"Greening the Cities of Tomorrow: A case study on Rooftop Organic Farming - an Innovative Policy and Strategic Framework for Sustainable and Inclusive Organic Supply Chains"

Ms. Jyotsana Agarwala,
(Research Scholar: Smt. MMK College of Commerce & Economics, Bandra),
Vishal R. Tomar,
Research Guide (Smt. M.M.K College of Commerce and Economics, Mumbai),
Dr. Suraj Agarwala,
Assistant Professor, (B. K. Birla College (Empowered Autonomous), Kalyan)

Abstract:
The increasing urbanization of India poses both obstacles and opportunities in achieving the national objective of Viksit Bharat. In light of apprehensions regarding food security, environmental deterioration, and constrained urban space, rooftop organic farming presents a feasible and sustainable remedy. This case study examines the potential of rooftop gardening and novel supply chain tactics that facilitate its incorporation into urban ecosystems, specifically in Badlapur, Maharashtra. The study evaluates the execution of a rooftop organic farming initiative in the Kulgaon-Badlapur area, examining essential supply chain elements including input procurement (organic seeds, compost), vertical and container farming methods, post-harvest logistics, aggregation centres, and direct-to-consumer (D2C) delivery systems. Technological innovations, such as IoT monitoring systems and mobile applications for real-time farm-to-fork communication, are assessed for their revolutionary effects on operational efficiency and customer trust. Research indicates that decentralized food production techniques, such as rooftop gardening, diminish reliance on rural agriculture, lower carbon emissions, and improve urban food sovereignty. Innovative approaches like community-supported agriculture (CSA) and hyperlocal distribution networks are recognized as essential facilitators for establishing transparent, efficient, and resilient urban food supply chains.
The research additionally examines significant obstacles, such as scalability, standardization, legal impediments, and insufficient customer awareness. It provides pragmatic ideas for legislators, urban planners, and agricultural entrepreneurs to mitigate these deficiencies through supportive frameworks, incentive-driven initiatives, and awareness campaigns.
Rooftop organic farming aligns environmental objectives with grassroots creativity, providing a means for urban revitalisation, environmental stewardship, and inclusive economic development. This research underscores that urban greening is not merely an ecological necessity, but also a strategic measure in cultivating a resilient, self-sufficient, and sustainable Viksit Bharat.

Keywords: Rooftop Organic Farming, Urbanization, Supply Chain Management, Organic Farming, Post-Harvest Logistics.

1. Introduction:

India's swift urbanization, although indicative of economic advancement and infrastructure enhancement, poses intricate obstacles that obstruct the achievement of the nation's long-term aspiration of Viksit Bharat—a developed and inclusive India. Among these challenges, issues related to food security, environmental degradation, and limited urban space have surfaced as major impediments to sustainable urban life. The notion of rooftop organic farming presents a revolutionary and localized solution that merges ecological sustainability with socio-economic empowerment.

Urban agriculture, especially through rooftop organic farming, is increasingly acknowledged as an effective approach to mitigate the widening gap between daily demand and food supply in densely populated urban areas. This approach facilitates the growth of fresh, organic produce on neglected rooftops, so enhancing urban food sovereignty, diminishing reliance on extensive food supply chains, and reducing the carbon footprint linked to conventional agricultural logistics. Aligned with the Viksit Bharat strategy, which prioritizes environmental stewardship, equitable growth, and technological innovation, rooftop farming presents a chance to transform metropolitan areas into hubs of green productivity.

This research article examines a case study of the Kulgaon-Badlapur region in Maharashtra, where rooftop organic farming is investigated as both an agricultural practice and a supply chain innovation. Basically, the case study considered the daily required vegetables like coriander, chilly, mint, ginger, turmeric, onion, garlic, tomato, and spinach. The study provides a comprehensive perspective on the operation of decentralized food production within an urban environment by examining essential elements such as input sourcing (organic seeds, compost), vertical/container farming methods, and hyperlocal delivery networks. The integration of emerging technologies—such as the Internet of Things (IoT) for remote monitoring, blockchain for traceability, and mobile applications for direct customer engagement—illustrates how digital tools can improve transparency, efficiency, and consumer trust in urban agriculture.

The implementation of hyperlocal distribution models and community-supported agriculture (CSA) enhances the development of resilient, efficient, and inclusive supply chains. The scalability of rooftop agriculture is hindered by policy uncertainty, the absence of standardization, infrastructural obstacles, and insufficient public awareness. This paper examines these constraints while suggesting strategic measures for urban planners, policymakers, and agricultural entrepreneurs to sustainably expand rooftop farming.

This research frames rooftop organic farming as a comprehensive solution that corresponds with the overarching objectives of Viksit Bharat—promoting urban self-sufficiency, ecological equilibrium, and grassroots economic advancement.

2. Review of Literature

a)   Despommier, D. (2010) stressed the necessity of vertical and rooftop agriculture in reaction to swift urbanization, promoting optimal land utilization and diminished environmental harm. His research offers fundamental insights into the potential of urban agriculture to convert cities into productive ecosystems.

b)   Saha et al. (2014) examined rooftop gardens in Indian cities, emphasizing their contribution to improving urban food security and mitigating heat island impacts. They proposed the merging of policy support and urban planning to enhance scalability.

c)   Grewal & Grewal (2012) evaluated the viability of urban agriculture in U.S. cities, determining that rooftop gardening may provide a substantial fraction of urban food requirements while reducing the carbon emissions linked to food transportation.

d)   Lal (2020) reviewed climate-smart agriculture and underscored how integrating rooftop farming with technology like IoT and data-driven tools improves yield efficiency and sustainability.

e)   Khosla, R. (2016) explored how green infrastructure, including rooftop farming, contributes to India's smart city agenda and promotes sustainability, aligning with urban renewal missions like AMRUT and Viksit Bharat.

f)   Bhatt & Kong (2021) discovered that blockchain and traceability technologies can markedly improve transparency and consumer confidence in urban agriculture, particularly for direct-to-consumer models

g)   Bailkey & Nasr (2000) highlighted community engagement in rooftop agriculture, demonstrating how Community Supported Agriculture (CSA) models can enhance urban resilience and socioeconomic inclusiveness

h)   Roy, M. (2015) addressed the obstacles of urban agriculture in India, including insufficient legal acknowledgment, inadequate zoning regulations, and infrastructural deficiencies, advocating for comprehensive reforms to facilitate its development.

i)   Garnett (2011) explored the obstacles of urban farming in India, including insufficient legal recognition, weak zoning regulations, and infrastructural deficiencies, advocating for systemic reforms to facilitate its development.

j)   Prasad & Kumar (2022) performed a case study on urban farming projects in Maharashtra, elucidating how mobile applications and IoT have enhanced consumer participation and diminished food wastage.

3. Research Methodology

a. Research Gap

Research on rooftop organic farming in India is limited, focusing on technology and environmental benefits, but lacks comprehensive implementation challenges. Localized case studies, particularly from Tier-II cities like Badlapur, are lacking, highlighting the need for comprehensive implementation.

b. Need for the study

India's urban expansion and Viksit Bharat goals demand sustainable, inclusive food production systems. Rooftop organic farming is a viable solution to address food insecurity, environmental degradation, and rural dependency. However, understanding operational, social, and policy challenges in semi-urban areas is crucial. A ground-level case study in regions like Badlapur is needed to develop scalable models supporting urban resilience, food sovereignty, and economic inclusiveness.

c. Scope of the study

The study examines rooftop organic farming in Kulgaon-Badlapur, Maharashtra, as an agricultural practice and supply chain innovation. It assesses key supply chain elements, evaluates technological enablers like IoT monitoring, and analyzes innovative distribution models. Barriers to scalability include policy gaps, infrastructural challenges, and limited public awareness. The study provides strategic recommendations for urban planners, entrepreneurs, and policymakers to integrate rooftop farming into urban development and food policies. The findings can be applied to other Tier-II and Tier-III urban areas in India.

d. Objective of the study

This case study evaluates rooftop organic farming's feasibility, challenges, and potential as a sustainable, decentralized solution for urban food security in the Kulgaon-Badlapur region of Maharashtra. Specifically, to assess the operational viability of rooftop organic farming, the effectiveness of hyperlocal distribution models, identify the key challenges, and recommend strategic actions for the same.

4. **Case Study Background**

India's urbanization is causing environmental and social challenges, including shrinking green spaces, food insecurity, and long supply chains. Rooftop organic farming is a solution that combines ecological sustainability with community empowerment. A pilot initiative in Mohan Greenwoods, Phase III in Manjarli area in Badlapur, west of the Kulgaon-Badlapur region in Maharashtra, used container and vertical farming techniques, organic inputs, and emerging technologies for the supply chain. This case study aims to build localized food production systems on underutilized urban rooftops, contributing to Viksit Bharat's vision.

5. **Case Study Analysis**

A specific project was initiated in the Mohan Greewoods Co-operative Housing Society, Phase III, located in the Manjarli region of Badlapur West inside the Kulgaon-Badlapur Municipal Area. This cooperative housing society has six buildings. The society comprises 163 units, with 80% currently inhabited. A total of 12 plastic grow bags (dimensions 72x36x12) were erected on the roof as part of a trial experiment. To prepare the soil, a mixture of 80% coco-pit and 20% soil is utilised to decrease the weight of the grow bag and minimise water usage. In addition to grow bags, plastic trays are utilised for cultivating veggies. Plastic drums are utilised for the production of organic fertiliser. Seeds were obtained from the local market and regional farmers. Residents were asked to segregate vegetable and fruit trash to ensure a constant supply of organic fertilisers. It urged individuals to deposit all rubbish into the plastic drums. Cow dung and desiccated leaf waste are utilised in the production of organic fertiliser. Experts in agriculture were appointed for the agricultural process. Short-term vegetables were evaluated based on their capacity to fulfil daily requirements. Crops such as coriander, chilli, mint, ginger, turmeric, onion, garlic, tomato, and spinach were planted in the grow bags. Organic manure and fertiliser were routinely employed to promote the robust development of crops. The vegetables were ready for harvest within one to three months. The vegetables were collected by the youth of the community under the supervision of specialists. The cultivation was structured to ensure that fundamental requirements are met by daily harvesting. Following the collection of the specified vegetables, the pertinent information was sent via the society's WhatsApp group, and each morning, the harvested veggies were allocated among the society members.

The building's roof load-bearing capacity was considered, for which a coco-pit was utilised to diminish the weight of the grow bags. To maximise fertiliser efficiency, the drained water was collected using an appropriate system. Authorisation was secured from the chairman and secretary for the project. The logistical charges were negligible, limited to the procurement of seeds and cultivation aids, while selling and distribution costs were virtually nonexistent as the harvested items were sold within the community. The risk of inadequate sales is nonexistent, hence the risk of unsold inventory is also null. All these advantages were conveyed to the client through a reduced selling price, which subsequently heightened the demand for fresh organic veggies. The profits derived from the sales were allocated to the community. The expenses for the rooftop gardening were fully recouped. Fresh veggies were provided to the public as a result of the real-time farm-to-fork policy. The diverse advantages, such as diminished carbon emissions from decreased logistics, enhanced urban food sovereignty, and improved health outcomes from organic components, are clearly evident. The green cultivation has also affected the weather. This motto also achieved the objective of Greening the Cities of Tomorrow. If the project can be implemented in every cooperative housing society through expertise, innovative policy, and a strategic framework for sustainable and inclusive organic supply chains, the realisation of Viksit Bharat in each housing society is within reach.

6. **Discussion**

The establishment of rooftop organic farming in the Mohan Greenwoods Co-operative Housing Society in Badlapur West exemplifies a viable and replicable strategy for sustainable urban agriculture. This pilot project has revealed critical insights regarding the feasibility, efficacy, and community-level influence of decentralised food production systems in a semi-urban Indian   setting.

A key finding is the efficient utilisation of constrained urban area for food production while maintaining the building's structural integrity. The smart application of lightweight growing media (80% coco-pit and 20% soil) guaranteed that the strain on rooftops remained reasonable while concurrently decreasing water consumption. This methodology is consistent with climate-resilient agriculture methods and promotes sustainable urban development.

The experiment underscores the feasibility of hyperlocal farm-to-fork systems from a supply chain standpoint. The idea effectively reduced post-harvest logistics, eradicated intermediaries, and eliminated waste and unsold inventory by farming and distributing vegetables within the housing society. The minimal distribution costs, along with reduced input procurement charges and community engagement, produced a self-sustaining economic model advantageous to all people. The earnings reinvested   into   the   community   further   augmented   the   project's   inclusion   and   sustainability. Moreover, the project showcased strong community engagement, from waste segregation for composting to collective farming activities led by local youth under expert guidance. This participatory paradigm empowered residents and fostered

environmental awareness and accountability. The utilisation of a WhatsApp group to notify members of daily harvests and distributions established a transparent and effective communication route, enhancing trust and engagement. The initiative achieved a reduction in carbon footprint by minimising transportation emissions and fostering circular waste management via composting organic waste. It also facilitated microclimatic enhancements, as vegetation on rooftops aids in lowering ambient temperatures and mitigating urban heat island impacts.

The initiative's success emphasises the significance of affordable, scalable treatments bolstered by community leadership, fundamental technical expertise, and minimum infrastructure. The research indicates the need for policy-level assistance, standardised safety and scalability frameworks, and extensive awareness efforts to duplicate these ideas in other housing societies.

This case study confirms the feasibility of rooftop farming in urban India and illustrates its capacity to promote various Sustainable Development Goals (SDGs), such as zero hunger, good health and well-being, sustainable cities and communities, and climate action. The Mohan Greenwoods experiment exemplifies how localised, inclusive, and technology-driven green practices can facilitate the realisation of Viksit Bharat.

7.   Policy and Strategic Framework

Informed by the results of the rooftop organic farming initiative at Mohan Greenwoods Co-operative Housing Society in Badlapur, the subsequent policy recommendations are put forth to promote extensive replication, guarantee sustainability, and advance the vision of Viksit Bharat:

a)   Framework for Urban Agriculture Policy

Develop a comprehensive urban agriculture policy focusing on rooftop organic growing, integrate it into smart city initiatives, and establish protocols for secure rooftop load capacities and structure modifications.

b)   Incentives and Subsidies

Offer financial incentives for rooftop agriculture, tax reductions for green roofs and agricultural spaces, and subsidies for grow bags, organic inputs, rainwater gathering systems, and composting drums.

c)   Capacity Development and Technical Assistance

Implement training programs, establish urban agriculture resource centers, and establish certification systems for urban organic produce to enhance customer trust and expertise.

d)   Waste-to-Wealth Programs

Promoting biodegradable trash separation for community composting, distributing kits and systems, and implementing waste segregation infrastructure in housing developments. Utilizing IoT devices, mobile applications, and blockchain-based traceability for transparency and crop quality.

e)   Legal and Regulatory Assistance

Establish explicit zoning restrictions that facilitate rooftop gardening without onerous permissions. Streamline authorisation for the installation of lightweight infrastructure such as vertical gardens and container farms on residential properties.

f)   Consciousness and Community Involvement

Public awareness campaigns highlight rooftop agriculture's health, environmental, and economic benefits, promote its implementation in educational institutions, and recognize community-oriented urban farming models through state and national accolades.

g)   Assistance for Market Connections

Promote community-supported agriculture (CSA) initiatives and local farmers' markets to distribute excess food. Facilitate partnerships with local stores, online platforms, or cooperative societies for hyperlocal distribution of organic vegetables.

h)   Rooftop Agriculture in Economical Housing

Require the incorporation of rooftop gardens in affordable housing initiatives to guarantee equitable access to fresh produce and green areas. Offer micro-financing alternatives or eco-friendly loans to economically disadvantaged populations for rooftop gardening initiatives.

i)   Oversight and Assessment

Create a centralised database to monitor rooftop farming initiatives in various cities for benchmarking and policy enhancement. Urge academic and research institutions to perform impact assessments and offer ongoing policy feedback.

8.   Conclusion

India's aspirational vision of Viksit Bharat—a developed, inclusive, and sustainable nation—necessitates inventive and context-specific solutions to the issues presented by growing urbanisation. Food hunger, diminishing green areas, and ecological degradation have surfaced as urgent issues for radical actions in urban planning, community involvement, and supply chain management. The case study of rooftop organic farming at Mohan Greenwoods Co-operative Housing Society in Badlapur, Maharashtra, exemplifies how localised, community-oriented, and technology-enhanced agricultural techniques may substantially advance this national vision.

The establishment of rooftop organic farming in this cooperative housing society exemplifies a microcosm of self-sufficient, sustainable urban living. The initiative effectively transformed underutilised rooftop spaces into profitable agricultural zones through a planned combination of coco-pit-soil cultivation, organic inputs, and community-driven harvesting and distribution. This initiative is distinguished by its operational simplicity and its comprehensive impact—socially, environmentally, and economically.

The project promoted community engagement, ownership, and empowerment from a social standpoint. Residents participated actively in composting, planting, harvesting, and overseeing the farm-to-fork supply chain. Members of the youth community assumed responsibility for the daily distribution of veggies under expert oversight, fostering skill development and leadership. The incorporation of communication platforms such as WhatsApp facilitated transparency, effective cooperation, and increased confidence among residents. This participatory strategy embodies the notion of "Jan Bhagidari"—public involvement—which is fundamental to Viksit Bharat.

The project substantially advanced sustainability and climate resilience from an environmental perspective. Local food production reduces carbon emissions linked to extensive food supply chains, a significant contributor to urban pollution. The conversion of biodegradable garbage into organic compost established a circular economy paradigm, alleviating landfill burden and enhancing soil quality. Furthermore, rooftop plants mitigated the urban heat island effect, resulting in reduced ambient temperatures and improved urban microclimate health.

The model demonstrated economic viability and sustainability. The input expenses were negligible—restricted to grow bags, seeds, and growing aids—while logistics and distribution expenditures were virtually nonexistent, as the produce was consumed within the housing society. Absence of unsold inventory eliminated risk, allowing proceeds from sales to be reinvested in community welfare, while the expenses of rooftop farming were entirely recuperated. This concept promotes food security at the family level and helps to local economic circulation.

The project's success highlights the feasibility of decentralised urban agriculture as a scalable paradigm. The experiment demonstrated that, with appropriate supervision, affordable inputs, and fundamental infrastructure, semi-urban regions such as Badlapur can create a reproducible model for rooftop organic gardening. This is especially pertinent when considering India's expanding network of Tier-II and Tier-III cities, which are experiencing rapid urbanisation yet frequently lack organised food delivery networks and green spaces.

The case study underscores specific issues and systemic obstacles that need to be resolved for broader replication. Prominent issues include the absence of a specific urban agricultural strategy, legislative difficulties concerning rooftop utilisation, insufficient public knowledge, infrastructure limitations, and the lack of financial incentives or certifications for organic urban produce. Addressing these obstacles necessitates a unified and multifaceted policy framework that facilitates rooftop farming via legal, financial, technological, and community participation strategies.

The proposed Policy and Strategic Framework in this study functions as a roadmap. It underscores the necessity for an Urban Agriculture Policy that incorporates rooftop farming into comprehensive smart city and environmental initiatives. It necessitates financial incentives and subsidies, capacity enhancement via training programs and technical assistance, and legal clarity through simplified zoning regulations. It underscores the significance of community awareness initiatives, CSA-oriented market connections, and the integration of rooftop agriculture in affordable housing programs to foster equitable access. Additionally, it advocates for the implementation of emerging technologies such as IoT for real-time monitoring and blockchain for supply chain traceability to improve transparency and efficiency.

The creation of a centralised monitoring and evaluation system, backed by academic institutions, will facilitate the benchmarking of best practices, impact evaluations, and ongoing policy enhancement. This would guarantee that the rooftop organic farming movement is not an isolated project but rather an essential element of India's urban growth and sustainability plan.

The Mohan Greenwoods case study illustrates that urban rooftops, typically seen as unused areas, may be converted into dynamic hubs of productivity, sustainability, and community welfare. It asserts that urban agriculture encompasses not just food production but also the promotion of self-sufficiency, environmental awareness, and collective prosperity. It is in complete accordance with the Sustainable Development Goals (SDGs), encompassing zero hunger, good health and well-being, sustainable cities and communities, climate action, and responsible consumption and production.

In conclusion, rooftop organic farming presents not just a remedy for urban food shortages but also a vision for a more sustainable, healthier, and inclusive future. This concept embodies the core of Atmanirbhar Bharat—a self-reliant India—and directly leads to the achievement of Viksit Bharat. This case study demonstrates that the rooftops of Indian cities provide significant untapped potential. Through an optimal combination of policy innovation, community involvement, and technology assistance, this potential may be realised to establish a resilient urban India, where each rooftop narrates a tale of growth, sustainability, and social advancement.

9. Suggestions

The exemplary case study of rooftop organic gardening at Mohan Greenwoods Co-operative Housing Society in Badlapur, Maharashtra, highlights the revolutionary capacity of decentralised urban agriculture in realising the goal of Viksit Bharat. To duplicate and expand these sustainable practices throughout India, various strategic initiatives are advised.

There is an immediate necessity for a specialised Urban Agriculture Policy. This policy must acknowledge rooftop farming as an essential element of sustainable urban design and integrate it with current Smart City, Swachh Bharat, and climate-resilient projects. Comprehensive legislative frameworks and construction rules must be established to govern and authorise rooftop agricultural use, facilitating compliance for both residential and commercial enterprises.

Secondly, financial support mechanisms, including subsidies for inputs (e.g., grow bags, organic seeds), tax incentives, and micro-financing for community-led initiatives, should be established. Urban agriculture must to be incorporated into housing development initiatives, especially in Tier-II and Tier-III cities, to guarantee accessibility and equity for economically disadvantaged groups.

Capacity building and technical training are crucial for empowering communities to initiate and maintain rooftop farming. Collaborations with agricultural colleges, non-governmental organisations, and local entities can offer practical training, consulting services, and mentorship. The incorporation of youth via organised volunteer or internship programs can enhance skill acquisition and employment opportunities.

Technological integration is advised to improve impact and efficiency. Incorporating IoT sensors for soil and moisture monitoring, alongside blockchain platforms for establishing traceability and trust in urban agriculture, can establish resilient farm-to-fork systems. Furthermore, digital platforms like smartphone applications or WhatsApp groups can enhance collaboration, awareness, and transparency among communities.

Establishing Community Supported Agriculture (CSA) models in urban environments will enhance local food security and facilitate market connections for excess products. Certification systems for urban organic products can enhance customer confidence and facilitate official sales opportunities.

Finally, a centralised monitoring and evaluation mechanism, overseen by academic institutions and policy think tanks, should assess progress, document exemplary practices, and enhance the national roadmap informed by local insights. This would guarantee that rooftop agriculture is integrated into India's comprehensive environmental and socio-economic change.

Through the cultivation of a synergistic framework encompassing policy support, community engagement, and innovation, India may convert its urban rooftops into emblems of self-sufficiency, environmental stewardship, and inclusive progress.

10. References

1. ailkey, M., & Nasr, J. (2000). From brownfields to greenfields: Producing food in North American cities. Community Food Security News, 2(3), 6–7.
2. Bhatt, C., & Kong, N. (2021). Blockchain and the future of food supply chain transparency. Journal of Agricultural Informatics, 12(2), 34–45.
3. Despommier, D. (2010). The vertical farm: Feeding the world in the 21st century. Thomas Dunne Books.
4. Garnett, T. (2011). Where are the best opportunities for reducing greenhouse gas emissions in the food system? Food Policy, 36(S1), S23–S32. https://doi.org/10.1016/j.foodpol.2010.10.010
5. Grewal, S. S., & Grewal, P. S. (2012). Can cities become self-reliant in food? Cities, 29(1), 1–11. https://doi.org/10.1016/j.cities.2011.06.003
6. Khosla, R. (2016). Sustainable urbanization in India: Challenges and opportunities. Current Science, 110(5), 567–572.
7. Lal, R. (2020). Home gardening and urban agriculture for advancing food and nutritional security in response to the COVID-19 pandemic. Food Security, 12(4), 871–876. https://doi.org/10.1007/s12571-020-01058-3
8. Prasad, A., & Kumar, S. (2022). Smart farming and urban agriculture in India: An exploratory case study. Journal of Urban Management, 11(1), 22–35.
9. https://doi.org/10.1016/j.jum.2021.12.001
10. Roy, M. (2015). Rethinking urban agriculture in India: Constraints and opportunities. Environment and Urbanization ASIA, 6(2), 175–191.
11. https://doi.org/10.1177/0975425315591421
12. Saha, R., Ravindran, K., Das, T. K., Majumdar, B., & Ghosh, P. K. (2014). Urban agriculture and rooftop gardening: An Indian perspective. Indian Journal of Agricultural Sciences, 84(6), 706–711

Annexure:
Glimpses of the project: