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Integrating Urban Agriculture into City Planning for Enhancing Urban Community Food Provision: A Case Study of Bhubaneshwar

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Abstract: ***Rapid urbanization in Global South cities has intensified pressure on urban food systems, resulting in increasing dependence on long-distance food supply chains, fragmented distribution networks, and declining spatial integration of food production within urban planning frameworks. Despite growing recognition of urban agriculture as a Nature-Based Solution (NBS) capable of strengthening food resilience, its integration within statutory planning systems remains limited in rapidly urbanizing Indian cities. This study examines the spatial, institutional, and planning feasibility of integrating urban agriculture into the urban planning structure of Bhubaneswar, India. The research adopts a mixed-method planning framework combining spatial interpretation, policy analysis, household surveys, vendor assessments, peri-urban farmer surveys, institutional surveys, and stakeholder consultations. The analytical framework evaluates urban land availability, rooftop feasibility, food accessibility, supply-chain dependency, institutional readiness, and decentralized food-production potential across the Bhubaneswar Municipal Corporation (BMC) area. The findings reveal that nearly 80% of surveyed households possess rooftops, balconies, or backyard spaces suitable for decentralized food production, while approximately 70% demonstrate high willingness toward urban farming adoption despite limited existing practice (35%). Vendor assessments indicate strong dependence on peri-urban and external food inflows ranging between 10–50 km, contributing to seasonal price instability (80–90%) and food wastage (10–25%). Institutional surveys further demonstrate substantial implementation potential, with 56% of institutions possessing usable open land and 67% demonstrating rooftop suitability for urban agriculture integration. Spatial analysis identifies institutional corridors, peri-urban interfaces, waterbody edges, mixed-use wards, and transportation corridors as high-potential urban agriculture intervention zones The study proposes a planning-oriented framework integrating urban agriculture into zoning regulations, master plans, decentralized food infrastructure systems, and urban resilience strategies through interventions such as rooftop farming, edible campuses, community nutrition gardens, aquaponics, vertical farming systems, decentralized food hubs, and farmer-to-city supply networks. The framework contributes toward strengthening urban food resilience, reducing food miles, improving food accessibility, enhancing socio-ecological sustainability, and promoting climate-responsive urban development within rapidly urbanizing cities.***

Keywords: Urban Agriculture; Urban Food Systems; Food Resilience; Spatial Planning; Nature-Based Solutions; Bhubaneswar; Sustainable Urban Development.

I. INTRODUCTION

The increasing complexity of urban food systems within rapidly urbanizing cities has generated growing concern regarding food accessibility, supply-chain resilience, environmental sustainability, and spatial planning integration. Contemporary urban development patterns have significantly widened the disconnect between food production and urban consumption, resulting in increased dependence on centralized and externally driven food systems. In response to these challenges, urban agriculture has emerged as an important planning and resilience strategy capable of integrating decentralized food production within urban environments. The following sections discuss the emerging vulnerabilities of urban food systems, the role of urban agriculture within sustainable and resilient planning frameworks, the existing planning gaps within the Indian urban context, and the research gaps that necessitate the present study.

A. Urbanization and Emerging Urban Food Vulnerabilities

Rapid urbanization across Global South cities has significantly transformed urban food systems, increasing

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dependence on long-distance supply chains, centralized wholesale markets, and externally dependent food distribution structures. As urban populations continue to expand, the spatial disconnect between food production and food consumption has widened, creating growing concerns regarding food accessibility, affordability, environmental sustainability, and urban resilience. In many Indian cities, food commodities frequently travel more than 500–1500 km before reaching urban consumers, making urban food systems increasingly vulnerable to climate disruptions, transportation inefficiencies, fuel-price volatility, and supply-chain fragmentation.

Simultaneously, conventional urban planning frameworks continue to prioritize residential expansion, transportation infrastructure, commercial development, and real-estate growth while largely neglecting food systems within statutory land-use planning and development regulations. Consequently, food production remains spatially disconnected from urban development processes despite increasing pressure on food accessibility and nutritional security within rapidly urbanizing metropolitan regions.

B. Urban Agriculture as a Planning and Resilience Strategy

Urban agriculture has increasingly emerged as a Nature-Based Solution (NBS) and circular urban metabolism strategy capable of integrating food production, ecological systems, waste recycling, water management, and localized economies within urban environments. The productive utilization of rooftops, vacant lands, institutional campuses, peri-urban interfaces, transportation corridors, and community spaces offers substantial opportunities for strengthening decentralized food systems and improving urban resilience.

C. Indian Urban Context and Planning Gaps

Despite growing global recognition, urban agriculture in Indian cities remains fragmented, informal, and weakly institutionalized within planning systems. Most master plans, zoning regulations, and urban development policies inadequately recognize food systems as a formal planning component. Indian cities allocate less than 5% of urban land for food-related activities, reflecting a significant planning blind spot within contemporary urban development practices.Bhubaneswar represents a critical case within this context. As one of India's rapidly expanding planned capital cities and a Smart City Mission participant, Bhubaneswar demonstrates strong institutional growth, expanding transportation infrastructure, and increasing peri-urban transformation. However, the city's food system remains highly dependent on external and peri-urban supply networks originating from Balianta, Pipili, Jatni, Khordha, and surrounding agricultural belts.Although Bhubaneswar possesses substantial potential for decentralized food production through rooftops, institutional lands, peri-urban interfaces, waterbody corridors, and underutilized urban spaces, urban agriculture remains largely absent from formal planning structures, zoning systems, and resilience frameworks.

D. Research Gap

Existing literature extensively discusses urban agriculture in relation to food security, community participation, and environmental sustainability. However, limited research examines the spatial integration of urban agriculture within statutory planning systems in rapidly urbanizing Indian cities. Furthermore, insufficient attention has been given to:

- ward-level urban agriculture suitability,
- peri-urban food-system linkages,
- institutional readiness for urban farming,
- decentralized food infrastructure planning,
- and integration of food systems into urban planning frameworks.

Therefore, a substantial gap exists in developing planning-oriented frameworks capable of integrating urban agriculture into formal urban spatial planning systems within Global South cities.

E. Aim and Objectives

The study aims to evaluate the role of urban agriculture in strengthening decentralized urban food systems and integrating food-production landscapes into the spatial planning structure of Bhubaneswar.

The objectives include:

- To examine the existing urban food system structure and food supply dependencies within Bhubaneswar.
- To assess spatial and institutional feasibility for integrating urban agriculture within urban planning systems.
- To analyze household willingness, food accessibility conditions, peri-urban supply linkages, and implementation barriers.
- To develop a planning-oriented framework for integrating urban agriculture into urban resilience and spatial planning strategies.

II. LITERATURE REVIEW

The literature on urban agriculture increasingly emphasizes its role in strengthening urban food security, environmental sustainability, socio-ecological resilience, and decentralized urban systems within rapidly urbanizing cities. Contemporary research recognizes urban agriculture not merely as a food-production activity, but as an integrated planning approach capable of linking food systems, ecological infrastructure, community participation, and climate-responsive urban development. Existing studies explore multiple dimensions of urban agriculture, including food urbanism, productive landscapes, circular urban metabolism, community-based food systems, and Nature-Based Solutions (NBS), highlighting its growing significance within sustainable urban planning discourse. However, despite substantial global research on urban agriculture, limited studies examine its integration within formal spatial planning frameworks, particularly in rapidly urbanizing Indian cities where food systems remain weakly embedded within statutory planning structures.

A. Urban Agriculture and Urban Food Systems

Urban agriculture has increasingly emerged as a critical component of sustainable urban development, particularly within rapidly urbanizing cities experiencing growing pressure on food systems, land resources, and ecological infrastructure. Mougeot defines urban agriculture as the production, processing, and distribution of food within and around urban areas using urban resources such as land, water, labor, and organic waste. Contemporary literature further expands this understanding by positioning urban agriculture not merely as a food-production activity, but as a multidimensional spatial planning mechanism capable of strengthening urban resilience, decentralized food systems, and socio-ecological sustainability.

The increasing complexity of urban food systems has intensified scholarly interest in food urbanism, productive landscapes, and resilient food infrastructures. Urban food systems are now understood as interconnected spatial networks involving production, transportation, storage, distribution, consumption, and waste management operating across urban and peri-urban territories. In rapidly urbanizing regions, the widening spatial disconnect between food production zones and urban consumption centers has increased dependence on centralized wholesale markets and long-distance food transportation systems. Such dependency exposes cities to climate disruptions, transportation inefficiencies, fuel-price volatility, and supply-chain instability. Consequently, decentralized urban agriculture systems are increasingly viewed as essential mechanisms for strengthening local food accessibility, reducing food miles, and improving urban resilience.

B. Conceptual Dimensions of Urban Agriculture

Urban agriculture is closely associated with the broader framework of food urbanism, which conceptualizes food systems as an integral component of urban spatial structure and everyday urban life. The framework argues that food production, food accessibility, and food distribution should be embedded within urban planning systems rather than treated as peripheral agricultural functions. Food urbanism emphasizes neighborhood-scale food systems, community participation, productive landscapes, and decentralized food accessibility, thereby strengthening localized resilience and social infrastructure within cities.

The concept of circular urban metabolism further strengthens the relevance of urban agriculture within contemporary planning discourse. Circular urban metabolism examines cities as interconnected systems of resource flows involving food, water, waste, energy, and ecological processes. Urban agriculture contributes toward circularity by integrating composting systems, reducing transportation energy consumption, promoting localized food production, and improving resource efficiency within urban environments. Rooftop farming, aquaponics, edible landscapes, and productive green infrastructure collectively contribute toward low-carbon urban development and climate-responsive planning approaches.

TABLE 1
CONCEPTUAL LITERATURE (RELEVANT THEORIES, CONCEPTS AND MODELS)

Planning Concept	**Planning Perspective**	**Relevance to Urban Food Systems**
Urban Agriculture	Integration of food production within urban environments	Enhances food accessibility and strengthens local food supply chains
Food Urbanism	Urban agriculture as a strategy for social mobility and community development	Demonstrates role of food production in strengthening social networks and livelihoods

Post-Industrial Urban Agriculture	Reimagining food production within post-industrial urban landscapes	Supports decentralized and resilient urban food systems
Urban Gardens as Social Infrastructure	Community gardens functioning as civic and social spaces	Strengthens community participation and urban resilience
Urban Food Systems Planning	Integration of urban agriculture into municipal planning policies	Enhances environmental quality and local food production
Urban Farming in Built Environments	Embedding urban farming within architectural and urban design frameworks	Supports sustainable urban development and food accessibility

Simultaneously, urban agriculture is increasingly recognized as a Nature-Based Solution (NBS) capable of enhancing socio-ecological resilience within cities. Nature-Based Solutions utilize ecological systems and natural processes to address urban challenges associated with climate adaptation, environmental degradation, biodiversity decline, and food insecurity. Existing studies demonstrate that urban agriculture contributes toward microclimatic regulation, biodiversity enhancement, stormwater management, urban heat mitigation, and improved environmental quality. Community gardens and neighborhood food systems additionally strengthen social cohesion, civic participation, and adaptive capacity within vulnerable urban communities.

C. International Experiences in Urban Agriculture Integration

Several international cities demonstrate successful integration of urban agriculture within formal planning systems through policy support, land allocation mechanisms, and community-based governance frameworks. Havana, Cuba, represents one of the most significant examples of large-scale urban agriculture integration. Following economic disruptions and food shortages during the 1990s, Havana adopted decentralized community farming systems supported through institutional land allocation, local food distribution systems, and neighborhood participation. These interventions significantly improved local food production, employment generation, and food resilience within the city.

European cities such as Bologna, Milan, Turin, and Rome have similarly integrated urban agriculture into planning frameworks through urban gardening policies, productive landscape strategies, and zoning provisions. Forte (2021) demonstrates that municipal-level planning integration plays an important role in institutionalizing food systems within urban development strategies. Research conducted across cities such as Oakland, Detroit, and New York further illustrates how community-driven urban agriculture movements can influence urban governance and food justice planning. Roberts (2023) emphasizes that grassroots food initiatives strengthen localized food systems while simultaneously shaping broader planning agendas and governance structures.

Within the Indian context, rooftop farming initiatives in Hyderabad demonstrate the productive utilization of underused rooftops and residential spaces for decentralized food production. These initiatives reveal substantial opportunities for integrating compact farming systems within dense urban environments where land availability remains constrained. Such international and national experiences collectively indicate that urban agriculture can function as an effective planning instrument when supported through institutional frameworks, policy integration, and spatial planning mechanisms.

D. Urban Agriculture in the Indian Planning Context

Despite increasing global recognition, urban agriculture within Indian cities largely remains fragmented, informal, and weakly institutionalized within planning systems. Existing master plans and land-use regulations continue to prioritize residential expansion, transportation infrastructure, commercial development, and industrial growth while inadequately incorporating food systems into urban spatial planning structures. Consequently, food production remains spatially disconnected from urban development despite increasing pressure on food accessibility and nutritional security.

Several structural barriers constrain urban agriculture integration within Indian cities, including the absence of dedicated zoning provisions, fragmented governance systems, limited institutional coordination, weak policy frameworks, and inadequate implementation mechanisms. However, Indian cities simultaneously possess strong opportunities for decentralized food production due to extensive rooftop availability, peri-urban agricultural interfaces, mixed land-use structures, and strong informal food networks. Rapidly urbanizing Smart Cities such as Bhubaneswar therefore provide significant opportunities for integrating urban agriculture within resilience-oriented and climate-responsive planning frameworks.

E. Research Gap

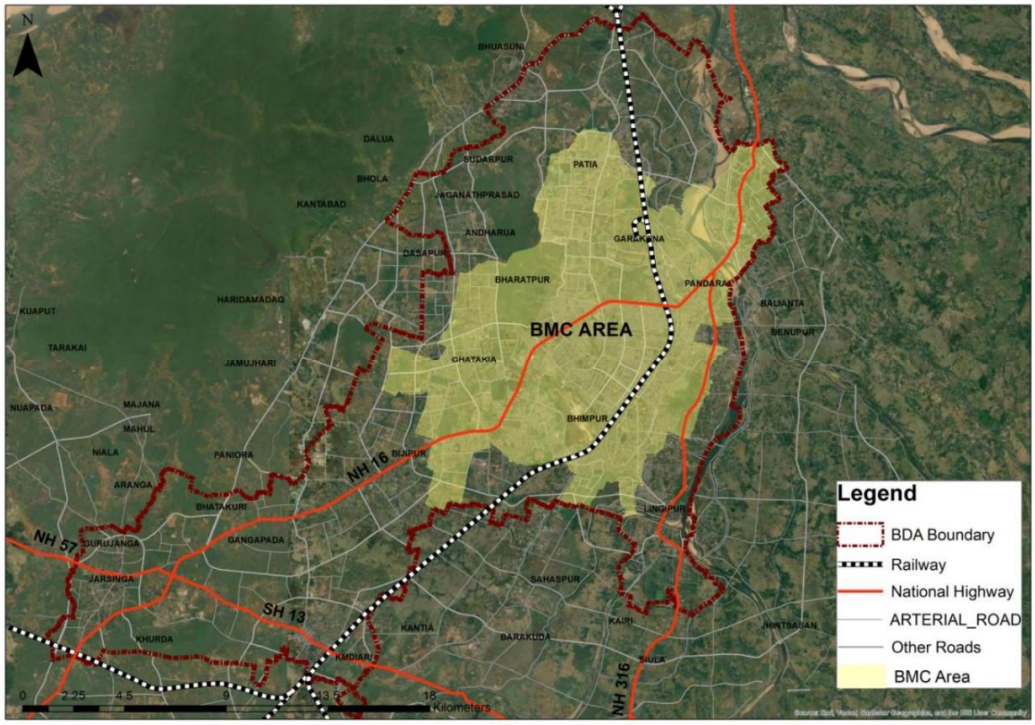
The literature review indicates that existing studies primarily focus on the environmental, social, and food-security dimensions of urban agriculture. While substantial research discusses community gardening, localized food production, and environmental sustainability, limited attention has been given to the spatial integration of urban agriculture within statutory planning systems in rapidly urbanizing Indian cities. Existing research inadequately addresses ward-level spatial suitability assessment, institutional implementation readiness, peri-urban food-system linkages, and decentralized food infrastructure planning within formal urban planning frameworks.

Furthermore, insufficient research examines urban agriculture as a spatial planning instrument capable of strengthening climate resilience, circular urban metabolism, and decentralized food systems within Global South urban contexts. Therefore, a significant research gap exists concerning the development of planning-oriented frameworks capable of integrating urban agriculture into formal urban spatial planning systems. The present study attempts to bridge this gap by examining the spatial, institutional, and planning feasibility of integrating urban agriculture into the planning structure of Bhubaneswar through spatial assessment, food-system analysis, and resilience-oriented planning strategies.

III. STUDY AREA PROFILE

Bhubaneswar, the capital city of Odisha, represents one of the fastest-growing planned urban centers in eastern India and functions as an important administrative, institutional, educational, and emerging economic hub. The city falls under the jurisdiction of the Bhubaneswar Municipal Corporation (BMC) and forms part of the broader Bhubaneswar Development Authority (BDA) planning region. Geographically, the city is strategically positioned within the coastal urban corridor of Odisha and demonstrates rapid urban expansion driven by institutional growth, infrastructure development, real-estate transformation, and increasing migration.

The city possesses a relatively organized urban structure characterized by planned road networks, institutional corridors, residential sectors, commercial districts, and expanding peri-urban interfaces. Bhubaneswar has experienced substantial demographic growth over the past two decades, with the population increasing from approximately 0.84 million in 2011 to an estimated metropolitan population exceeding 1.1–1.2 million at present. Such rapid urbanization has intensified pressure on land resources, infrastructure systems, ecological assets, transportation networks, and urban food supply systems.



Map 1 Bhubaneswar showing BMC Area within the Bhubaneswar Development Authority (BDA) Planning Region, Source: Author

The spatial structure of Bhubaneswar demonstrates a strong dependency on peri-urban and regional agricultural systems for daily food supply. Peri-urban agricultural belts such as Balianta, Jatni, Pipili, Khordha fringe settlements, and adjoining rural production zones contribute significantly toward the city's vegetable and food supply network. The urban food system therefore functions through a core–periphery structure where the BMC area primarily operates as a consumption zone dependent on external and peri-urban inflows. Major transportation corridors including NH-16 and NH-316 serve as critical food distribution routes connecting agricultural hinterlands with urban markets and wholesale distribution centers such as Baramunda Market.

TABLE 2
CITY PROFILE

Parameter	Details (Source: BDA)
City Name	Bhubaneswar
Population	837,737 (Census 2011); part of a metropolitan region of around 1.1 million people
Administrative Authority	Bhubaneswar Municipal Corporation and planning by Bhubaneswar Development Authority
Key Characteristics	Capital city of Odisha; known as the "Temple City of India"; planned urban layout with organized road network; major educational and IT hub; strong cultural and heritage significance
Relevance of Study Area	Represents a rapidly developing capital city balancing heritage conservation and modern urban development, making it important for studying sustainable urban growth, infrastructure planning, and mobility systems.

Despite possessing strong institutional infrastructure and planned urban development characteristics under the Smart City Mission, food production remains weakly integrated within the city's formal planning structure. Existing planning frameworks largely prioritize residential, transportation, commercial, and infrastructure development while providing limited recognition to food systems within statutory land-use planning and development regulations. Simultaneously, the city demonstrates substantial potential for decentralized food production due to the availability of rooftops, institutional campuses, vacant lands, peri-urban interfaces, transportation corridors, and waterbody influence zones.The study therefore considers Bhubaneswar as an important representative case for examining the integration of urban agriculture within rapidly urbanizing Indian cities. The city's combination of planned urban form, expanding peri-urban transformation, institutional concentration, ecological resources, and growing food-system dependency provides an appropriate context for evaluating the spatial and institutional feasibility of integrating urban agriculture into formal urban planning systems.

IV. METHODOLOGY

The study adopts a mixed-method planning approach integrating spatial interpretation, primary surveys, secondary data assessment, stakeholder consultation, and policy analysis to examine the feasibility of integrating urban agriculture within the planning structure of Bhubaneswar. The methodological framework was designed to evaluate the spatial, social, institutional, and infrastructural dimensions of urban food systems while identifying opportunities for decentralized food-production integration within the Bhubaneswar Municipal Corporation (BMC) area. The methodology was structured into four major phases comprising problem identification, data collection, analytical assessment, and proposal formulation. The initial phase involved an extensive review of literature related to urban agriculture, food urbanism, resilient food systems, circular urban metabolism, Nature-Based Solutions (NBS), and urban planning integration. This phase assisted in identifying key analytical parameters associated with food accessibility, urban land availability, community participation, environmental sustainability, decentralized food systems, and planning integration.

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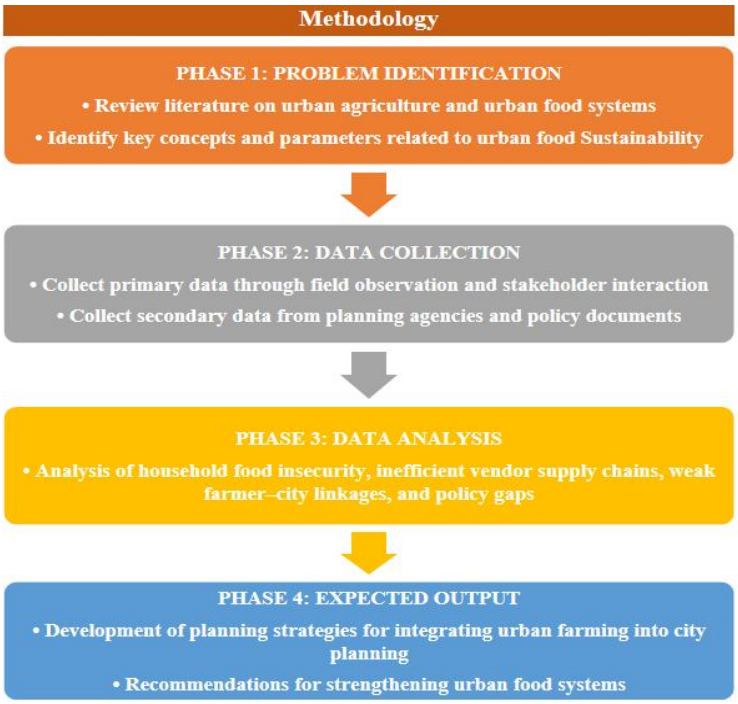


Figure 1 Research Methodology

The second phase focused on primary and secondary data collection. Primary surveys were conducted across different stakeholder groups to capture household-level food accessibility conditions, spatial feasibility for urban farming, supply-chain dependency, institutional readiness, and implementation barriers. Household surveys comprising 110 samples were conducted to assess food expenditure patterns, availability of rooftop and backyard spaces, willingness toward urban agriculture adoption, and major constraints affecting implementation. Slum household surveys were additionally conducted to evaluate food insecurity, affordability concerns, nutritional accessibility, and potential for community-based food systems within vulnerable settlements.

Vendor surveys were undertaken to examine supply-chain characteristics, food inflow distances, storage limitations, price fluctuations, and transportation dependency within the urban food system. Peri-urban farmer surveys focused on understanding production patterns, irrigation dependency, market linkage structures, intermediary dependence, and the relationship between peri-urban agriculture and urban food supply systems. Institutional surveys and key informant interviews were conducted across schools, offices, colleges, planning agencies, and administrative institutions to assess open-land availability, rooftop suitability, policy integration potential, and institutional willingness for urban agriculture implementation.

Secondary data were collected from Bhubaneswar Development Authority (BDA) documents, Odisha Agriculture Statistics 2023–24, Census of India records, Smart City Mission reports, transport datasets, land-use maps, planning policies, and urban development reports. These datasets supported the analysis of agricultural dependency, transportation connectivity, land-use distribution, peri-urban interfaces, and urban food-system structure within Bhubaneswar.

The analytical phase integrated both spatial and non-spatial interpretation techniques. Spatial assessment focused on identifying rooftops, institutional lands, vacant parcels, transportation corridors, peri-urban interfaces, waterbody influence zones, and mixed-use wards suitable for urban agriculture interventions. Simultaneously, survey findings were analyzed to evaluate food accessibility, household readiness, implementation barriers, supply-chain inefficiencies, and decentralized food-production potential. Planning interpretations were derived through comparative assessment of stakeholder responses, food-system dependencies, and spatial suitability conditions.

The final phase involved the formulation of planning proposals and an integrated urban agriculture framework for Bhubaneswar. The proposals were developed through synthesis of spatial feasibility analysis, food vulnerability assessment, institutional readiness evaluation, and peri-urban linkage interpretation. The framework emphasizes decentralized food systems, productive landscapes, peri-urban food integration, and resilience-oriented urban planning strategies capable of integrating urban agriculture within statutory planning systems and future urban development policies.

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V. URBAN FOOD SYSTEM, SPATIAL FEASIBILITY, AND PLANNING ANALYSIS

This section examines the existing urban food system structure of Bhubaneswar and evaluates the spatial, institutional, and socio-economic feasibility of integrating urban agriculture within the city's planning framework. The analysis combines household surveys, slum vulnerability assessment, vendor and peri-urban farmer surveys, institutional readiness evaluation, and spatial interpretation to understand the functioning of the current food system and identify opportunities for decentralized food-production integration. The assessment further investigates food accessibility conditions, supply-chain dependency, implementation barriers, peri-urban linkages, and land-use suitability in order to develop a planning-oriented understanding of how urban agriculture can strengthen food resilience, localized food systems, and sustainable urban development within the Bhubaneswar Municipal Corporation (BMC) area.

A. Urban Food System Structure of Bhubaneswar

The spatial structure of Bhubaneswar reflects a predominantly transport-driven and externally dependent urban food system characterized by strong reliance on peri-urban and regional agricultural inflows. The Bhubaneswar Municipal Corporation (BMC) area functions primarily as a major consumption zone supported by a network of peri-urban agricultural settlements, wholesale markets, transportation corridors, and informal vendor systems. Major regional corridors such as NH-16 and NH-316 play a critical role in facilitating food inflow into the city, while peri-urban agricultural belts including Balianta, Jatni, Pipili, and Khordha fringe settlements contribute substantially toward daily vegetable and fresh produce supply.

The city demonstrates a core–periphery food distribution structure in which food production remains spatially concentrated outside the urban core, thereby increasing dependency on external supply chains and transportation systems. Although Bhubaneswar possesses relatively strong transportation infrastructure and regional connectivity, the urban food system remains highly centralized around wholesale markets and intermediary-based distribution systems. Such dependency creates vulnerabilities associated with seasonal disruptions, transport inefficiencies, price fluctuations, and supply-chain instability.

Simultaneously, the city possesses several spatial and ecological characteristics favorable for decentralized urban food production. The presence of extensive rooftops, institutional campuses, peri-urban interfaces, transportation corridors, open lands, and approximately 200+ water bodies creates significant opportunities for integrating productive landscapes and localized food systems within the urban structure. Despite this potential, existing planning systems continue to demonstrate weak integration of food-production landscapes within statutory urban planning frameworks.

B. Household Survey Analysis

The household survey analysis reveals substantial latent potential for decentralized urban agriculture within Bhubaneswar. Approximately 80% of surveyed households possess rooftops, balconies, or backyard spaces suitable for small-scale food production. Rooftops alone account for nearly 40% of identified usable spaces, indicating significant spatial feasibility for terrace farming and compact food-production systems within dense urban environments.

Despite strong physical feasibility, only 35% of households currently practice any form of urban farming, indicating a substantial implementation gap between available urban space and actual adoption levels. Simultaneously, nearly 70% of respondents expressed strong willingness toward urban agriculture adoption, reflecting high social acceptance and immediate implementation potential. The findings therefore suggest that urban agriculture within Bhubaneswar is constrained less by land availability and more by institutional, informational, and implementation-related barriers.

Knowledge deficiency emerged as the dominant barrier affecting urban agriculture adoption, followed by concerns related to space, cost, and time availability. The findings indicate that awareness gaps and limited technical guidance represent more critical barriers than infrastructural limitations. Consequently, planning interventions focused on training systems, awareness programs, demonstration projects, and low-cost starter models may significantly improve urban agriculture adoption rates within the city.

Food expenditure patterns further demonstrate the relevance of localized food systems within urban households. Nearly 50% of respondents belong to middle-income categories and spend moderate proportions of household expenditure on food and vegetables. Although most households currently access food markets within reasonable distance ranges, the system remains highly dependent on external supply networks and market-based distribution structures.

C. Food Vulnerability in Slum Settlements

The slum household analysis highlights significant inequalities in food accessibility and affordability within vulnerable urban communities.

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Approximately 72% of respondents identified high vegetable prices as a major challenge affecting household food access, while nearly 56% reported inadequate proximity to fresh food markets and reliable food-distribution systems. These findings indicate that affordability and physical accessibility collectively function as the primary constraints affecting nutritional security within informal settlements.

The survey additionally revealed strong dependence on informal vendors and market-based supply systems among low-income households. Irregular income patterns, fluctuating food prices, and limited access to fresh vegetables further intensify food vulnerability within slum-dominated wards. The absence of localized food-production systems within these settlements increases dependency on external market systems and exposes vulnerable populations to supply-chain instability and price fluctuations.

The findings demonstrate the need for community-based food systems, shared nutrition gardens, and neighborhood-scale urban agriculture interventions capable of improving food accessibility and affordability within low-income urban communities. Such interventions can simultaneously strengthen nutritional security, social participation, and localized resilience within vulnerable settlements.

D. Vendor and Supply Chain Analysis

The vendor survey analysis reveals that Bhubaneswar's urban food system remains heavily dependent on peri-urban and external agricultural inflows. Vegetable vendors operating within local markets and street vending corridors primarily source produce from agricultural regions located approximately 10–50 km away from the urban core. This dependency on external supply systems significantly increases transportation costs, supply volatility, and food-system vulnerability.

Seasonal disruptions and transport inefficiencies contribute toward extreme price instability within the urban food system. Vendors reported price fluctuations ranging between 80–90%, particularly during periods of climatic variability and supply-chain disruption. Additionally, the absence of adequate cold-storage infrastructure and decentralized food logistics contributes toward food wastage levels ranging between 10–25%, particularly for highly perishable vegetables and leafy produce.

The findings indicate that the existing urban food system operates through centralized and intermediary-dependent market structures vulnerable to transportation disruptions and seasonal variability. Consequently, strengthening decentralized food-production systems, localized food hubs, and neighborhood-scale aggregation infrastructure becomes essential for improving food-system resilience and reducing food wastage within the city.

E. Peri-Urban Food Linkages and Farmer Analysis

The peri-urban farmer survey demonstrates the critical role of surrounding agricultural belts in sustaining Bhubaneswar's daily food demand. Agricultural regions such as Balianta, Pipili, and Jatni collectively contribute a substantial proportion of vegetables and fresh produce entering urban markets. Approximately 30–60% of agricultural produce generated within these peri-urban belts directly supplies Bhubaneswar's food system.

However, farmers remain strongly dependent on wholesale mandis and intermediary networks for market access. Nearly equal proportions of respondents rely on mandis and middlemen for selling agricultural produce, thereby reducing direct producer-to-consumer linkage efficiency and limiting profitability. Transportation inefficiencies, groundwater dependency, rising production costs, and fluctuating market prices further constrain peri-urban agricultural sustainability.

Despite these constraints, the survey findings reveal strong willingness among peri-urban farmers to participate in direct urban supply systems and decentralized food networks. This indicates substantial potential for strengthening city-region food systems through direct farmer-to-city linkage mechanisms, local aggregation systems, and peri-urban food integration strategies capable of reducing food miles and improving supply-chain efficiency.

F. Institutional Readiness and Spatial Feasibility

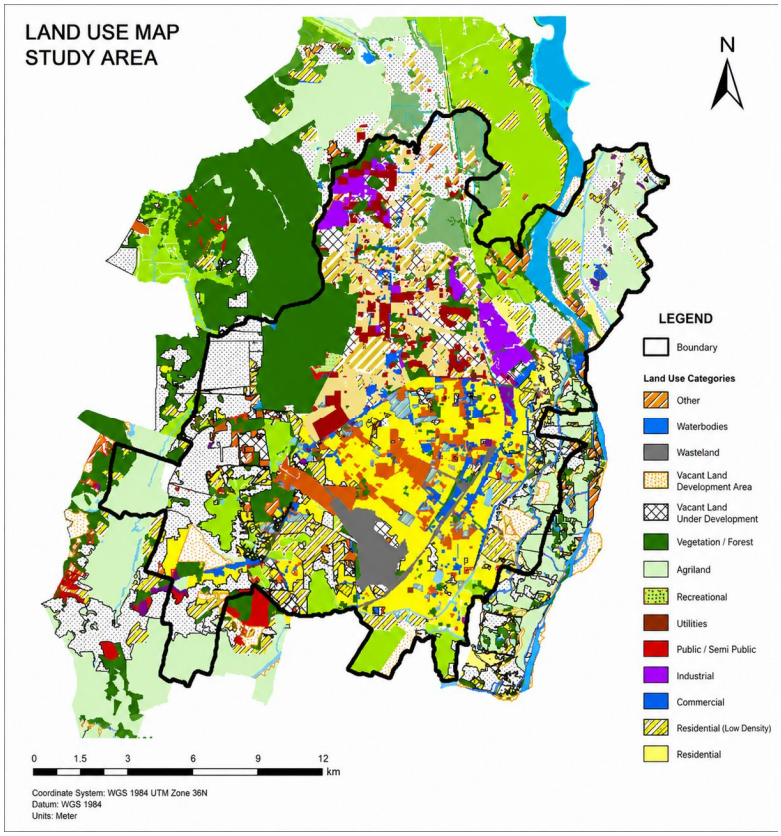
Institutional analysis reveals strong implementation potential for integrating urban agriculture within schools, offices, campuses, and institutional corridors across Bhubaneswar. Approximately 56% of surveyed institutions possess usable open lands suitable for productive landscapes and community farming systems, while nearly 67% demonstrate rooftop suitability for decentralized food production interventions.

Institutional willingness toward urban agriculture adoption remains significantly high, with nearly 89% of respondents expressing positive interest in implementing urban farming initiatives. Existing plantation and landscaping activities within institutional campuses additionally provide a favorable foundation for transitioning toward edible landscapes and productive green infrastructure systems.

The findings suggest that institutional corridors such as Patia–Chandrasekharpur possess particularly strong potential for pilot-scale implementation of rooftop agriculture, edible campuses, and demonstration-based food systems. However, barriers associated with funding, maintenance, governance coordination, and implementation mechanisms continue to constrain large-scale institutional integration.

G. Spatial Potential for Urban Agriculture Integration

The spatial assessment indicates that Bhubaneswar possesses substantial potential for integrating urban agriculture within its existing land-use structure without generating major land-use conflicts. Residential areas demonstrate high rooftop farming feasibility, while institutional lands, peri-urban interfaces, transportation corridors, public spaces, and waterbody edges collectively provide opportunities for decentralized food-production systems.



Map 2 Land Use Map - BMC Area

TABLE 3
LANDUSE DISTRIBUTION

Land Use Category	Approx. Area Share (%)	Planning Interpretation
Residential	31–34%	Dominant urban land use; high rooftop farming potential
Open / Vacant Land	20–24%	Major opportunity for productive landscapes
Institutional	11–13%	High feasibility for campus farming systems
Commercial	7–9%	Limited but suitable for terrace hydroponics
Industrial / Utility	4–6%	Potential for controlled-environment agriculture

Transportation & Corridors	8–10%	Edible corridors and green buffers
Public / Semi-Public	5–7%	Community gardens and ward food hubs
Water Bodies & Wetlands	3–5%	Aquaponics and blue-green integration
Utilities / Others	1–2%	Minor support infrastructure



Open and vacant lands account for approximately 20–24% of the broader land-use structure, while institutional land uses contribute an additional 11–13% with high implementation feasibility for productive landscapes and campus farming systems. Transportation corridors and ecological buffers further demonstrate potential for edible landscapes, green infrastructure systems, and climate-sensitive food-production interventions.

The analysis identifies institutional belts, peri-urban interfaces, mixed-use wards, apartment-dominated areas, market corridors, and waterbody influence zones as priority intervention areas for urban agriculture integration. The findings collectively indicate that urban agriculture integration within Bhubaneswar is spatially feasible and institutionally achievable when supported through planning frameworks, governance mechanisms, and decentralized implementation strategies.

VI. PLANNING PROPOSALS AND FRAMEWORK

The analysis demonstrates that Bhubaneswar possesses significant spatial and institutional potential for integrating urban agriculture within its existing urban structure. However, the current urban food system remains highly centralized, externally dependent, and weakly embedded within formal planning frameworks. The proposed planning framework therefore aims to transform urban agriculture from an isolated community practice into an integrated spatial planning strategy capable of strengthening decentralized food systems, urban resilience, socio-ecological sustainability, and localized food accessibility within the Bhubaneswar Municipal Corporation (BMC) area.The framework emphasizes the integration of urban agriculture into statutory planning systems, zoning regulations, productive landscapes, peri-urban food networks, and decentralized urban infrastructure. The proposed interventions are structured according to spatial typologies, food-system vulnerabilities, institutional capacities, and land-use characteristics identified during the analytical phase of the study. The approach additionally recognizes urban agriculture as a multi-functional planning instrument contributing simultaneously toward food resilience, climate adaptation, circular urban metabolism, environmental sustainability, and community participation.

Institutional corridors such as Patia–Chandrasekharpur and educational campuses within the KIIT–Infocity region demonstrate the highest implementation feasibility due to the availability of large rooftops, open spaces, and strong institutional willingness. These areas are proposed for edible campus frameworks integrating rooftop farming systems, community food gardens, composting systems, and demonstration-based urban agriculture initiatives. Such interventions can function as pilot-scale implementation models while simultaneously strengthening environmental awareness, localized food production, and institutional sustainability practices.Dense mixed-use wards including Saheed Nagar and Satya Nagar exhibit substantial potential for compact urban agriculture systems due to terrace availability and high food-consumption intensity. These wards are proposed for rooftop hydroponics, balcony farming systems, modular terrace agriculture, and vertical farming interventions capable of improving localized food accessibility within highly built-up urban environments. Apartment-dominated residential wards similarly demonstrate opportunities for compact farming systems integrating modular food-production infrastructure within residential housing typologies.

Market influence zones such as Unit-I, Unit-IV, and Baramunda represent critical nodes within Bhubaneswar's urban food distribution network. These areas currently experience high dependence on external food inflows, seasonal supply fluctuations, and food wastage associated with inadequate storage infrastructure. Consequently, the framework proposes decentralized food hubs, aggregation centers, vending infrastructure, neighborhood storage systems, and localized food logistics mechanisms capable of strengthening food-distribution efficiency and reducing supply-chain vulnerability.Slum-dominated wards and food-vulnerable settlements require community-oriented interventions focused on improving nutritional accessibility and affordability.

The framework therefore proposes community nutrition gardens, shared food-production spaces, neighborhood edible landscapes, and cooperative farming systems capable of strengthening localized food accessibility within vulnerable urban communities. Such interventions additionally support social participation, livelihood enhancement, and neighborhood-scale resilience.

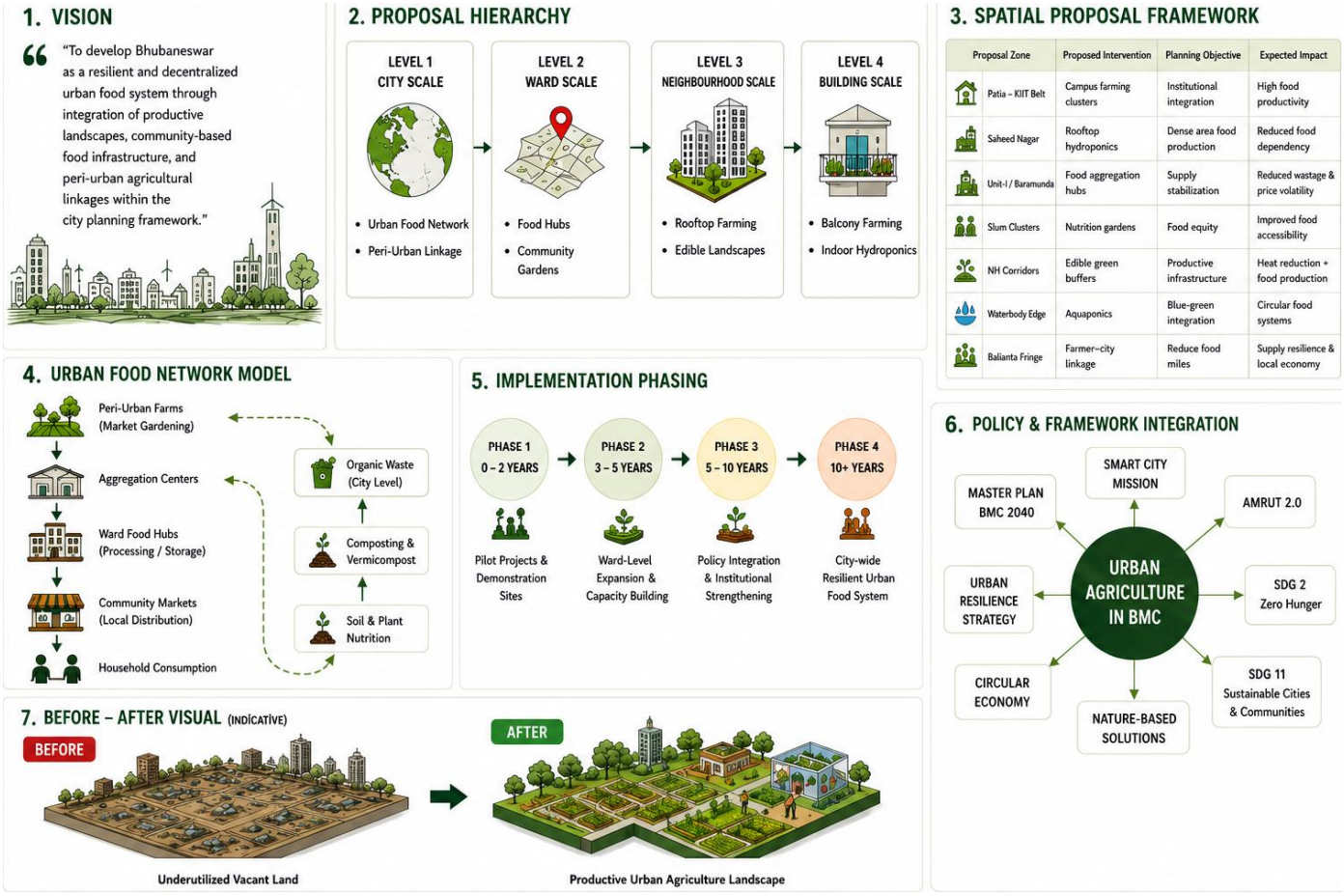


Figure 2 Integrated Proposals

Transportation corridors such as NH-16 and NH-316 function as major food inflow routes connecting peri-urban agricultural regions with the urban core. These corridors possess strong potential for integrating edible green infrastructure, food aggregation systems, and decentralized logistics networks. Similarly, waterbody influence zones and ecological corridors demonstrate opportunities for aquaponics, wetland farming systems, edible landscapes, and climate-sensitive blue-green infrastructure integration. The peri-urban interface surrounding Bhubaneswar forms a critical component of the city-region food system. Agricultural regions such as Balianta, Jatni, and Pipili contribute substantially toward urban food supply but remain weakly integrated with direct urban markets. The proposed framework therefore emphasizes strengthening farmer-to-city linkage systems, decentralized procurement networks, local aggregation mechanisms, and peri-urban food integration strategies capable of reducing food miles and improving supply-chain efficiency.At the policy level, the framework recommends integrating urban agriculture into master plans, development control regulations, zoning provisions, resilience planning strategies, and Smart City initiatives. Dedicated urban agriculture zones, rooftop farming incentives, institutional implementation guidelines, compost integration systems, and productive landscape regulations should be incorporated within future planning policies to institutionalize food systems within Bhubaneswar's urban development framework.

Overall, the proposed planning framework positions urban agriculture as an integrated urban planning strategy capable of strengthening decentralized food systems, climate-responsive urbanism, environmental sustainability, and socio-spatial resilience within rapidly urbanizing cities. The framework demonstrates that productive landscapes and localized food systems can be systematically integrated into urban planning structures without generating major land-use conflicts while simultaneously contributing toward sustainable urban development and food resilience.

VII. DISCUSSION

The findings of the study demonstrate that urban agriculture possesses significant potential to function as a spatial planning instrument for strengthening decentralized food systems, urban resilience, and socio-ecological sustainability within rapidly urbanizing Indian cities. The case of Bhubaneswar reveals that the city's food system is presently characterized by strong dependence on external and peri-urban supply networks, centralized wholesale distribution structures, and fragmented market systems vulnerable to transportation disruptions, seasonal variability, and price fluctuations. Despite these structural dependencies, the city simultaneously demonstrates substantial untapped spatial and institutional capacity for localized food production through rooftops, institutional campuses, peri-urban interfaces, transportation corridors, vacant lands, and ecological zones.

One of the most significant findings emerging from the study is that urban agriculture within Bhubaneswar is constrained less by physical space availability and more by governance fragmentation, implementation gaps, and limited institutional integration. The household survey analysis clearly indicates a substantial mismatch between physical feasibility and actual adoption. Although nearly 80% of households possess spaces suitable for urban farming, only 35% currently practice any form of decentralized food production. Simultaneously, high willingness toward adoption reflects strong social acceptance and indicates that urban agriculture can achieve significant expansion if supported through awareness programs, institutional facilitation, and planning integration mechanisms.

The study additionally highlights the growing vulnerability of centralized urban food systems within rapidly urbanizing cities. Vendor analysis reveals strong dependence on peri-urban and regional inflows accompanied by extreme price fluctuations and food wastage resulting from transportation inefficiencies and inadequate storage systems. These findings reinforce broader global discussions concerning food-system resilience and the need for decentralized urban food infrastructures capable of reducing supply-chain vulnerability and improving localized food accessibility.

The peri-urban interface emerges as another critical dimension of the urban food system. Agricultural belts surrounding Bhubaneswar continue to play an essential role in sustaining urban food demand, yet weak farmer-market integration and intermediary dependence reduce overall supply efficiency and economic resilience. The study therefore emphasizes the importance of viewing urban food systems through a regional planning perspective where peri-urban agriculture and urban consumption systems are functionally interconnected. Strengthening city-region food systems through direct farmer-to-city networks and decentralized procurement systems can substantially reduce food miles, improve food accessibility, and strengthen regional food resilience. The findings also demonstrate that urban agriculture should not be viewed solely as a food-security intervention but rather as a multi-functional planning strategy capable of generating environmental, social, economic, and resilience-oriented benefits simultaneously. Productive landscapes, edible campuses, rooftop agriculture, and community farming systems contribute toward climate-responsive urbanism through microclimatic improvement, biodiversity enhancement, localized resource circulation, and ecological infrastructure integration. Such interventions align strongly with the principles of Nature-Based Solutions (NBS), circular urban metabolism, and sustainable urban development.

At the planning level, the study identifies a major institutional gap within existing urban development frameworks. Despite the Smart City orientation and planned urban structure of Bhubaneswar, food systems remain weakly represented within zoning systems, land-use policies, and development regulations. Current planning frameworks largely prioritize transportation, residential growth, commercial expansion, and infrastructure development while overlooking the spatial dimension of food systems. This reflects a broader planning blind spot observed across many Indian cities where food accessibility and decentralized food production remain inadequately integrated within statutory planning processes.

VIII. CONCLUSIONS

The study examined the potential of integrating urban agriculture within the spatial planning framework of Bhubaneswar in order to strengthen decentralized urban food systems, food resilience, and sustainable urban development. The findings demonstrate that Bhubaneswar possesses substantial spatial, institutional, and social feasibility for integrating urban agriculture through rooftops, institutional campuses, peri-urban interfaces, transportation corridors, waterbody influence zones, and underutilized urban spaces. Despite this potential, the existing urban food system remains highly dependent on external supply chains, intermediary-driven distribution systems, and centralized market structures vulnerable to transportation disruptions, seasonal instability, and price fluctuations. The analysis reveals that urban agriculture within Bhubaneswar is constrained primarily by governance fragmentation, weak planning integration, limited institutional support, and knowledge gaps rather than by land scarcity. Household survey findings indicate strong willingness toward urban agriculture adoption despite relatively low implementation levels, reflecting substantial latent potential for decentralized food production systems.

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Simultaneously, vendor and peri-urban farmer analyses highlight structural vulnerabilities associated with long-distance food inflows, food wastage, market dependency, and inefficient supply-chain integration. The study further demonstrates that institutional corridors and peri-urban agricultural belts possess strong implementation potential for scalable urban agriculture interventions and decentralized food infrastructure systems.

The proposed planning framework emphasizes integrating urban agriculture into zoning regulations, master plans, urban resilience strategies, and decentralized infrastructure planning through interventions such as rooftop farming, edible campuses, community nutrition gardens, aquaponics, vertical farming systems, food aggregation hubs, and farmer-to-city linkage networks. The framework positions urban agriculture not merely as a food-production activity but as a multi-functional planning instrument capable of enhancing socio-ecological resilience, strengthening localized food accessibility, reducing food miles, and supporting climate-responsive urban development.

The study contributes toward emerging planning discourse concerning food urbanism, productive landscapes, circular urban metabolism, and Nature-Based Solutions within rapidly urbanizing Global South cities. It further demonstrates that integrating food systems into urban planning structures is essential for developing resilient, inclusive, and sustainable urban futures. The findings may assist planning authorities, urban local bodies, and policy institutions in formulating resilience-oriented planning strategies capable of embedding decentralized food systems within future urban development frameworks.

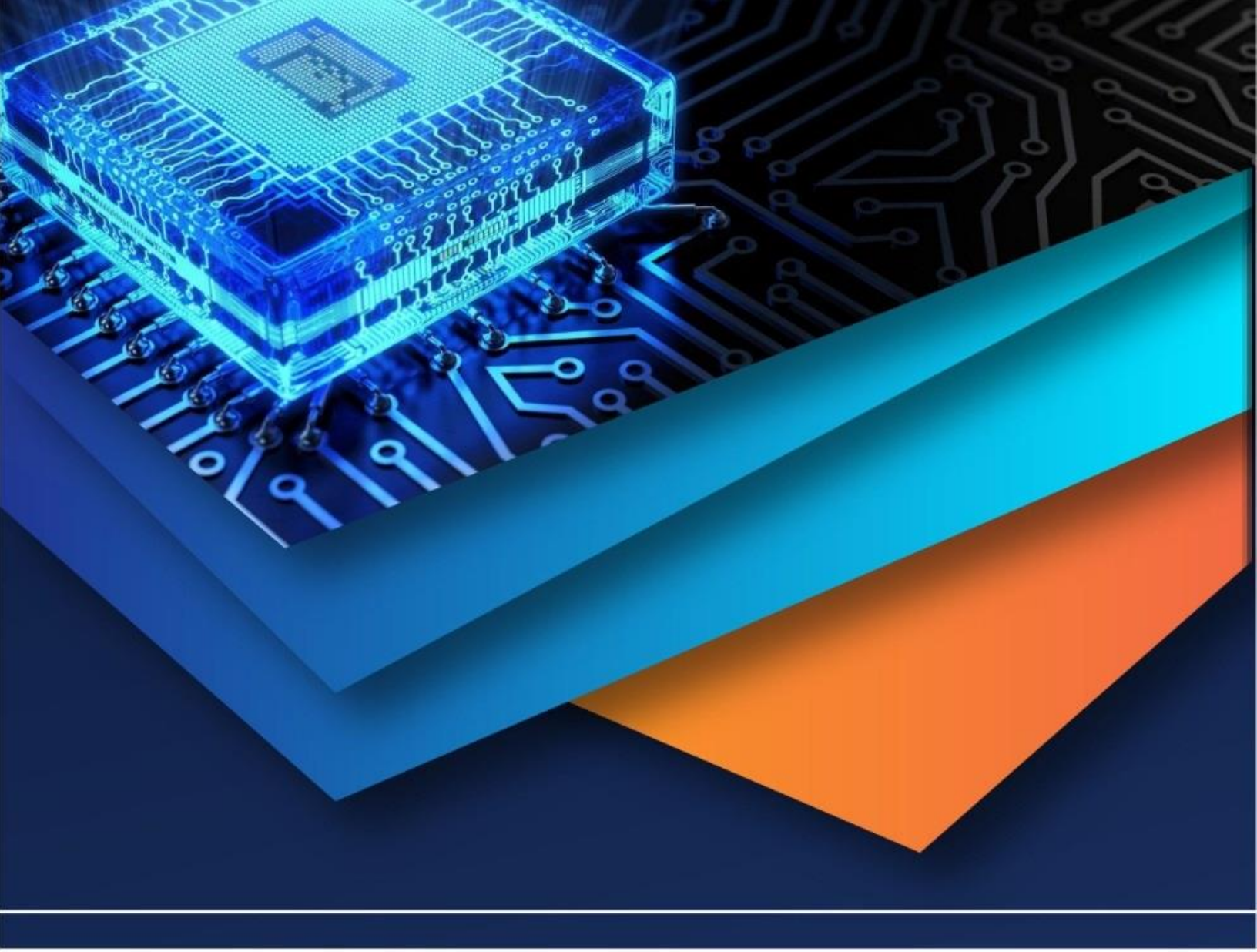
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