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Environmental and Nutritional Benefits of Rooftop Gardening in Dhaka City for Promoting Sustainable Development Goals 2, 3, 11, 12, and 13

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ABSTRACT

Rooftop gardening (RTG) is emerging as a viable urban strategy in Dhaka City to address pressing environmental and nutritional challenges associated with rapid urbanization. This study explores the dual benefits of RTG – environmental enhancement and improved household nutrition – within the framework of Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-being), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action). This research was conducted in the Dhanmondi and Mohammadpur areas of Dhaka, employing a mixed-methods approach involving 100 randomly selected rooftop gardeners from a target population of 250. Data collection occurred between March and May 2024 through structured interviews, focus group discussions, and key informant interviews. Quantitative analysis revealed that 49% of respondents perceived moderate environmental benefits, while 25% reported high benefits. Key ecological outcomes included increased rooftop vegetation (mean perception index = 245), reduction in indoor temperatures, and improved biodiversity. On the nutritional front, 65% of respondents reported significant benefits, with 63% acknowledging healthier dietary habits and 75% meeting a substantial portion of their vegetable needs through rooftop cultivation. Statistical analysis indicated strong positive correlations between both environmental and nutritional benefits with respondents' education level (r = 0.628 and r = 0.544, respectively) and gardening experience (r = 0.946 and r = 0.532, respectively) at the 1% significance level. However, challenges such as limited technical knowledge (PI = 231), seasonal water scarcity, high input costs, and pest management difficulties were cited by over half of the participants. The study concludes that rooftop gardening holds significant promise for promoting sustainable urban development, food security, and ecological well-being, and recommends policy integration, technical training, and resource support to maximize its impact across Dhaka and similar urban contexts.

Keywords: *Rooftop gardening, urban sustainability, environmental resilience, nutritional benefits, SDGs, Dhaka.*

INTRODUCTION

Rapid urbanization in developing megacities like Dhaka has imposed severe environmental and nutritional strains on urban populations, largely due to declining green spaces, air pollution, food insecurity, and the degradation of local ecosystems. As concrete expansion continues to replace arable land, urban agriculture, particularly rooftop gardening (RTG), has gained attention as a promising strategy to mitigate these challenges while advancing global sustainability targets.

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Rooftop gardening is increasingly recognized not only for its contribution to food production and dietary diversity but also for its potential to enhance environmental resilience, urban liveability, and public health–especially in dense cities of the Global South [18; 20]. In Dhaka, where the effects of climate change, air pollution, and food insecurity converge, rooftop gardening offers a localized and scalable solution aligned with Sustainable Development Goals (SDGs) 2 (Zero Hunger), 3 (Good Health and well-being), 11 (Sustainable Cities and Communities), 12 (Responsible Consumption and Production), and 13 (Climate Action). Urban agriculture on rooftops enhances household access to fresh produce, improves dietary diversity, and reduces dependency on external food supply chains [14; 5]. It also supports improved food resilience during crises such as the COVID-19 pandemic, when many households in Dhaka relied on homegrown produce to meet nutritional needs [7]. Beyond nutrition, rooftop gardens function as urban green infrastructure that contributes to multiple ecosystem services. These include carbon sequestration, improved air quality, noise reduction, and mitigation of the Urban Heat Island (UHI) effect. Empirical studies have demonstrated that RTG can reduce rooftop surface temperatures by up to 9°C and significantly lower indoor temperatures, reducing energy demands for cooling [10; 8]. RTG also fosters biodiversity by providing microhabitats for birds, pollinators, and beneficial insects within the urban fabric [15].

The benefits of RTG are increasingly being recognized in urban planning, yet its integration into formal policy frameworks remains limited in Bangladesh. While many residents and agriculture professionals support the idea of urban rooftop cultivation, the lack of institutional support, technical knowledge, and financial incentives has hindered its wider adoption [20]. Moreover, rooftop suitability varies based on structural conditions, water availability, sunlight exposure, and household motivation, which must be considered in future scaling efforts [22]. Research indicates that the success of RTG practices is closely linked to socio-demographic variables such as education, income, gender, and homeownership status [11]. Understanding these variables is essential for designing inclusive policies and programs that ensure equitable access to the benefits of rooftop gardening. Additionally, residents perceive RTG as not only a food source but also a culture and psychological asset, offering recreational value, mental well-being, and community cohesion [23]. Economically, rooftop gardens have shown potential in generating modest household income and reducing grocery expenditures. Current RTG practices in Dhaka could contribute around BDT 362 million annually, with a large share of produce consumed by the growers themselves [14]. From a sustainability perspective, these benefits support the city's transition towards circular food systems and resource-efficient urban models, as promoted in SDG 12 [31]. However, several challenges persist in the mainstreaming of RTG practices. These include limited technical training, water scarcity, lack of policy incentives, and poor coordination between municipal authorities and citizens. Studies suggest that overcoming these challenges requires integrated planning, financial subsidies, and institutional reforms to include urban agriculture in city planning frameworks [1; 6]. This study aims to assess both the environmental and nutritional benefits of rooftop gardening in Dhaka, examine the socio-demographic and structural factors influencing these outcomes, and identify the barriers limiting its widespread adoption. By generating context-specific evidence, the study will contribute to the growing body of urban sustainability research and offer actionable insights for policy integration, particularly in alignment with the SDGs.

METHODOLOGY

Study Area:

The present study was conducted in Dhanmondi & Mohammadpur, an urban neighbourhood in Dhaka City, selected due to its growing engagement in rooftop gardening practices and its relevance to urban environmental and nutritional challenges. The area features a high density of residential buildings, limited green space, and increased public interest in sustainable urban agriculture, making it a suitable site for assessing the benefits of rooftop gardening in relation to SDGs 2, 3, 11, 12, and 13.

Population and sample:

The target population consisted of households engaged in rooftop gardening within Dhanmondi & Mohammadpur. From a population of approximately 250 rooftop gardeners, a total of 100 respondents were randomly selected using simple random sampling to ensure objective and unbiased representation in the study.

Collection of Data:

Data were collected using a structured interview schedule developed by the research team. The instrument was pilot-tested with a subset of rooftop gardeners to evaluate clarity, relevance, and response accuracy. Necessary revisions were made based on feedback prior to full deployment. Primary data were collected between March and May 2024, through direct interviews conducted at the respondents' residences. To enrich the findings, Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs) were carried out using pre-designed checklists. These qualitative tools explored urban gardening practices, perceived environmental and nutritional outcomes, and barriers to sustainability.

Measurement of independent variables:

This study incorporated seven independent variables to examine their influence on the environmental and nutritional benefits of rooftop gardening among urban households. These variables were selected based on their relevance to household-level gardening practices and their potential impact on sustainability outcomes. Age was measured in completed years as reported by each respondent. This variable served to capture generational differences in participation and engagement in rooftop gardening. Educational level was assessed by recording the total number of years of formal schooling successfully completed by the respondent, providing an indicator of academic attainment. Family size was defined as the total number of individuals living permanently in the household, including the respondent, spouse, children, and any dependent family members. Gender was recorded based on the respondent's self-identified sex, categorized as male or female, to explore gender-based patterns in the gardening behaviour and benefit perception. Occupation was determined by identifying the respondent's primary income-generating activity. Categories included formal employment, self-employment, household-based business, or informal labour, offering insights into the socio-economic background of participants. Communication media contact was measured using a structured four-point scale to assess the frequency of interaction with the agricultural or environmental information sources. These included television programs, radio broadcasts, online platforms, printed materials, and outreach by extension personnel. Responses were coded as: 1 = not at all, 2 = seldom, 3 = occasionally, and 4 = frequently. Gardening experience was quantified as the number of years the respondent has been engaged in rooftop gardening, either continuously or intermittently, to capture accumulated practical knowledge and exposure to urban cultivation techniques. All independent variables were collected through a structured interview schedule administered directly to respondents. Descriptive statistics, including frequencies, means, and standard deviations, were used to summarize the data. To examine the relationships between these independent variables and the benefit indices, Pearson's product-moment correlation coefficients were computed. Statistical significance was evaluated at both the 5% ($p < 0.05$) and 1% ($p < 0.01$) levels to test the study's hypotheses.

Measurement of dependent variables:

The dependent variables—Environmental Benefits of Rooftop Gardening and Nutritional Benefits of Rooftop Gardening—were each measured using ten predefined indicator statements that captured respondents' perceptions of ecological and dietary outcomes.

To quantify these perceptions, a four-point ordinal scale was employed, with the following values: 0 = Disagree, 1 = Agree, 2 = Slightly Agree, and 3 = Strongly Agree. This scale enabled the systematic evaluation of individual responses while maintaining consistency across participants. The scores for each variable were aggregated and subsequently transformed into a standardized score ranging from 0 to 100, allowing for comparative and statistical analysis.

RESULT AND DISCUSSION

A. Socio-economic profile of the respondent:

Table 1 reveals that the majority of rooftop gardeners in Dhaka are older individuals, with 57% above 55 years of age, reflecting a trend where elderly populations are more engaged in home-based environmental activities – a pattern also observed in a study in Khulna City [21]. Educational attainment among respondents was comparatively high, with 47% holding a graduate degree. This suggests that individuals with higher education are more inclined to practice rooftop gardening, likely due to their increased access to information and better understanding of its benefits— a relationship similarly reported in an earlier study [9].

Regarding family structure, 56% of respondents came from medium-sized households (5-6 members). The availability of multiple family members in such households may create a supportive environment for managing gardening activities, as earlier research also indicates the positive role of household size in sustaining home-based practices [25]. A substantial proportion of rooftop gardeners were female (64%), highlighting women's active engagement in household food production and small-scale urban cultivation. This participation reflects their important contribution to improving household nutrition, a relationship similarly supported in earlier research [14]. Communication access was moderate among respondents (51%). Limited access may reduce opportunities to receive information on sustainable gardening methods and related support services, a challenge also noted in earlier research on communication and outreach barriers [20]. Lastly, 48% of gardeners reported more than 7 years of experience, showing long-term engagement, a factor linked with higher productivity and environmental stewardship in studies [13]. Together, these socio-economic traits suggest that experienced, educated, and female-led households are key actors in the adoption and sustainability of rooftop gardening in Dhaka.

Table 1. Profile of the Rooftop gardeners

Characteristics	Categories	Rooftop gardeners (%)	Observed range	Mean	SD
Age (year)	Young (up to 35)	22	19-71	48.85	14.59
	Middle (36 -55)	21			
	Old (>55)	57			
Education (score)	Illiterate (1)	2	1-5	4.09	1.07
	Primary (2)	9			
	Secondary (3)	14			
	Higher Secondary (4)	28			
	Graduate (5)	47			
Family size (member number)	Small (up to 4)	20	2-8	5.52	1.30
	Medium (5-6)	56			
	Large (>7)	24			
Profession (score)	Government employee (1)	21	1-5	2.79	1.15
	Private employee (2)	15			
	Business (3)	24			
	Others (4)	36			
Gender (Score)	Male (1)	36	1-2	1.64	0.48
	Female (2)	64			
Communication media (score)	Low (up to 8)	39	3-18	9.54	2.89
	Medium (9-13)	51			
	High (>13)	10			
Experience (Years)	Low (up to 4)	18	1-11	6.62	5.49
	Medium (5-7)	31			
	High (>7)	48			

B. Time spent on rooftop gardening

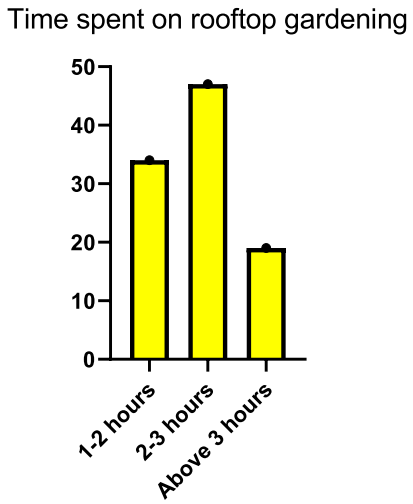

Figure 1. Distribution of Time Spent on Rooftop Gardening

The results presented in Figure 1 show that the highest proportion of respondents (47%) spent 2-3 hours daily on rooftop gardening, followed by 34% who spent 1-2 hours, and only 19% who reported investing more than 3 hours. This indicates a moderate to high level of engagement among most rooftop gardeners. Similar patterns were noted in earlier studies [13], which observed that time spent on gardening is closely linked to perceived benefits and available resources. Additional research [14] also emphasized that in urban Dhaka, gardeners tend to integrate rooftop cultivation into their daily routines to meet food and environmental needs.

C. Growing Seasons on the rooftop

The data in Figure 2 indicates that the majority of rooftop gardeners (54%) cultivate crops during the Rabi season, while 35% engage in gardening during the Kharif season, and only 11% maintain year-round cultivation.

This seasonal preference may be attributed to favourable climatic conditions and lower pest pressure in the Rabi period. Similar seasonal trends in rooftop gardening were observed in a study, which noted that winter conditions often support better yields and crop diversity in urban rooftop settings.

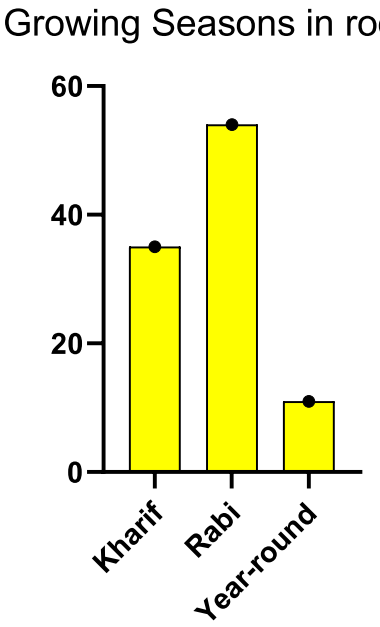

Figure 2. Growing Seasons in Rooftop Gardens

D. Pest and Disease Incidence in Rooftop Gardens

Table 2. Incidence of Pests and Diseases in Rooftop Gardens

SL	Disease	Pest
01	Powdery Mildew	Aphids
02	Downy Mildew	Whiteflies
03	Late Blight	Fruit Flies
04	Cercospora Leaf Spot	Mealybugs
05	Anthracnose	Spider Mites
06	Fusarium Wilt	Leaf Miners
07	Damping-off	
08	Sooty Mold	

Table 2 illustrates the presence of several common pests and diseases affecting rooftop gardens. Notable diseases included powdery mildew, downy mildew, late blight, and Fusarium wilt, white aphids, whiteflies, mealybugs, and leaf miners were frequently reported pests. These findings align with observations from earlier studies [21], which identified leaf curling, dieback, and viral infections as major disease challenges in urban rooftop gardens, alongside pests like mealybugs and ants. Additional research [25] similarly emphasized inadequate pest and disease management practices among rooftop growers, which can compromise productivity and sustainability. The prevalence of these pests and diseases underlines the importance of improved training and integrated pest management (IPM) practices for urban farmers.

E. Use of pesticides for controlling pest and diseases of fruits and vegetables in the existing rooftop garden

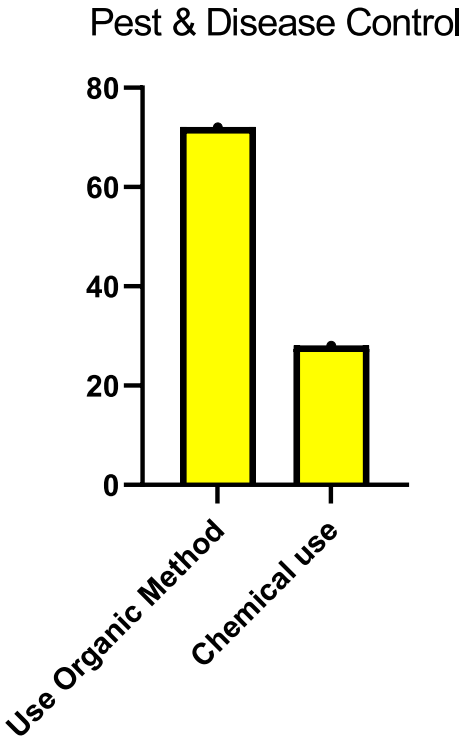

Figure 3. Use of Pesticides to Control Pests and Diseases in Existing Rooftop Fruit and Vegetable Gardens

Figure 3 reveals that a significant majority (72%) of rooftop gardeners in the study area preferred organic methods for managing pests and diseases, while only 28% relied on chemical pesticides. This trend toward organic practices reflects growing environmental awareness and concern for food safety among urban gardeners. Recent studies [6] indicate that the use of organic inputs in rooftop gardening is gaining popularity due to their ecological benefits and alignment with urban sustainability goals. The preference for organic management also supports several Sustainable Development Goals (SDGs), particularly SDG 3 (Good Health and Well-being), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action), by reducing chemical exposure and promoting environmentally friendly food systems.

F. Environmental Benefits of Rooftop Garden

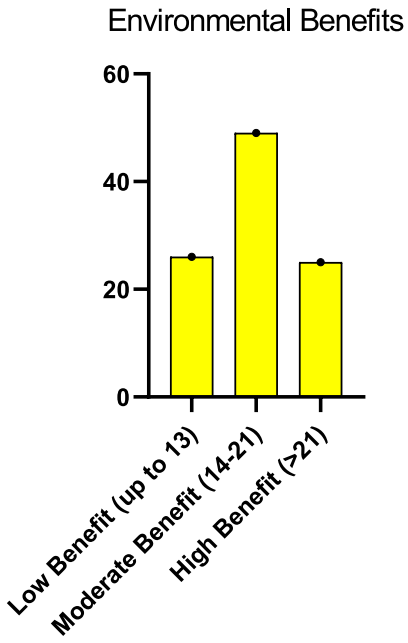

Figure 4. Distribution of Environmental Benefits in Rooftop Gardens

Figure 4 presents the environmental benefits perceived by rooftop gardeners in Dhaka. The results show that 49% of respondents experienced moderate benefits, followed by 26% reporting low benefits and 25% indicating high benefits. These outcomes suggest that while rooftop gardening is not yet fully optimized, it is increasingly recognized for its contribution to urban environmental sustainability. Rooftop gardens have been shown to enhance air quality, reduce heat stress, and increase urban greenery, especially in densely built-up cities [4]. Such benefits directly support SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action) by promoting green infrastructure and climate resilience. Moreover, earlier studies [3] highlights that rooftop gardening plays a significant role in enhancing energy efficiency by reducing the cooling demand of buildings, thereby functioning as a passive strategy for climate mitigation in urban environments. Integrating vegetated spaces into city infrastructure not only improves thermal regulation but also aligns with the principles of sustainable urban planning. Furthermore, recent research [26] emphasizes that increased exposure to greenery positively influences both physical and mental health, contributing to overall well-being. These environmental and health-related outcomes directly support the achievement of Sustainable Development Goals (SDGs), particularly SDG 3 (Good Health and Well-being) and SDG 13 (Climate Action). In the context of highly urbanized areas such as Dhaka, promoting rooftop gardening offers measurable ecological benefits while advancing the broader agenda of sustainable urban development.

G. SDG-Aligned Ranking of Environmental Benefits of Rooftop Gardening in Dhaka City

The analysis of perceived environmental benefits reveals that the most significant advantage identified by participants was the increase in green cover and ecological value (Rank 1), with a perception index of 245. This finding is consistent with previous research [12], which highlights that rooftop vegetation enhances urban biodiversity and provides ecological niches that contribute to healthier urban ecosystems. The expansion of greenery in densely populated areas like Dhaka supports SDG 11 (Sustainable Cities and Communities) by promoting inclusive and sustainable urban environment.

The second-highest ranked benefit was the contribution of rooftop gardens to reducing indoor temperatures in buildings (Index 225). This aligns with research [19], which demonstrates that green roofs significantly lower rooftop surface temperatures, thereby reducing the building's cooling energy demands. Such passive cooling supports SDG 13 (Climate Action) by mitigating the urban heat island effect and reducing greenhouse gas emissions from energy use.

Table 3. Rank Order of Perceived Environmental Benefits from Rooftop Gardening in Relation to Sustainable Development Goals in Dhaka City

Sl. No.	Environmental Benefits	Participant N=100				Perceptions Index	Rank Order
		(3)	(2)	(1)	(0)		
1	Rooftop gardens contribute to a reduction in indoor temperatures in buildings	50	30	15	5	225	**2nd**
2	Rooftop vegetation helps improve local air quality in urban areas	40	30	18	12	198	6th
3	The presence of rooftop gardens reduces dust levels in surrounding environments	35	37	18	10	197	7th
4	Rooftop gardens support urban biodiversity by attracting birds and pollinators	48	27	22	3	220	**3rd**
5	Buildings with rooftop gardens experience lower ambient noise levels	27	23	35	15	162	9th
6	Composting of organic waste is commonly practiced in rooftop gardens	45	28	21	6	212	**4th**
7	Rooftop gardens are effective systems for harvesting rainwater	17	24	54	4	153	10th
8	Rooftop gardening contributes to mitigating the urban heat island effect.	44	32	14	10	206	**5th**
9	Rooftop gardens increase green cover and ecological value in cities.	55	35	10	0	245	**1st**
10	Rooftop gardening promotes environmental awareness in urban communities	37	30	24	9	195	8th

Ranked third was the support of urban biodiversity through the attraction of pollinators (Index 220). A study in Singapore, where rooftop gardens became vital habitats for birds and insects, enhancing urban biodiversity [28]. This aligns with SDG 15 (Life on Land) and also indirectly supports food production (SDG 2) by maintaining pollinator populations.

Composting of organic waste in rooftop gardens (Rank 4, Index 212) was another major benefit. This reflects principles of the circular economy, promoting sustainable waste management in line with SDG 12 (Responsible Consumption and Production). The practice not only diverts waste from landfills but also improves soil health and productivity in urban agriculture [20].

The fifth-ranked benefit was rooftop gardening's role in mitigating the urban heat island effect (Index 206). Green infrastructure in cities contributes to localized cooling and thermal regulation, which enhances urban resilience against climate-related risks. This outcome further underscores the role of rooftop gardening in achieving SDG 13 by integrating nature-based solutions into urban planning [26].

H. Nutritional Benefits of Rooftop Garden

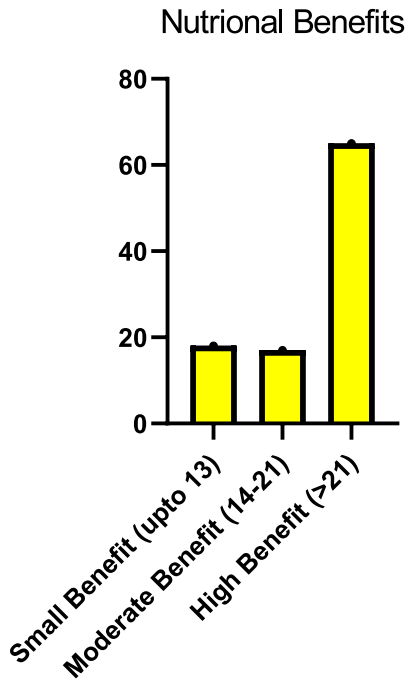

Figure 5. Distribution of Nutritional Benefits in Rooftop Gardening

The study reveals that 65% of respondents experienced high nutritional benefits from rooftop gardening, indicating its significant role in enhancing household dietary diversity and food security in urban areas. Rooftop gardens offer urban residents a direct source of fresh fruits and vegetables, which is crucial for meeting daily micronutrient requirements and reducing dependence on chemically treated market produce [3]. In densely populated cities like Dhaka, where access to affordable and safe food is a growing concern, such practices align with Sustainable Development Goal 2 (Zero Hunger) by supporting localized, sustainable food systems [14]. Additionally, rooftop gardening promotes self-sufficiency in food production, reducing the carbon footprint associated with long supply chains and food transport, thereby contributing to SDG 12 (Responsible Consumption and Production). The majority of rooftop gardeners in Dhaka consume a substantial portion of their produce, which not only enhances nutritional intake but also reinforces resilience against urban food insecurity [24]. Furthermore, the cultivation of organic produce in rooftop settings fosters health-conscious food choices, directly supporting SDG 3 (Good Health and Well-being). Studies have shown that homegrown vegetables are typically richer in nutrients due to reduced post-harvest losses and minimal processing [2]. The nutritional impact is particularly relevant for low-income urban families, who benefit from cost savings and increased access to diverse food crops. Thus, rooftop gardening emerges as a viable strategy for integrating nutrition-sensitive agriculture into urban planning, reinforcing sustainable food systems in alignment with multiple SDGs.

I. SDG-Aligned Ranking of Nutritional Benefits from Rooftop Gardening in Dhaka City

The findings demonstrate that rooftop gardening plays a pivotal role in enhancing household nutrition in Dhaka. A majority of respondents (63%) identified the promotion of healthier food consumption patterns as the most important benefit (Rank 1, PI = 249). This observation aligns with the targets of SDG 3 (Good Health and Well-being) by facilitating dietary diversification through improved access to fresh, safe, and pesticide-free produce. As emphasized by previous research [13], urban horticulture contributes significantly to dietary quality by enabling regular consumption of nutrient-rich foods, especially in areas where access to safe market produce is limited.

The second-ranked benefit (PI = 248) pertains to the consistent availability of fresh fruits and vegetables, underscoring rooftop gardens as a dependable source of nutrition, particularly in times of market disruptions or economic uncertainty. This contributes directly to SDG 2 (Zero Hunger) by improving household food self-sufficiency and reducing reliance on commercial food systems. Another study found that a significant proportion of urban households in Dhaka derive up to 75% of their vegetable intake from rooftop gardens, illustrating their tangible impact on food security [14].

The cultivation of seasonal and indigenous crops ranked third (PI = 247), reflecting the role of rooftop gardening in preserving local agrobiodiversity and promoting more sustainable, traditional diets. These crops often require fewer inputs, are better adapted to local conditions, and are nutritionally dense, thereby supporting SDG 12 (Responsible Consumption and Production). Integrating such crops into urban gardening practices contributes to both environmental sustainability and dietary diversity [24].

Table 4. Rank Order of Perceived Nutritional Benefits from Rooftop Gardening in Relation to Sustainable Development Goals in Dhaka City

Sl. No.	Nutritional Benefits	Participant N=100				Perceptions Index	Rank Order
		(3)	(2)	(1)	(0)		
1	Rooftop gardens provide a reliable source of fresh vegetables and fruits	58	32	10	0	248	**2nd**
2	Rooftop food production reduces household dependence on market produce	56	27	9	8	231	**5th**
3	Rooftop gardening increases the diversity of available food crops.	58	26	13	3	239	**4th**
4	Rooftop gardens contribute to improved household dietary quality	21	62	15	2	202	9th
5	Produce from rooftop gardens is typically free from chemical (pesticides)	52	28	15	5	227	6th
6	Rooftop gardening helps reduce food-related household expenditures	42	26	32	0	210	8th
7	Rooftop gardening promotes healthier food consumption patterns	63	24	12	1	249	**1st**
8	Rooftop produce contributes significantly to household food security.	23	52	20	5	193	10th
9	Rooftop gardens enable the cultivation of seasonal and indigenous crops	61	25	14	0	247	**3rd**
10	Rooftop gardening aligns with principles of safe, sustainable nutrition	45	30	20	5	215	7th

Ranked forth (PI = 239), the diversification of available food crops enhances the nutritional adequacy of urban diets by addressing micronutrient deficiencies, which are prevalent in low-resource settings. Increased crop variety not only enriches household diets but also improves community resilience, aligning with SDG 11 (Sustainable Cities and Communities) through localized, adaptive food systems [3].

Finally, the fifth-ranked benefit (PI = 231) highlights a reduction in dependence on market-based produce. This finding is particularly relevant in low-income urban contexts, where the cost and quality of market food are major concerns.

J. Perceptions of Rooftop Gardening and Its Role in Advancing Sustainable Development Goals

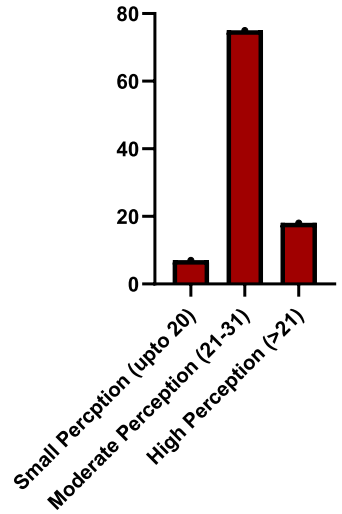

Figure 6. Perceptions of Rooftop Gardening and Its Contribution to the SDGs

The results indicate that a majority of respondents (75%) held a moderate perception of rooftop gardening and its role in advancing Sustainable Development Goals (SDGs), while only 18% exhibited high awareness, and 7% had low perception. These findings suggest that although rooftop gardening is gaining traction as a sustainable urban practice, there remains a gap in deep public understanding of its multifaceted benefits.

Similar trends have been reported in urban Bangladesh, where around 70% of citizens demonstrated a favourable attitude toward rooftop gardening, driven by its environmental and nutritional benefits [16]. However, knowledge levels and institutional support remain inconsistent, limiting full-scale adoption [20]. From the SDG perspective, moderate perception levels suggest a need for enhanced policy integration and public awareness to fully align urban gardening practices with goals such as SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-being), and SDG 11 (Sustainable Cities and Communities).

Moreover, the positive correlation between environmental awareness and rooftop gardening practices underscores the potential of this approach as a participatory sustainability tool in densely populated cities like Dhaka [15]. However, to leverage this potential, broader stakeholder engagement and strategic policy inclusion are essential.

K. Problem faced by the respondents in rooftop gardening practices

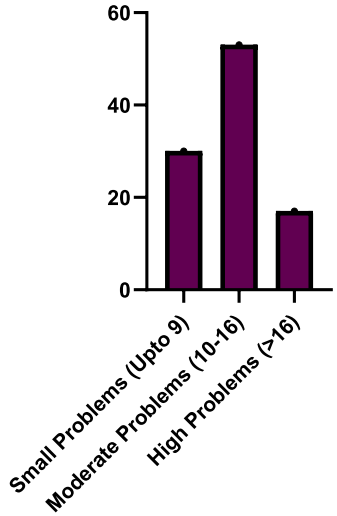

Figure 7. Constrains in Rooftop Gardening Reported by Respondents

The study reveals that a significant proportion (53%) of rooftop gardeners in Dhaka reported encountering moderate difficulties in managing their rooftop gardens, while 30% experienced minimal issues, and only 17% reported severe challenges. These difficulties primarily stem from pest infestations, inconsistent water availability, extreme heat exposure, and inadequate rooftop infrastructure. Such obstacles present tangible barriers to the broader adoption of rooftop gardening, which otherwise holds considerable potential for enhancing urban food security (SDG 2) and promoting sustainable urban development (SDG 11).

The sustainability of rooftop gardening practices in densely populated areas is often compromised by a lack of technical expertise, limited policy support, and vulnerability to climatic stressors [17]. In line with this, other researchers emphasize that urban agriculture initiatives in the Global South frequently operate in the absence of formal support mechanisms, exposing practitioners to infrastructural deficiencies and environmental uncertainties [27]. These findings underscore the need for integrated urban planning and policy interventions to address the systemic barriers hindering the growth of rooftop gardening in rapidly urbanizing contexts like Dhaka.

L. Multifaceted Constraints Faced by Rooftop Gardeners

The analysis of constraints faced by rooftop gardeners in Dhaka revealed that the most pressing challenges were the lack of technical knowledge and skill (PI = 231), limiting effective crop management and sustainable practices. This aligns with Sheel *et al*. (2019), who emphasized the importance of training in enhancing rooftop farming outcomes in urban Bangladesh. The second most critical issue was water scarcity during dry seasons (PI = 228), a factor exacerbated by inadequate irrigation infrastructure [29]. High input costs, including soil, compost, and containers (PI = 227), ranked third, reflecting economic barriers commonly faced by informal urban growers [27]. Pest and disease management emerged as the fourth major issue (PI = 224), with the exposure and limited biodiversity increasing susceptibility [24]. Finally, time constraints due to household and professional obligations (PI = 191) ranked fifth, echoing concerns raised by earlier studies [17] on the limited time urban residents can devote to gardening. Collectively, these challenges highlighted structural, technical, and socio-economic gaps that must be addressed to optimize rooftop gardening's contribution to SDGs 2, 11, and 13.

Table 5. Rank Order of Constraints Faced by Rooftop Gardeners

Sl. No.	Constraints	Participant N=100				Perceptions Index	Rank Order
		(3)	(2)	(1)	(0)		
1	Lack of space on the rooftop limits the expansion of gardening activities	40	23	24	13	190	6th
2	Water shortage during dry months makes rooftop gardening difficult	59	18	15	8	228	**2nd**
3	High temperatures and strong winds on rooftops damage plants	35	34	15	16	188	7th
4	Lack of technical knowledge and skills hinders effective gardening	62	15	15	8	231	**1st**
5	Cost of inputs (e.g., soil, compost, containers) is too high	56	26	7	11	227	**3rd**
6	Pests and diseases are difficult to manage in rooftop gardens	51	25	21	3	224	**4th**
7	Insufficient time due to work or household responsibilities affects gardening	48	14	19	9	191	**5th**
8	Rooftop structural limitations (e.g., load-bearing concerns) restrict gardening	24	18	44	14	152	10th
9	Lack of support or guidance from agricultural extension services	27	39	25	9	184	8th
10	Difficulty in accessing quality seeds or planting materials	22	20	54	4	160	9th

M. Vegetables, Fruits, and Medicinal Plants produced in the current RTG's in Dhaka

Rooftop gardening in Dhaka demonstrates a significant degree of agrobiodiversity, encompassing a variety of vegetables such as red amaranth, Malabar spinach, eggplant, tomato, and okra. In addition to these, fruits including guava, papaya, banana, and pomegranate are commonly cultivated. Moreover, the incorporation of medicinal and culinary herbs such as aloe vera, turmeric, ginger, and mint suggest that rooftop gardens serve multifunctional roles—addressing both nutritional needs and basic healthcare at the household level. This diverse cultivation contributes meaningfully to dietary diversity and enhances urban food resilience. Empirical evidence from recent studies [14] indicates that rooftop gardens in Dhaka can provide up to 75% of a household's fruit and vegetable requirements, underscoring their relevance in supporting household food security and advancing Sustainable Development Goal (SDG) 2 (Zero Hunger). Complementing this, additional research [31] identified rooftop green spaces in Dhaka as critical urban ecosystems that deliver a range of services—provisioning, regulatory, and cultural—particularly through the cultivation of edible and medicinal species. Collectively, these findings highlight the strategic potential of rooftop gardening in urban sustainability planning and food systems transformation in rapidly urbanizing cities.

Table 6. Vegetables, Fruits, and Medicinal Plants Produced in Current Rooftop Gardens (RTGs) in Dhaka

SL	Vegetables produced in rooftop garden	Fruits produced in rooftop garden	Edible and Medicinal Plants
1	Red amaranth	Papaya	Aloe vera
2	Malabar spinach	Guava	Turmeric
3	Spinach	Banana (dwarf varieties)	Ginger
4	Bottle gourd	Pomegranate	Holy basil
5	Ridge gourd	Mango (container varieties)	Mint
6	Eggplant	Strawberry	
7	Tomato	Dragon fruit	
8	Green chili	Litchi	
9	Cucumber	Sapota	
10	Okra	Jujube	
11	Radish	Fig	
12	Pumpkin		
13	Coriander		
14	Cherry tomato		
15	Lettuce		
16	Capsicum		
17	Cauliflower		
18	Beans (French bean, yard long bean)		

N. Relationships between the selected characteristics of the respondents and Environmental Benefits

The results of the correlation analysis indicate that among the selected independent variables, level of education (r = 0.628) and gardening experience (r = 0.946) exhibit statistically significant positive relationships with the perceived environmental benefits of rooftop gardening, significant at the 1% probability level. This finding implies that individuals with higher educational attainment and greater practical experience in rooftop cultivation are more likely to acknowledge and benefit from environmental improvements such as enhanced air quality, microclimate, regulation and support for urban biodiversity. Conversely, variables such as age, gender, profession, family size, and access to communication media were not found to have a statistically significant association, suggesting that these factors may play a limited role in shaping perceptions of environmental advantages derived from rooftop gardening practices.

Table 7. Correlation coefficients between selected characteristics of rooftop gardens and environmental benefits

Dependent Variable	Independent Variable	Computed value for 'r'	Table value of 'r'	
			0.05	0.01
Environmental Benefits	Age	-0.145 ^{NS}	0.196	0.256
	Level of education	0.628**		
	Family size	0.089 ^{NS}		
	Profession	0.021 ^{NS}		
	Gender	-0.002 ^{NS}		
	Communication media	0.019 ^{NS}		
	Experience	0.946**		

^{NS}*Non-significant relationship*
**Significant at 0.05 level of probability*
***Significant at 0.01 level of probability*

O. Relationships between the selected characteristics of the respondents and Nutritional Benefits

The correlation analysis of nutritional benefits derived from rooftop gardening revealed that two variables—level of education (r = 0.544) and gardening experience (r = 0.532)—were significantly and positively associated with perceived nutritional outcomes at the 1% level of significance. These results suggest that individuals with higher educational attainment and prolonged involvement in rooftop gardening are more likely to recognize and achieve nutritional gains, such as increased access to fresh, safe, and diverse produce for household consumption. On the other hand, variables such as age, family size, profession, gender, and communication media exposure did not exhibit statistically significant relationships. This implies that these demographic factors do not substantially affect perceptions or experiences of nutritional benefits in the context of urban rooftop gardening, emphasizing the dominant role of practical knowledge and educational background in improving household-level nutrition through sustainable urban agriculture practices.

Table 8. Correlation coefficients between selected characteristics of rooftop gardeners and nutritional benefits

Dependent Variable	Independent Variable	Computed value for 'r'	Table value of 'r'	
			0.05	0.01
Nutritional Benefits	Age	0.026 ^{NS}	0.196	0.256
	Level of education	0.544**		
	Family size	-0.111^{NS}		
	Profession	0.026 ^{NS}		
	Gender	0.044 ^{NS}		
	Communication media	0.044 ^{NS}		
	Experience	0.532**		

^{NS}*Non-significant relationship*
**Significant at 0.05 level of probability*
***Significant at 0.01 level of probability*

Table 9. Functional Linkages Between Rooftop Gardening and Relevant Sustainable Development Goals (SDGs)

Rooftop Gardening Function	Linked SDG	Explanation of Contribution
Household production of fresh vegetables	SDG 2 – Zero Hunger	Enhances household food availability and dietary diversity, addressing urban food insecurity.
Access to pesticide-free homegrown produce	SDG 3 – Good Health and Well-Being	Reduces exposure to harmful agrochemicals and promotes safer nutrition for household members.
Expansion of green spaces in cities	SDG 11 – Sustainable Cities and Communities	Improves urban microclimates, increases biodiversity, and contributes to environmental quality.
Organic waste composting and reuse	SDG 12 – Responsible Consumption and Production	Encourages recycling of household waste and efficient use of local resources.
Microclimate regulation and carbon offset	SDG 13 – Climate Action	Helps mitigate urban heat island effects and enhances resilience to climate-related impacts.

As shown in Table 1, the ecological and nutritional dimensions of rooftop gardening exhibit strong alignment with multiple Sustainable Development Goals (SDGs). The cultivation of pesticide-free, homegrown produce contributes meaningfully to household food security (SDG 2) and the promotion of healthier dietary practices (SDG 3). Simultaneously, the environmental services provided by rooftop gardens—such as organic waste composting, enhancement of urban greenery, and microclimate regulation—are consistent with the objectives of SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action). These relationships highlight the potential of rooftop gardening as a locally grounded, scalable approach to advancing sustainable development in high-density urban contexts like Dhaka.

CONCLUSION

This study highlights the significant role of rooftop gardening (RTG) in enhancing environmental sustainability and household nutrition in Dhaka City. The findings demonstrate that RTG contributes to improved air quality, reduced indoor temperatures, enhanced urban biodiversity, and effective organic waste management. These environmental benefits are especially relevant in addressing urban challenges such as heat stress and pollution, while supporting climate resilience and the broader objectives of SDGs 11 and 13. Nutritionally, RTG improves dietary diversity and food security by providing consistent access to fresh, safe, and pesticide-free produce, directly supporting SDGs 2, 3, and 12. Education level and gardening experience were found to be positively correlated with both environmental and nutritional outcomes, underscoring the importance of knowledge and long-term engagement in realizing RTG's full potential. However, several structural and practical barriers persist, including limited technical knowledge, water scarcity, high input costs, and pest management challenges. These obstacles highlights the need for targeted policy interventions, such as training programs, financial incentives, and improved infrastructure, to promote the scalability and inclusiveness of RTG practices.

Overall, rooftop gardening emerges as a practical and sustainable urban intervention with the capacity to transform food systems, enhance ecological health, and contribute meaningfully to the achievement of multiple Sustainable Development Goals in rapidly growing cities like Dhaka.

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