (windfall to private)	**₹750 Cr+ (BDA)**	Public institution captures 40% of infrastructure windfall
Gender-Equitable Land Titles Issued	Near-zero in fringe	**22,000+ joint titles**	First large-scale joint-titling programme in Odisha

Table 5.15: Key Performance Indicators — 2025 Baseline vs. 2035 Targets for the LPS and Polycentric Planning Framework (Source: Author; Chapter 4 Data; CDP 2040 Targets)

The Planning Compact: Why These Five Interventions Must Proceed Together

The Polycentric Framework decentralizes the economic pressure that drives uncontrolled peripheral growth. The Land Pooling Scheme creates the spatial and financial infrastructure that makes managed growth possible. The Residential Zone Proposals give structure to housing demand that would otherwise materialize as plotted sprawl. The Infrastructure and Resilience Proposals ensure that the water, road, and ecological crises are addressed proactively rather than managed retrospectively at four times the cost. The Zoning and DCR Framework ensures that the density enabled by the LPS is channelled into livable, walkable, mixed-use environments rather than anonymous residential blocks. The Financial Model demonstrates that the entire programme pays for itself — and generates a ₹1,639 Crore cumulative surplus — from the land value it creates. Remove any one of these five elements and the entire compact fails. Taken together, they constitute the most comprehensive and implementable framework for peri-urban planning along an Indian ring road yet proposed in the academic literature.

The time for proactive planning is not after the window closes — it is now. Phase I must begin in 2025. The LPS notifications must be issued before Bhubaneswar's peri-urban future is built by the market, without a plan, and at a cost that no subsequent planning intervention can fully repair. Bhubaneswar has the legislative tools (Odisha LP Rules, 2015), the institutional framework (BDA, CDP 2040), and — as demonstrated in Section 5.9 — the financial model to fund the transition without dependency on the state capital budget. What remains is the political will to implement it, and the institutional courage to designate the Peri-Urban Management Cell with the authority it needs to do so.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary of Key Findings

This thesis set out to investigate a central planning challenge confronting Bhubaneswar: the rapid, unregulated, and infrastructure-deficient expansion of the city's peri-urban fringe in the context of the proposed 111 km Capital Region Ring Road. Through a rigorous multi-phase methodology combining spatio-temporal LULC analysis, CA-Markov predictive modeling, infrastructure gap assessment, service accessibility mapping, environmental vulnerability analysis, and Land Pooling Scheme design, the research has produced a comprehensive and evidence-grounded diagnostic and prescriptive account of Bhubaneswar's peri-urban growth crisis.

The principal findings may be summarised as follows. Between 2010 and 2025, the built-up footprint of the Bhubaneswar Development Authority (BDA) region expanded by 89.7%, with the Sprawl Index rising from 1.82 to 2.34 — confirming that growth has become progressively more fragmented, dispersed, and costly to service. Agricultural land declined by 51.7%, largely through informal conversion processes outside the reach of statutory planning control. Three distinct Growth Heat Zones were identified along the Ring Road corridor: the Knowledge Corridor on the northern fringe, the Residential Surge Zone on the south-western fringe (the primary study area, recording a growth rate of 145%), and the Industrial/Logistics Node on the southern fringe.

The infrastructure deficit analysis revealed conditions of acute service deprivation across the peri-urban interface: piped water supply coverage stood at 35 LPCD against a standard of 135 LPCD; sewerage connectivity was effectively zero; stormwater drainage coverage was 90% below the required standard; and 82% of peri-urban roads were dead-ends or unpaved lanes incapable of carrying emergency vehicles. The environmental assessment identified critical floodplain encroachment along the Daya River corridor, groundwater depletion at 1.2 metres per year, and the systematic destruction of natural drainage channels. The governance analysis revealed a 'planning vacuum' generated by the unresolved jurisdictional fragmentation between the BDA, BMC, and 23 Gram Panchayats operating in the study area.

The CA-Markov 2035 'Do-Nothing' scenario projected a further 34–38% increase in built-up area concentrated within 2 km of the Ring Road alignment, confirming that in the absence of proactive intervention, the structural failures documented in 2025 will intensify substantially in the coming decade. The Land Pooling Scheme (LPS) proposals developed for the three growth zones demonstrate that a 40:60 reconstitution model — grounded in the Odisha Land Pooling Rules, 2015 — can simultaneously secure road rights-of-way, reserve land for public amenities, fund trunk infrastructure, prevent floodplain encroachment, and deliver a financially attractive value proposition to landowners.

6.2 Conclusions

6.2.1 The Ring Road as a Planning Instrument, Not Just a Transport Corridor

The most fundamental conclusion of this research is that the Capital Region Ring Road must not be conceived or managed solely as a transport infrastructure project. Its construction is the most consequential spatial planning event in Bhubaneswar's recent history — one that will determine the form, density, equity, and sustainability of the metropolitan region for the next fifty years. The analysis demonstrates conclusively that allowing market forces to direct peri-urban growth along the Ring Road alignment — in the absence of a concurrent, spatially integrated planning response — will produce a pattern of unserviced, environmentally vulnerable, and economically inefficient sprawl that no amount of retrospective investment can fully correct. The per-capita cost of retrofitting trunk infrastructure into an already-built-out peri-urban fringe is estimated to be three to four times higher than providing it proactively through a Land Pooling framework. The window for proactive intervention, while still open in the southern and south-western fringe, is closing rapidly. Every year of further inaction reduces the fiscal and spatial options available to planners and policymakers.

6.2.2 Land Pooling as the Appropriate Instrument

The Land Pooling Scheme emerges from this research as the most appropriate, legally grounded, and financially viable instrument for managing peri-urban growth in the Bhubaneswar Capital Region. Unlike conventional land acquisition, which alienates landowners and generates legal conflict, the LPS creates a value-sharing partnership that aligns the economic interests of the state, landowners, and future residents. The incremental land value analysis demonstrates that landowners who contribute 40% of their holdings within an LPS framework will hold reconstituted plots worth three to four times the value of their original 100% agricultural holdings by 2035 — provided that the scheme is implemented competently, transparently, and within a governance framework that inspires confidence.

The Gujarat Town Planning Scheme model and the Odisha Land Pooling Rules, 2015, together provide a robust legislative and procedural foundation for this approach. What is required is not further legislative innovation but institutional commitment, technical capacity, and the political will to deploy this instrument at the scale and pace that the growth dynamic demands.

6.2.3 The Polycentric City Vision

The thesis's spatial proposals — organizing development along the Ring Road into a series of mixed-use, transit-oriented polycentric nodes at 8–12 km intervals — represent a fundamental departure from the monocentric growth model that has characterized Bhubaneswar's expansion to date. A polycentric structure distributes economic opportunity, employment, and amenity access more equitably across the metropolitan region, reduces the traffic and congestion burden on the central city core, and enables each growth node to develop a distinct economic identity and functional specialization. The Knowledge Corridor, the Residential Surge Zone, and the Industrial/Logistics Node each have distinct comparative advantages; the LPS framework, if deployed effectively, can crystallize these advantages into planned, productive, and well-serviced urban extensions rather than allowing them to dissipate in the disorder of uncontrolled sprawl.

6.3 Recommendations

6.3.1 Immediate Actions (2025–2027)

- The Bhubaneswar Development Authority should formally declare the three identified Growth Heat Zones as ‘Land Pooling Priority Areas’ under the Odisha Land Pooling Rules, 2015, and initiate the statutory process of Mouza-level LPS preparation without delay. The south-western fringe (Zone B: Tamando–Patrapada–Sundarpada) should be the first priority, given its highest growth rate (145%), remaining land availability (38%), and severity of infrastructure deficit (IGI: 0.84).
- A moratorium on all individual building permissions within the designated LPS boundaries should be implemented pending scheme preparation and notification. Gram Panchayats operating within these boundaries should be instructed to refer all building applications to the BDA for joint review.
- The BDA should commission detailed cadastral surveys and Mouza-level land ownership records for all three Growth Heat Zones as a prerequisite for LPS preparation. Transparent, publicly accessible databases of land ownership, encumbrance, and occupancy should be established.
- Emergency measures to prevent further floodplain encroachment along the Daya River corridor should be implemented immediately, including the demarcation and legal notification of a 100-metre no-construction buffer zone along both banks.

6.3.2 Medium-Term Actions (2027–2030)

- A Peri-Urban Planning Authority (PUPA) should be established as a dedicated statutory body with unified planning, development control, and infrastructure delivery jurisdiction over the Ring Road influence corridor. PUPA should have representation from BDA, BMC, OSDMA, the Housing Department, and elected Panchayati Raj representatives.
- The three LPS layouts should be formally notified, landowner consultations conducted, and the 70% consent threshold achieved through transparent

community engagement, using the incremental value analysis as the primary persuasion instrument for owner participation.

- Transit-Oriented Development (TOD) node plans should be prepared for each polycentric hub location along the Ring Road, specifying mixed-use zoning envelopes, FAR incentives for affordable housing, public space standards, and feeder transit connectivity requirements.
- A metropolitan-level Stormwater Master Plan should be prepared to restore the natural Naya drainage network, establish storm water retention zones along the Daya River floodplain, and specify drainage standards for all new development within the LPS areas.

6.3.3 Long-Term Recommendations (2030–2035 and Beyond)

- The polycentric urban structure for the Bhubaneswar Capital Region should be formally embedded in the next revision of the Comprehensive Development Plan (CDP), planned for 2040, with statutory land use designations, FAR schedules, and infrastructure provision standards specified for each Ring Road node.
- A Land Value Capture Fund should be established to receive and reinvest the public value generated by the LPS process, financing subsequent phases of trunk infrastructure, public transit, and social amenity provision across the metropolitan region.
- Environmental monitoring protocols should be established for groundwater levels, floodplain extent, vegetation cover, and urban heat island intensity in the peri-urban study area, enabling evidence-based adaptive management of the LPS implementation process.
- The governance and fiscal model demonstrated in Bhubaneswar should be evaluated for replication in other rapidly growing Odisha cities — including Cuttack, Berhampur, and Rourkela — where similar peri-urban challenges are emerging at a smaller scale but with comparable urgency.

6.4 Scope for Further Research

This thesis has established the analytical and prescriptive foundation for peri-urban growth management in the Bhubaneswar Capital Region. Several areas merit deeper investigation in subsequent research. First, a detailed financial and economic modelling exercise should be conducted to determine the optimal LPS plot reconstitution ratios under different growth-rate and land-value scenarios, enabling dynamic adjustment of the scheme parameters as market conditions evolve. Second, a comparative study of the social outcomes of LPS implementation in Gujarat — specifically, the distributional effects of value capture on low-income and small-holding farming families — should inform the equity safeguards embedded in the Odisha framework. Third, the CA-Markov model used in this thesis, while robust, relies on historical trend extrapolation; a deeper agent-based modeling exercise that incorporates behavioral responses to LPS implementation could produce more nuanced growth projections. Finally, longitudinal post-implementation assessment of the first notified LPS in Bhubaneswar will be essential to evaluate whether the value-sharing outcomes projected in this thesis are realized in practice, and to identify corrective adjustments for subsequent schemes.

In conclusion, this thesis offers both a diagnosis and a prescription. The diagnosis is clear: the Bhubaneswar Capital Region's peri-urban fringe is in a state of accelerating, unmanaged, and environmentally and institutionally precarious growth. The prescription is equally clear: a proactively deployed, LPS-anchored, polycentric planning framework, operationalized through reformed governance and sustained political commitment, can transform this crisis into an opportunity — an opportunity to build, for the next generation of Bhubaneswar's residents, a metropolitan region that is not merely larger, but genuinely more equitable, more resilient, and more liveable.

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