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REVIEW ARTICLES

EVALUATING THE ECONOMIC FEASIBILITY OF HYDROPONICS IN URBAN AGRICULTURE AT KATHMANDU, NEPAL

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ABSTRACT

This review paper explores hydroponics as a progressive method of urban agriculture, addressing challenges of confined land availability, food security, and environmental worries resulting from urbanization. Hydroponics, a soilless agricultural technique, emerges as a sustainable response to the urban challenges of limited arable land and water scarcity. Overall, this review synthesizes the study's insights into setup costs, operational challenges, and profitability, aligning them with global trends and local constraints. Recommendations for strategic interventions, including subsidies, training, and urban planning integration, highlight pathways to foster the adoption of hydroponic farming in urban contexts.

Keywords: Economic feasibility, Hydroponic farming, Soil-less agriculture, Sustainability, Urban agriculture

INTRODUCTION

Hydroponic farming is a transformative method in urban agriculture that is increasingly vital for food security in densely populated areas, mainly like Kathmandu Valley. As a soilless farming technique, hydroponics provides a possible answer to the challenges posed by urbanization, which includes developing vegetation in a water-based, nutrient-rich solution offering higher productivity per unit area by utilizing the resources available. However, the economic viability of such systems in resource-constrained settings like Kathmandu Valley remains complex, necessitating comprehensive evaluation.

In Kathmandu Valley, a place in an urban area with less space and scarcity of water is a growing concern; adapting hydroponic farming could significantly

enhance urban food security and sustainability. However, the economic feasibility of hydroponic systems remains uncertain due to high initial setup costs, ongoing maintenance requirements, and the need for specific technical expertise. Additionally, the market for hydroponically grown vegetables is still developing, with varying levels of consumer acceptance and market demand.

IMPORTANCE AND RELEVANCE TO URBAN AGRICULTURE IN KATHMANDU VALLEY

The adoption of hydroponic farming in city areas, such as Kathmandu Valley, affords a sustainable answer to the challenges posed by using fast urbanization and restrained agricultural land. Hydroponics requires extensively much less house and water in contrast to common farming methods, making it perfect for densely populated city environments the place land and water sources are scarce (Kumar et al., 2023). In Kathmandu Valley, hydroponic farming has the plausible to beautify city meal protection via enabling the neighborhood manufacturing of clean veggies and herbs. This reduces dependency on imported produce and shortens the grant chain, main to more energizing produce with fewer transportation-related carbon emissions (Wagh et al., 2020).

Moreover, the managed surroundings of hydroponic structures can mitigate the outcomes of detrimental climate prerequisites and soil degradation, which are big challenges for ordinary farming in the place (Sela Saldinger et al., 2023). In Kathmandu, research has proven that hydroponics, particularly in rooftop settings, can furnish tremendous inexperienced cover, supporting minimizing the city's warm island impact and merchandising nearby meal production (Shrestha et al., 2021).

By integrating hydroponic farming into city planning, Kathmandu Valley can tackle several city sustainability goals, consisting of decreasing city warmness island effects, bettering inexperienced spaces, and promoting sustainable agricultural practices (Khan et al., 2020). This revolutionary strategy can additionally create new monetary possibilities by way of fostering the improvement of nearby agribusinesses and aiding city farmers with current agricultural strategies (Cifuentes-Torres et al., 2020). Furthermore, the possibility for aquaponics, an aggregate of aquaculture and hydroponics, is being explored in Kathmandu, demonstrating the feasibility of integrating these structures into city settings (Khadka & Maharjan, 2019).

COMPARATIVE ANALYSIS WITH LITERATURE

This review included studies from various regions in Nepal and globally, providing a broader context for understanding hydroponic farming practices and investment costs.

Initial Investment Costs

The scatter plot shows a positive linear relationship between the scale of operation and the initial investment cost, as indicated by the equation y=68068.33x+86173 with an R2=0.5. Larger-scale operations, particularly in locations like the USA and Western Greece (Alder et al., 2000; Michalis et al., 2023), exhibit significantly higher initial investment costs compared to smaller-scale operations in other regions. The observed trend suggests that larger-scale hydroponic systems require more substantial initial investments, possibly due to the need for more advanced technology and infrastructure. However, the moderate R2 value indicates that while the scale is an important factor, other variables such as local economic conditions and technology costs also significantly influence initial investment requirements across different regions.

Operational Costs

The operational costs vary significantly across different regions, with the USA showing the highest costs at approximately $289,760 per year (Alder et al., 2000), followed by Western Greece with costs around $35,491 per year (Michalis et al., 2023). Other regions, such as Australia and Germany, have notably lower operational costs, with values closer to $10,000 and $6,213 per year, respectively (Filho et al., 2017; Souza et al., 2023).

The disparity in operational costs reflects the varying levels of resource availability, labor costs, and technological sophistication across these regions. Higher costs in the USA and Western Greece may be attributed to the scale of operations and the inclusion of labor and variable capital costs (Alder et al., 2000; Michalis et al.,2023), while lower costs in regions like Australia and Germany suggest more efficient resource utilization and smaller-scale operations (Filho et al., 2017; Souza et al.,2023).

The profitability metrics across different hydroponic farming locations reveal varied economic outcomes, with Kathmandu showing a strong B/C ratio of 2.32 and a positive NPV (Thapa, 2021), while locations like the USA and Germany demonstrate favorable NPVs and reasonable payback periods (Alder et al., 2000,

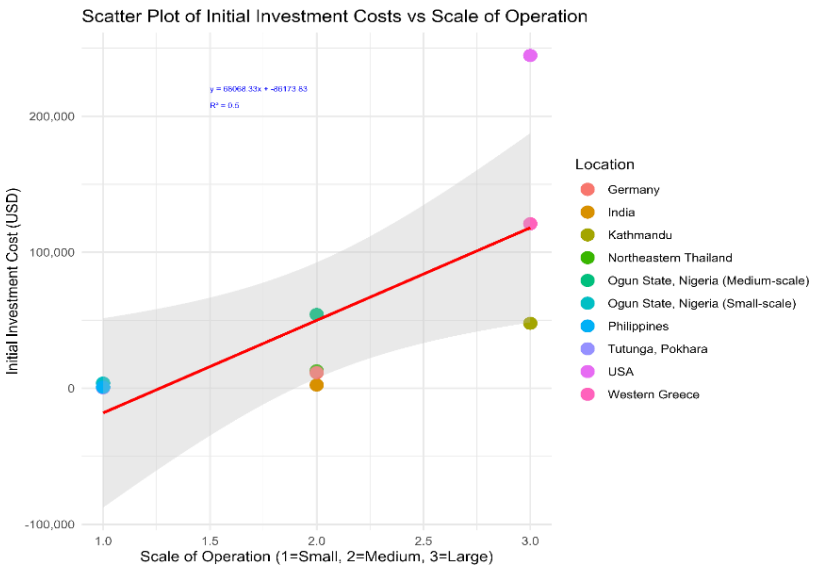

Figure 1. Scatter plot for initial investment costs vs scale of operation

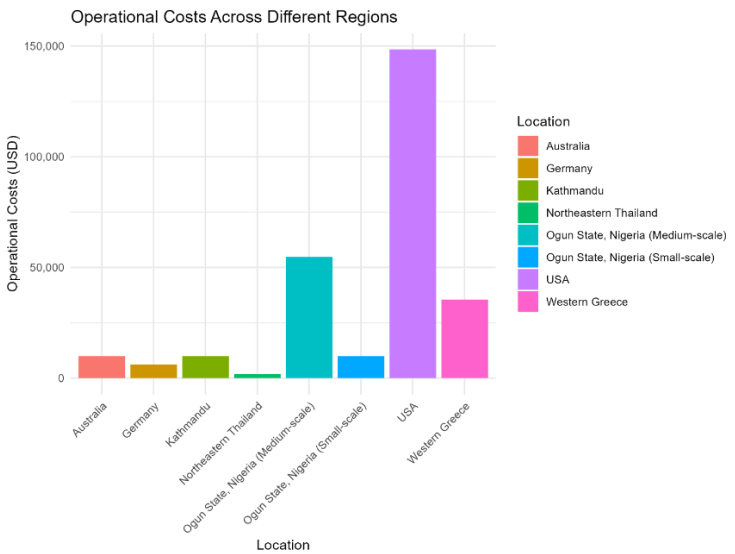

Figure 2. Operational Costs across different regions

Table 1. Revenue and Profitability Analysis

Location	B/C Ratio	NPV	IRR (%)	Payback Period (Years)
Kathmandu (Thapa,2021)	2.32	Positive	0.27	-
Pokhara		Positive	-	Quick payback periods
India (Mishra et al., 2024)	-	-	-	INR 1,05,000 profit; Higher profitability compared to traditional farming
USA (Alder et al., 2000)	-	Potential 12.5% return	-	7.5 years
Australia (Filho et al., 2017)	-	-	-	Highest annual profit of $18,880 using Furlani's mineral solution
Northeastern Thailand (Urayama et al., 2015)	-	57% higher profit in the rainy season	95% higher in the dry season compared to open-field cultivation	-
Germany (Souza et al.., 2023)	-	15575.63	0.3287	3.69 years
Western Greece (Michalis et al., 2023)	-	EUR 25,270.67	0.13	5 years
Ogun State, Nigeria (Folorunso et al., 2023)	-	€42,895 (Small-scale), €331,465 (Medium-scale)	0.83	-
Philippines (Sace et al., 2024)	1.56	Ph P 129,084.05	-	2.1 years

Souza et al., 2023). Notably, Northeastern Thailand exhibits significant profitability with up to 95% higher returns in the dry season compared to open-field cultivation (Urayama et al., 2017). The positive NPVs and relatively short payback periods in several locations suggest that hydroponic farming can be a viable investment, particularly when optimized for local conditions.

CHALLENGES AND SOLUTIONS

Operational Challenges

The most frequently reported operational challenge in hydroponic farming is the high initial investment/setup costs, mentioned 11 times, followed by dependency on energy/electricity and market price fluctuations/volatility, reported 5 and 4 times, respectively.

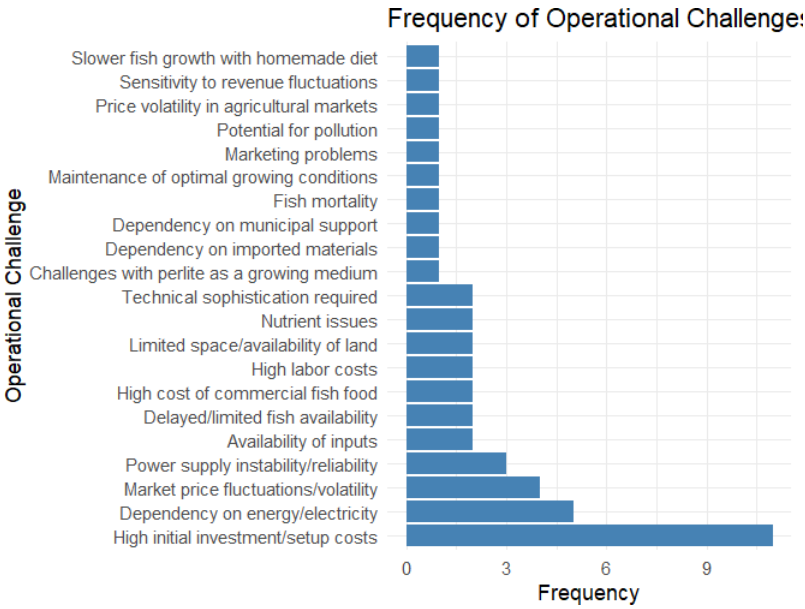

Figure 3. Operational challenge in hydroponic farming

The high frequency of challenges related to initial investment/setup costs indicates that capital intensity is a significant barrier to entry or scaling in hydroponic farming. The dependency on energy/electricity and market price fluctuations further emphasizes the need for reliable infrastructure and stable economic conditions to maintain profitability and operational stability. Addressing these challenges could enhance the viability and sustainability of hydroponic farming operations, potentially lowering entry barriers and operational risks.

Mitigation Strategies

The most frequently cited mitigation strategies include the use of local resources/materials (6 mentions), renewable/alternative energy sources (5 mentions), and advanced technology/innovation (4 mentions). Less frequently mentioned strategies involve public-private partnerships (2 mentions), agricultural insurance (1 mention), and the utilization of small urban spaces (1 mention).

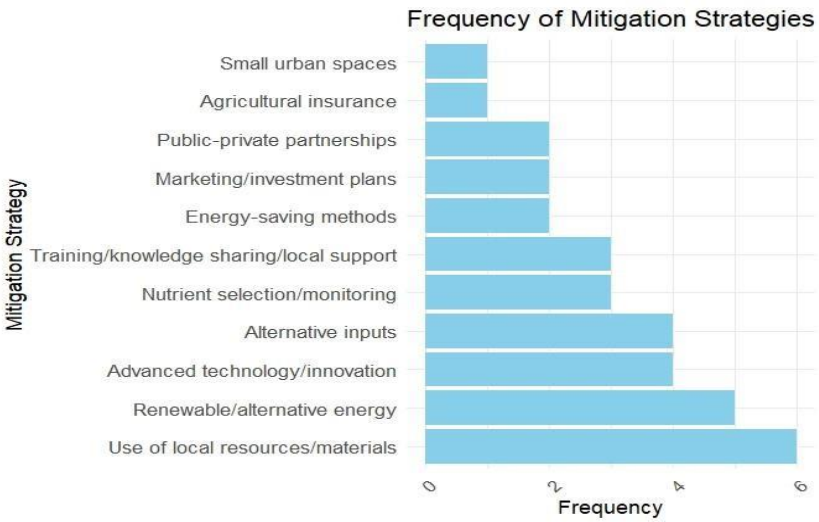

Figure 4. Mitigation strategies

MARKET TRENDS AND CONSUMER PREFERENCES IN LITERATURE

The bar chart shows that local markets are the most frequently used market channel, with a total frequency of 8. Self-consumption is the second most common market channel, with a frequency of 4. Although local markets and direct restaurant sales dominate distribution channels, reflecting consumer preferences for fresh, locally sourced produce. However, challenges persist in expanding these networks, with online sales and wholesale underutilized.

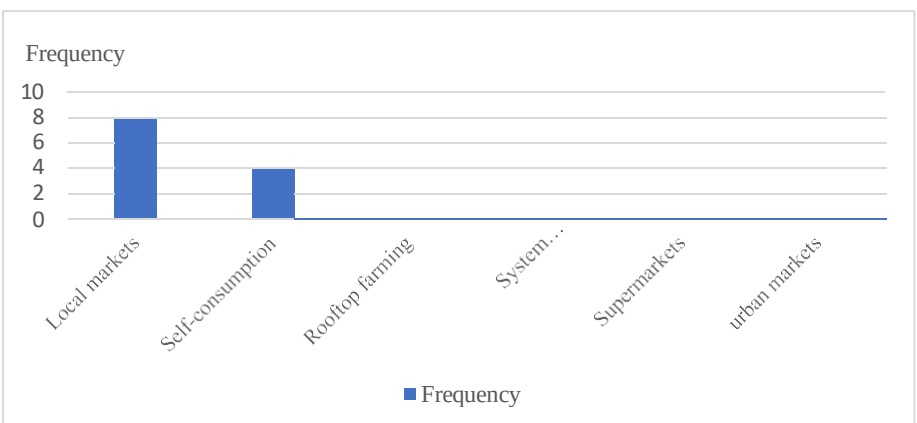

Figure 5. Different marketing channels

Consumer Preferences

The primary consumer preference for hydroponic produce is "Fresh, locally grown," highlighted 8 times, demonstrating the importance of freshness and local sourcing. There is growing demand for hydroponic produce, perceived as high-quality, pesticide-free, and sustainable. These attributes align with global consumer trends prioritizing health and environmental considerations.

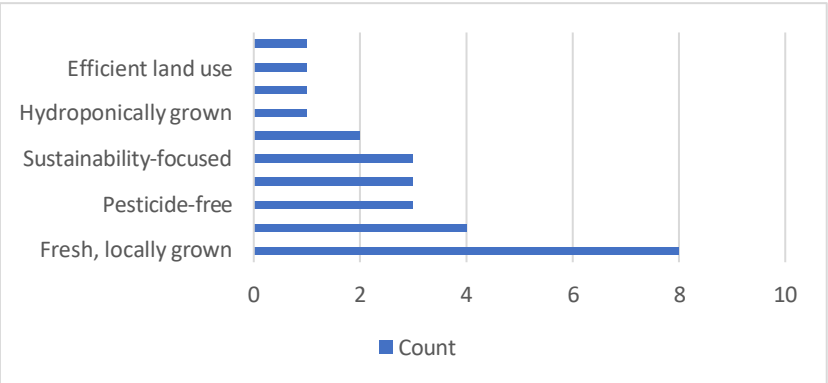

Figure 6. Consumer preference for hydroponic produce

CONCLUSION

The study aligns with global trend, where hydroponic farming faces similar economic and operational hurdles. Yet, specific to Kathmandu are localized challenges such as limited technical capacity and unique market conditions, which affect feasibility. Global success stories emphasize the role of government support and technological innovation in overcoming these barriers.

The study also highlights significant initial setup cost (NPR 1,000,000-20,000,000), deterring widespread adoption. The costs align with global findings, where scalability often dictates profitability. Ongoing operational costs, driven by energy, nutrient solutions, and maintenance, further challenge small-scale farmers. Hydroponics systems, despite high costs, demonstrate long-term profitability through efficient resource use and higher crop yields. Lettuce, identified as the most productive crop in Kathmandu, showcases the system's capability for generating consistent revenue streams. Despite of shortage in skilled labor, seasonal water scarcity, and lack of financial incentives hydroponic farming presents a promising avenue for sustainable urban agriculture in Kathmandu Valley. While economic and operational challenges persist, strategic interventions can unlock its potential, contributing to food security and environmental sustainability.

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