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Perceived benefits and challenges of urban rooftop gardening in Dhaka city

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ABSTRACT

The purpose of the study was to assess the perception of urban residents on rooftop gardening in Dhaka Metropolitan Area (DMA). The study was conducted by surveying 63 rooftop gardeners from Uttara and Mirpur of DMA. Primary data were collected using a pre-tested structured interview schedule. Most of the respondents of the study area were old, retired professionals having post-graduate education and moderate experience and knowledge on rooftop gardening. Friends, Facebook, and extension agents are top-ranked information sources. Majority of the respondents developed their gardens on the rooftop of their own houses, utilized 40-80% of their rooftop space for gardening, spent 2-3 hours daily in rooftop gardening, and planted a large number of vegetables (32 species), fruits (40 species), spices (11 species), flowers (48 species), and medicinal plants (12 species) in their rooftop gardens. Receiving safe and nutritional food for the family members, air quality development, and development of family mental health were the topmost perceived benefits of rooftop gardening by the respondents. Perception of the respondents on rooftop gardening was positively related to their experience in gardening, initial cost spent for garden development, contact with information sources, knowledge, and total species cultivated on rooftop gardening. Concerns about losing open spaces for kids to play due to rooftop gardening, difficulties in the collection of quality seeds and seedlings, lack of proper training and technical guidance on rooftop gardening were the major problems faced by the respondents. This research highlights critical policy implications for the sustainable intensification of rooftop agriculture in Dhaka.

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Introduction

Rooftop gardens are artificially created green areas on the upper floors of industrial, commercial, and residential buildings. They might also be used to grow vegetables, give play space, provide color and shelter, or just serve as a living, green place. Rooftop gardens serve as a social hub, serving as a place to relax and enjoy the outdoors with family and friends. It also fosters a sense of self-identification and independence, with opportunities to learn about oneself and emotions while viewing special flower-free seasons as well as providing a relaxing break from stressful daily activities in the city's high-rise residential buildings (Nur *et al.*, 2022; Rashid and Ahmed, 2010).

Rooftop gardens can encompass areas such as balconies, corridors, and other open areas, in addition to the rooftop of a building. Green roofs have been used for over 3000 years; nevertheless, green roof technology became popular and entrenched in Europe in the 1960s, and is now used in many nations (Sultana *et al.*, 2024; Doncean, 2014; Ong, 2003; Bass and Baskaran, 2003).

In Bangladesh, rooftop gardening is a relatively new concept. The concept is evolving steadily, and it has the potential to provide some advantages if it is given sufficient attention (Sultana *et al.*, 2024; Nur *et al*., 2022; Town, 2012). Bangladesh's land resources are limited, making it difficult to feed a large population. To meet the growing demand for housing and to address unemployment in Bangladesh, the complete amount of cultivable land is being converted into industrial and residential areas. It is a significant problem for our country. In Bangladesh, research on rooftop gardens is scarce, and household gardening is restricted. While the cultivable lands are diminishing, a rooftop garden may give room for growing extra crops. As a result, feeding the growing population will be difficult if cultivable land continues to decline. In this case, a rooftop garden may give extra room for producing food in a residential environment. Rooftop gardening, in addition to being visually pleasing, may help to conserve biodiversity in the urban environment, achieve sustainable cities, particularly those required for food production, and enhance the general quality of urban life. Rooftop gardening contributes significantly to urban agriculture. Rooftop farming is a technique that uses container gardens, air-dynaponics systems or aeroponics, hydroponics, or green roofs (Islam, 2004; Islam and Ahmed, 2011; Walker, 2013; Rahman *et al*., 2013; Uddin *et al*., 2016).

Dhaka is the capital of Bangladesh and the country's largest and fastest-growing city. As a consequence of its fast growth, Dhaka is under significant pressure. In part due to the city's residential system, retail malls, flyovers, roads, and several other urban development projects, the city is losing a significant amount of its land area. A vast number of high-rise buildings were developed across the city, in every neighborhood. On the top of the building, residents may grow vegetables, fruits, flowers, and decorative plants. Unfortunately, the majority of them do not garden on their rooftops. Since the beginning

of urbanization, the environment has been degraded due to a lack of suitable plant growth. Citizens are suffering from a variety of ailments and deformities. The DMA's public health and quality of life are being harmed by rising air and water pollution caused by traffic congestion and industrial waste. Water bodies and wetlands in the Dhaka area are being drained in order to make way for multi-story buildings and other real estate developments. As a result, flooding in urban areas is frequent during days of heavy monsoon rainfall, disrupting millions of people's daily lives and disrupting educational, economic, and other professional activities due to poor connectivity and restricted access to basic facilities. When combined with deforestation, natural habitat destruction threatens to wipe out much of the region's biodiversity (Karmakar, 2016; Khatun, 2015; Mannan, 2016; Nira, 2006).

Implementing rooftop gardening might be a viable approach to alleviate food shortages, increase urban self-sufficiency, and make fresh veggies more accessible to city dwellers. It is predicted that 10,000 acres of Dhaka city can be converted to rooftop gardening, allowing citizens to enjoy fresh vegetables while also meeting over 10% of demand (Wardard, 2014). According to a study, the majority of Dhaka city's roofs are appropriate for gardening and do not need extensive renovations; in some cases, minor changes are all that is required (Islam, 2004).

Rooftop gardening may be a beneficial method of securing food supply and satisfying residents' nutritional demands (Ong, 2003). Rooftop gardening has been performed in many buildings in the city for years, but there has seldom been a coordinated attempt on the part of the government, neighborhood organizations, or regular individuals to integrate it with municipal agriculture. Despite having many benefits, roof gardens face clear challenges from our country's perspective. The most significant are issues of access and roof load capacity, lack of knowledge or incentives, funding, water supply, safety, and the harshness of rooftop environments are major barriers. Lack of equipment, tools, water stress, wind, and storm are the key constraints (Town, 2012; Uddin *et al*., 2016; Uddin *et al*., 2021).

The purpose of the study was to explore the socio-economic profile of urban rooftop gardeners and the current state of rooftop gardening in Dhaka Metropolitan Area, assess residents' perceptions of rooftop gardening, examine the relationship between selected characteristics of gardeners and their perceptions, and identify the challenges they face in practicing rooftop gardening. A thorough understanding of the challenges and opportunities associated with the implementation of insurance policies will go a long way toward improving the city's food supply. Rooftop gardens, when handled on a modest scale, offer huge financial potential. As a result, a study of the current state of rooftop gardening, perception on rooftop gardening, and its issues will aid in the development of a suitable mechanism for further extension

and reinforcement of rooftop gardening in the Dhaka Metropolitan Area, thereby improving urban dwellers' socio-economic conditions, access to nutritious and safe foods, and environmental development.

Methodology

The study was carried out in Uttara and Mirpur region (Fig. 1), which is situated at 23°42′0″N latitude and 90°22′30″E longitude, on the east bank of the Buriganga River and in the heart of the of Dhaka Metropolitan (DMP) City with approximately 21741000 populations (Macrotrends, 2021). DMP has a tropical climate that is sunny, rainy, and humid. With an annual average temperature of 25°C (77°F) and monthly mean temperatures ranging from 18°C (64°F) in January to 29°C (84°F) in August, the city has a distinct monsoonal season. During the monsoon season, which runs from May to September, nearly 80% of the annual average rainfall of 1,854 millimeters falls (DSCC, 2024). The study areas were purposively selected to represent diverse urban conditions within DMP Area, where rooftop gardening is gaining attention as a potential climate adaptation and urban food security strategy. Areas were chosen based on key criteria such as population density, the prevalence of multi-storied buildings, the availability of rooftop space, and varying levels of engagement in rooftop agriculture. These locations also differ in socio-economic characteristics and municipal infrastructure, offering a representative cross-section of urban ecological and social variability.

The complexity of communicating with urban residents—often constrained by busy schedules—posed a particular challenge in this study. To address this, a combination of sampling strategies, including random and snowball sampling methods, was employed at various stages of the selection process. This approach acknowledges the practical limitations of engaging with urban populations while striving to ensure that the sample remains both feasible and representative for the study's objectives. According to Freund and Williams (1983), when the population size is known or approximately known and researchers are aware of population heterogeneity, any number equal to or greater than the statistically significant threshold of 30 sample units may be considered adequate. Based on this, a total of 63 rooftop gardeners were selected—33 from Mirpur and 30 from Uttara as sample respondents.

The information for this study was acquired from both primary and secondary sources. The information contained both quantitative and qualitative components. Before finalizing the main survey, a pre-designed interview schedule was created and pre-tested to ensure that it would be effective in collecting primary data from the respondents. Data were collected through different methods such as 63 face-to-face interviews, 04 Focus Group Discussions (FGDs), and 10 Key Informants' Interviews (KIIs).

A draft questionnaire was developed keeping the study objectives in mind. It was then

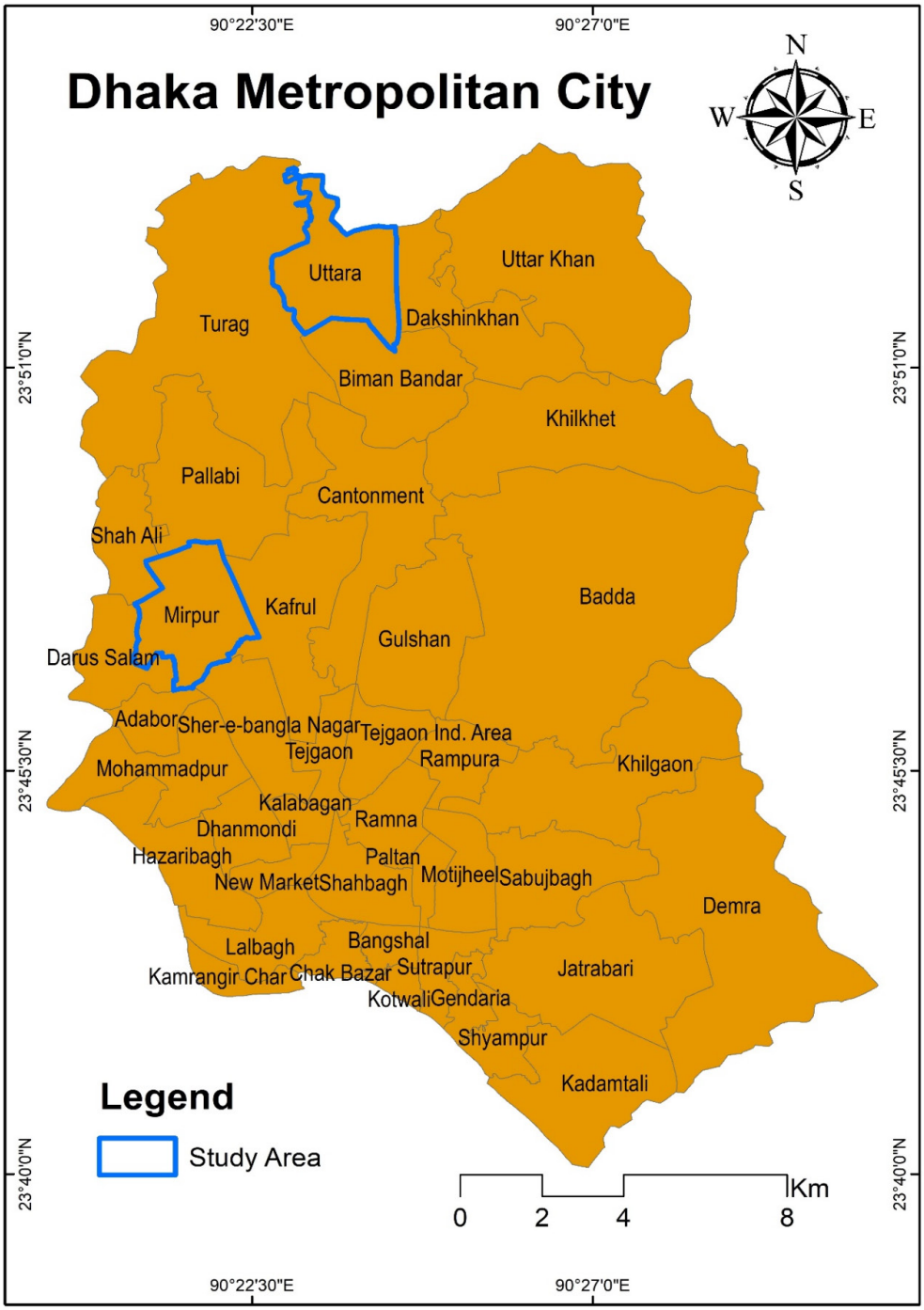

Fig. 1. Study area map

pre-tested with twelve respondents who were comparable to the research group were questioned. The dependent variable of the study is the perception of benefits on rooftop gardening. The independent variables of the study were age, education, profession, family size, income, housing type, house ownership pattern, time spent in the rooftop garden, the initial cost required in rooftop garden development, knowledge on rooftop gardening, etc; status of the rooftop gardening i.e. acreage of rooftop gardens, species diversity, nutrient management, diversity of crop species, water management, cultural operation, and pest and disease control.

Perceptions on rooftop gardening were assessed using a 5-point Likert type scale comprised of twenty items (statements) on urban rooftop gardening. Respondents were asked to check any of the five responses to show how much they agreed or disagreed with the statement. Subsequently, a statement-wise perception index was developed by calculating the arithmetic sum of scores for each statement following formula 1.

Perception Index (PI) = $(F_{SA}\times4) + (F_A\times3) + (F_N\times2) + (F_D\times1) + (F_{SD}\times0)$ ……. (1)

Where:

F_{SA}: Number of respondents who rated the statement as Strongly Agree (score = 4).

F_A: Number of respondents who rated the statement as Agree (score = 3).

F_N: Number of respondents who rated the statement as Neutral/No Opinion (score = 2).

F_D: Number of respondents who rated the statement as Disagree (score = 1).

F_{SD}: Number of respondents who rated the statement as Strongly Disagree (score = 0).

The Challenge Confrontation Index (CCI) was calculated to rank the crucial challenges that prevent Dhaka city dwellers on practicing rooftop gardening. On a 0–3 continuum challenge level (ranging from "not so severe" to "extremely severe"), respondents were asked to rate their perceived challenges. The CCI value was calculated using the following formula 2 (Ndamani and Watanabe, 2015):

$$CCI= C_{\_n}\times0+ C_{\_l}\times1+ C_{\_m}\times2+ C_{\_h}\times3 \qquad (2)$$

Where CCI = Challenge Confrontation Index; C_n = Number of respondents who rated the challenge as not so severe; C_l = Number of respondents who rated the challenge as low; C_m = Number of respondents who assigned a moderate rating to the challenge; P_h = Number of respondent who gave the challenge a high rating.

Data analysis was carried out using the SPSS/PC+ (version 26) computer program, which is the most up-to-date statistical software for social science research. To describe and analyze the data, descriptive statistical measures such as the range, mean, number and percentage distributions, and standard deviation were utilized, among other things. In order to better understand the link between independent and dependent variables, Pierson's coefficient of correlation analysis was performed. Throughout the investigation, a level of probability of 5.0 percent (0.05) and

1.0 percent (0.01), with an associated 95.0 percent and 100.0 percent confidence level, was employed to determine whether the null hypothesis should be rejected or accepted.

Results

Socio-economic characteristics of the rooftop gardeners

The study highlights the socio-economic characteristics of individuals engaged in rooftop gardening (Table 1). Most practitioners are older adults (71.4%), with fewer middle-aged (20.6%) and younger individuals (7.9%). A significant proportion have higher education levels, with 44.4% being post-graduates, 33.3% graduates, and 22.2% having completed higher secondary education. Small families (up to 4 members) dominate the group at 55.6%, while medium and large families account for 39.7% and 4.8%, respectively.

Table 1. Basic issues of various socio-economic characteristics of the rooftop gardeners

Parameter	Category	Frequency	Percent
Age	Young aged (below 35 years)	5	7.9
	Middle aged (35-50 years)	13	20.6
	Old aged (above 50 years)	45	71.4
Level of education	Higher secondary (up to 12 years)	14	22.2
	Graduate (12-16 years)	21	33.3
	Post-graduate (16-18 years)	28	44.4
Family size	Small (up to 4 members)	35	55.6
	Medium (5-7 members)	25	39.7
	Large (Above 7 members)	3	4.8
Profession	Govt. Service	5	7.9
	Doctor	4	6.3
	Engineer	5	7.9
	Business	19	30.2
	Housewife	9	14.3
	Retired person	21	33.3
Experience in rooftop gardening	Short (1-5 years)	12	19.1
	Moderate (5-10 years)	46	73.0
	Long (Above 10 years)	5	7.9
Ownership pattern of rooftop	Owner	53	84.1
	Shared owner	10	15.9
Extent of rooftop utilization	Low (up to 40%)	18	28.6
	Medium (40-80%)	35	55.6
	High (Above 80%)	10	15.9
Daily time spent in rooftop gardening	Below 1 hour	4	6.3
	1-2 hour	13	20.6
	2-3 hour	23	36.5
	Above 3 hour	23	36.5
Knowledge of rooftop gardening	Low (score below 10)	8	12.7
	Medium (10-15)	40	63.5
	High (Above 15)	15	23.8

Rooftop gardening attracts diverse professions, including retired individuals (33.3%), businesspersons (30.2%), housewives (14.3%), and a smaller proportion of government employees, engineers, and doctors. Most respondents (73.0%) have moderate experience (5–10 years), while a smaller group has short (19.1%) or long-term (7.9%) experience. Ownership plays a key role, with 84.1% being building owners and 15.9% shared owners. Medium rooftop utilization (40–80%) is most common, involving 55.6% of respondents, while 28.6% utilize less than 40% and 15.9% over 80% of their space. Time spent on gardening varies, with 73% investing 2 or more hours daily. Knowledge levels are moderate for most (63.5%), high for 23.8%, and low for 12.7%, emphasizing the importance of awareness and capacity-building initiatives to enhance participation and effectiveness. Therefore, these results suggest that businessman, retired person and old age people of small family size who bear moderate knowledge and experience about rooftop gardening have higher interest to grow crops in the roof garden.

As displayed in Figure 2, friends, extension agents, and Facebook are the top-ranked information sources for the respondents, respectively. That implies the credibility of these sources to the urban gardener. In fact, there are lots of Facebook groups on rooftop gardening and a significant portion of the respondents say that they are engaged with different groups where they share their experience and questions regarding rooftop gardening.

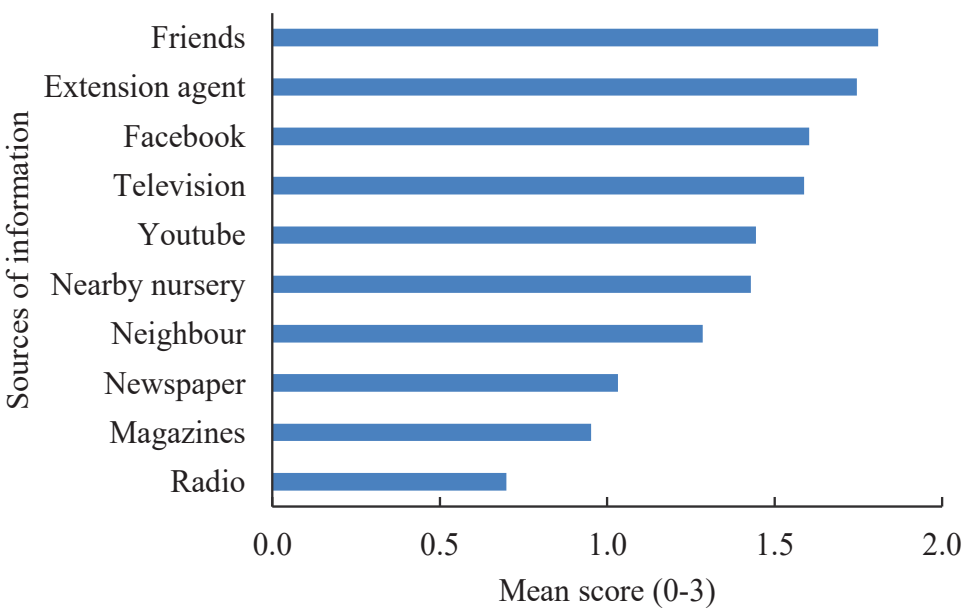

Fig. 2. Comparative importance of information sources to the respondents

Figure 3 depicts that the data reveals that rooftop gardening serves a variety of purposes for the respondents, reflecting its diverse benefits and motivations. A significant majority of respondents (93.7%) engage in rooftop gardening primarily for recreational purposes. This indicates that the activity provides a sense of relaxation and enjoyment, offering an escape from the stresses of urban life and enhancing mental well-being. Additionally, 71.4% of respondents cited nutritional benefits as a key motivation. Rooftop gardens allow households to grow fresh, safe, and chemical-free produce, contributing to improved family nutrition and food security, which is particularly important in urban settings with limited access to quality produce. Educational purposes were also highlighted by 55.56% of respondents, suggesting that rooftop gardening serves as a platform for learning about plants, agriculture, and environmental sustainability. It provides hands-on experience, especially for children, fostering awareness about the importance of sustainable living practices.

On the economic front, 22.2% of respondents mentioned the financial benefits of rooftop gardening, such as saving on grocery expenses or earning income from surplus produce. While not the primary purpose, this highlights the potential for economic gains if the practice is expanded and systematized. Environmental considerations were cited by only 19.1% of respondents, indicating that the ecological benefits of rooftop gardening, such as improved air quality, biodiversity enhancement, and urban heat island mitigation, are not fully recognized or prioritized by most participants. This suggests an opportunity to raise awareness about the broader environmental impacts of rooftop gardening to encourage its adoption as part of urban sustainability efforts. Overall, the data shows that while recreational and nutritional purposes dominate, there is

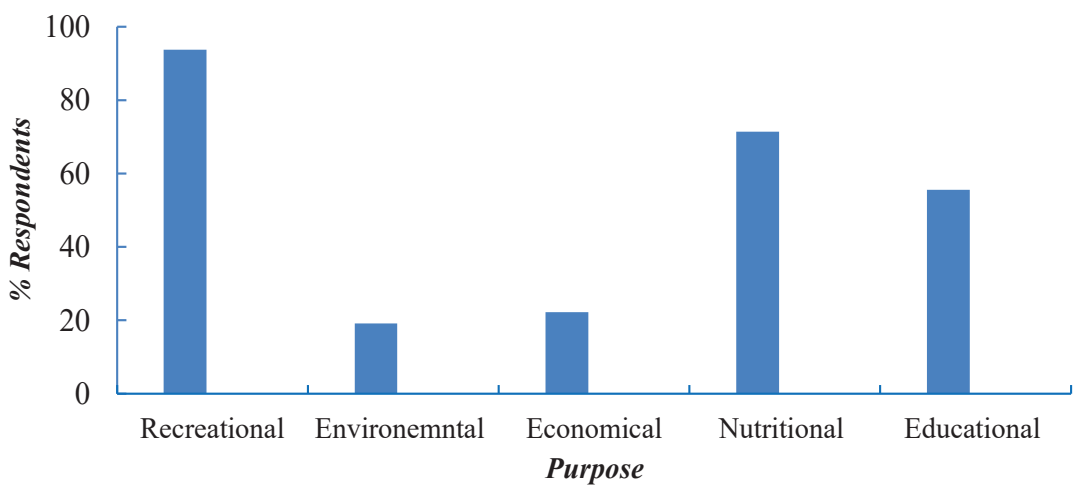

Fig. 3. Purpose of rooftop gardening

significant potential to leverage the economic and environmental benefits of rooftop gardening more effectively.

Status of rooftop garden, resource utilization, and garden management

It is depicted from Table 2 that the building land area range from 3.50 to 10.50 decimals with a mean of 6.37 and SD of 2.30. The building height (no. of stories) ranges from 2-13 with a mean of 6.08 and SD 2.50; rooftop size (sq. feet) ranges from 950 to 6000 with mean 3155.56 and SD 1619.12; potential area for rooftop garden (sq. feet) ranges from 750-5000 with mean 2498.41 and SD1336.58; gardened area (sq. feet) ranged from 500-3000 with mean 1467.94 and SD 748.25; initial cost (Tk.) ranges from 8000-500000 with mean 90.19 and SD 134.46; annual maintenance cost (Tk.) ranges from 2500-150000 with mean 47.28 and SD 46.09.

The total number of crop species in the garden ranges from 4-26 with mean 11.60 and SD 7.02; total number of fruit species in the garden ranged from 5-23 with mean 12.19 and SD 5.34; a total number of spices and condiments species in the garden ranged from 0-7 with mean 2.62 and SD 2.14; a total number of flower species in the garden ranged from 0-26 with mean 7.06 and SD 6.14; a total number of medicinal plant species in the garden ranged from 0-11 with mean 3.97 and SD 2.36, and lastly species richness of the garden ranges from 11-77 with mean 37.44 and SD 18.21.

As shown in Figure 4, respondents used different kinds of containers for planting vegetables, fruits, spices, flowers, and medicinal plants in their rooftop gardens. Among them, half plastic drum, plastic bucket, and earthen made tob containers have been used by the majority of the respondents,

Table 2. Rooftop garden information (per garden)

Items	Min.	Max.	Mean	SD
Building land area (decimal)	3.50	10.50	6.37	2.30
Building height (no. of stories)	2	13	6.08	2.50
Rooftop size (sq. feet)	950	6000	3155.56	1619.12
Potential area for rooftop garden (sq. feet)	750	5000	2498.41	1336.58
Gardened area (sq. feet)	500	3000	1467.94	748.25
Initial cost (’000 Tk.)	8000	500000	90.19	134.46
Maintenance cost (’000 Tk.)	2500	150000	47.28	46.09
Total number of crop species in the garden	4	26	11.60	7.02
Total number of fruit species in the garden	5	23	12.19	5.34
Total number of spices and condiments species in the garden	0	7	2.62	2.14
Total number of flower species in the garden	0	26	7.06	6.14
Total number medicinal plant species in the garden	0	11	3.97	2.36
Species richness of the garden	11	77	37.44	18.21

respectively. Different types of containers are suggested as suitable for rooftop gardening, such as vertical planting systems, aerohydroponic systems, and stackable hydroponic planters, each offering unique benefits for efficient space utilization and enhanced crop performance. Vertical planting systems make use of stackable containers that optimize vertical space on rooftops. These systems can be integrated with nutrient and water delivery mechanisms, ensuring uniform moisture and nutrient availability to plants, thereby improving their health and productivity (Bullock & Roberts, 2003). Aerohydroponic systems, which involve modular containers supporting root exposure to nutrient-enriched mist or solution, are particularly effective in promoting vigorous plant growth and high yields due to superior oxygenation and nutrient uptake (Kiernan, 2017; Kiernan, 2018). Additionally, stackable hydroponic planters are designed to accommodate multiple plants in compact arrangements, increasing the yield per unit area. Their adaptability to various irrigation systems, including drip or nutrient film techniques, makes them highly versatile and efficient for cultivating a wide range of crops in rooftop environments (Powell & Marks, 2001). Larger container sizes generally enhance root and shoot biomass, improving growth and yield. For rooftop farming, use containers of at least 5-10 gallons for annuals and 10-20 gallons for perennials, ensuring adequate rooting volume and moisture retention (NeSmith & Duval, 1998).

As shown in Figure 5, friends/relatives was the topmost preferred source by majority (78%) of the respondents for collecting their required planting materials such as seeds, seedlings,

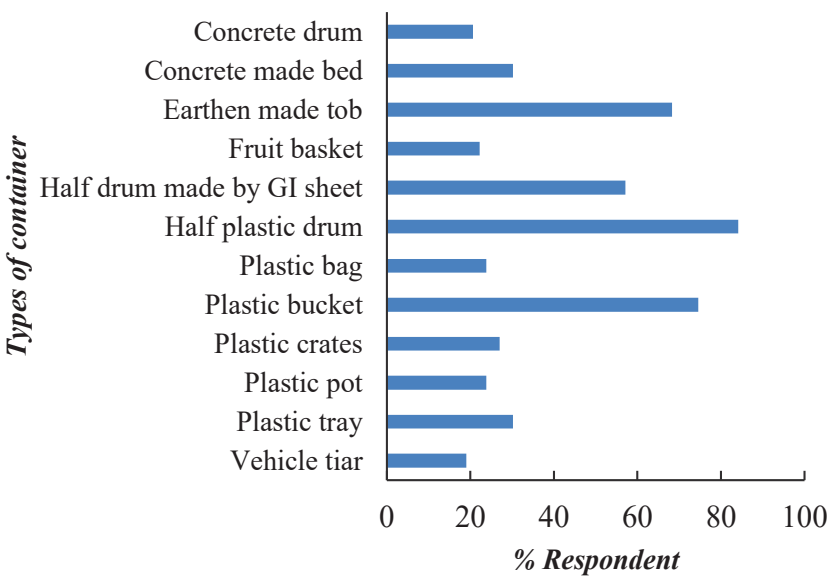

Fig. 4. Types of containers used

and saplings followed by agriculture fair, local nursery, horticulture center, and local markets, respectively. Institutional or government-linked sources provide certified, high-quality, and disease-free planting materials, which are often developed or recommended based on scientific research suited to the local environment. These sources ensure varietal authenticity, better germination rates, and are often accompanied by technical guidance on cultivation practices. Additionally, institutions like the Department of Agricultural Extension (DAE), BARI, and horticulture centers periodically introduce improved or climate-resilient crop varieties through fairs and exhibitions, allowing rooftop gardeners to access up-to-date innovations. These trusted sources contribute to greater success, higher yield, and sustainable practices in rooftop farming. However, one limitation is that access to institutional sources may be sporadic, seasonal, or location-specific, which can make timely procurement of specific plants or seeds challenging for urban gardeners. On the other hand, personal, local, or commercial sources are more easily accessible and flexible, especially in urban markets and neighborhood nurseries. Gardeners may receive cuttings, seeds, or saplings from friends or local vendors at low cost and with minimal effort. However, these sources often lack quality assurance, varietal labeling, or disease resistance, increasing the risks of poor germination, low yields, pest outbreaks, or introduction of invasive species. Additionally, the lack of professional advice from such vendors may result in improper planting techniques or mismatched varieties for rooftop conditions.

As shown in Figure 6, all the respondents (100%) used a manual method of irrigation followed by drip and sprinkler irrigation. So,

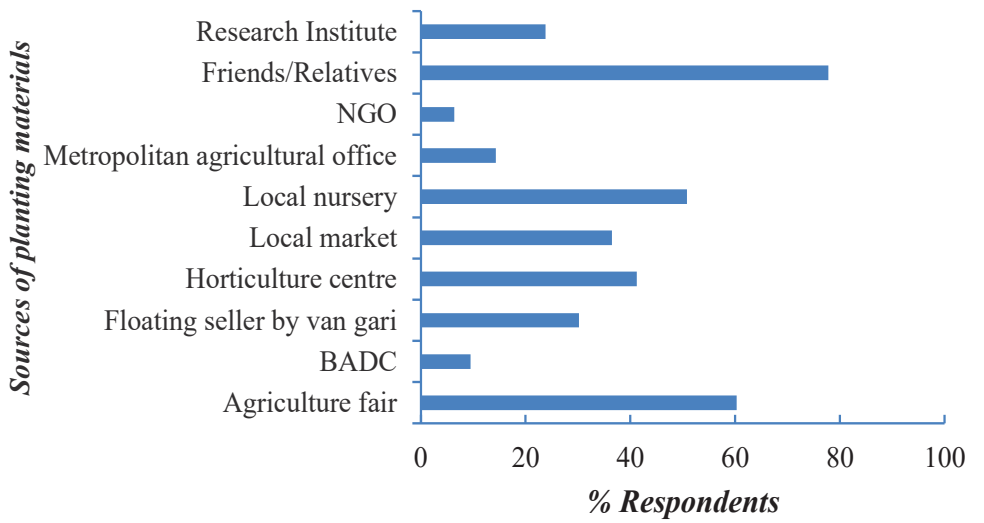

Fig. 5. Sources of seeds, seedling, and sapling

it is a matter of concern for the DMA because there may be wastage of a huge amount of drinkable tap water which is a very significant problem in DMA. In the context of Dhaka's rooftop gardening, the widespread use of manual irrigation methods, as observed among 100% of respondents in Figure 6, raises significant environmental and resource-use concerns—particularly regarding the wastage of potable tap water, which is already a critical issue in the DMA. While manual irrigation may be simple and cost-effective, it often leads to overwatering and inefficient water use, especially when not tailored to plant needs or environmental conditions. To address this, drip irrigation is considered one of the most suitable and environmentally feasible methods for rooftop gardens in Dhaka. Drip systems deliver water directly to the root zones of plants at a slow, controlled rate, minimizing evaporation and runoff. This method not only conserves water but also reduces the risk of plant diseases caused by excess moisture on leaves and soil surfaces. It is especially effective for vegetables and small fruit plants, which are common in rooftop gardens.

As shown in Figure 7, all the respondents (100%) sprayed pesticides/fungicides for pest/disease management. However, it promising that more than half of the respondents practiced weeding, mulching as cultural management. Besides, the majority of the respondents practices resistant crop variety and used different types of trapping techniques such as pheromone trap and bait trap for insect/pest management. However, proper guidelines on the threshold level of insecticide/pesticide/fungicide application should be informed by the agricultural department to reduce the possible adverse effect on urban climate and also health hazards of the urban gardener.

Information displayed in Figure 8 revealed that all the respondents applied urea, TSP, and compost fertilizer to maintain proper soil nutrients. However, it would be better to encourage them to reduce the amount of chemical fertilizer application in their gardens considering their role in climate change.

Perception on benefits of rooftop gardening

In order to assess the perception of the respondents on rooftop gardening, 20

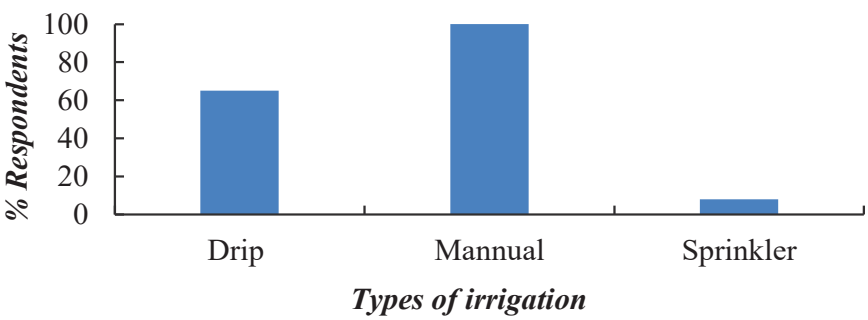

Fig. 6. Types of irrigation methods used

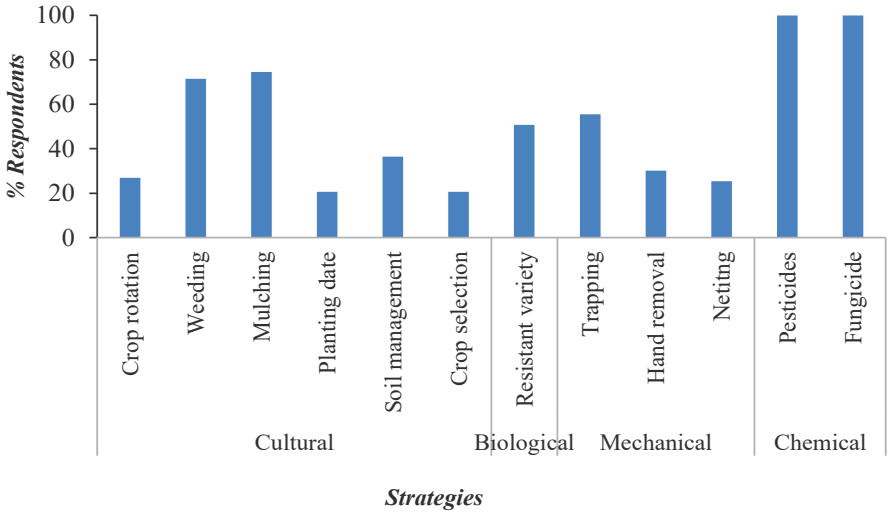

Fig. 7. Pest/disease management strategies

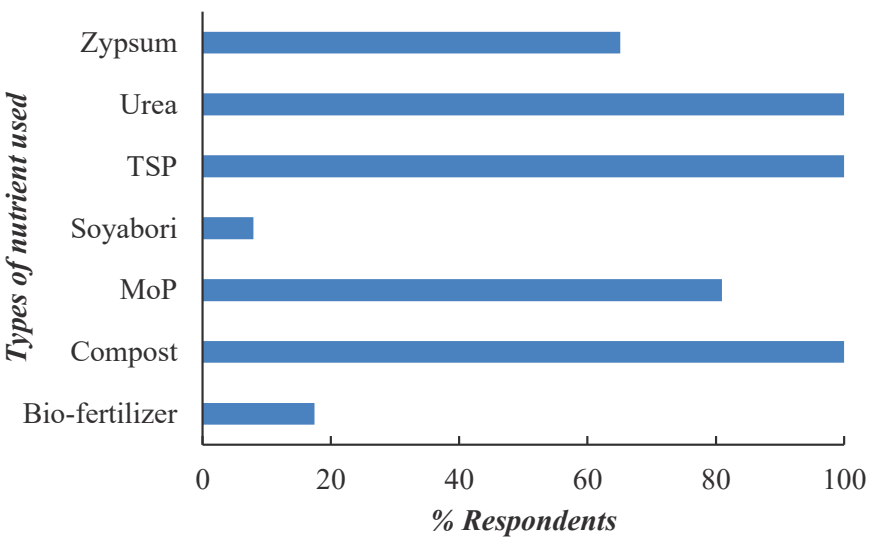

Fig. 8. Nutrient management system

statements were considered (Table 3) through a rigorous literature search and FGD with the respondents. Perception score of an individual respondent may vary from 0-80 while 0 means very negative perception and 80 means very positive perception.

The perception score varies from 49-73 with a mean of 59.41 and a standard deviation of 7.49. It implies that respondents had moderately positive to highly positive perceptions towards rooftop gardening. From the data shown in Table 3, the highest mean (3.36) was found in

Table 3. Distribution of the respondents according to their perception on rooftop agriculture

Perception statements	Mean (0-4)	PI
Rooftop gardens will absorb rainwater which will decrease the pressure put on storm-water drainage systems	3.11	196
The vegetation on rooftop gardens are able to improve air quality by filtering the air from pollutants	3.21	202
Alternate source of required green spaces in the city center	3.01	190
The government should provide financial support for the development of rooftop gardens	2.61	165
Improve mental health of the family members	3.25	205
Add value/ marketability of the property	2.93	185
Provision for agricultural education of the family members	2.96	187
Reduce urban heat island effect	2.80	177
Increase wildlife and biodiversity	2.96	187
Improve noise absorption	2.71	171
Rooftop gardens will decrease the overall temperatures of cities	3.20	202
Helps keep cold the house and decrease the discharge of CO_2	2.92	184
Decrease food miles and carbon footprints	2.93	185
Helps regulate climate change	2.65	167
Government should provide urban agriculture ecological certificates for greater motivation	2.71	171
Provide safe food and increase nutritional benefits for family members	3.36	212
Offers economic support by creating income generation activities	2.98	188
Increase social reputation	3.01	190
The municipality should include rooftop gardens in building policies	3.14	198
Rooftop gardens will help increase aesthetic value by beautifying the city center	2.87	181

statement sixteen (16) and the statement was, “Provide safe food and increase nutritional benefits for family members”. The second highest mean was in statement five (5), where the mean was 3.25, and the statement was “improve the mental health of the family members”. However, the lowest calculated mean (2.61) was found in case of the statement number four (04), and that was, “The government should provide financial support for the development of rooftop gardens”.

On the other hand, second-lowest score mean (2.65) was observed for statement fourteen (14), and that was, “Helps regulate climate change” which implies that respondents have less awareness about climate change and its possible adaptation/mitigation options. It was ascertained from Table 3 that, most of the respondents of the study area agreed that they receive safe food that increases nutritional benefits for family members. Besides this, a significant proportion of the respondents were

undecided or disagreed that the government's financial support is a factor in the further development of rooftop gardens. So, the urban residents have the willingness to pay for the development of rooftop gardens by their self-finance, but they need proper motivation, training, guidance, and reliable source of the inputs required in rooftop garden development.

Relationship between socio-demographic characters and perception on rooftop gardening

Table 4 illustrates that among the factors considered, knowledge of rooftop agriculture stands out with the highest positive correlation ($r = 0.656$, significant at the 1% level), indicating that individuals who possess more technical knowledge or awareness regarding rooftop gardening tend to have a more favorable perception. This highlights the importance of education, training, and information dissemination in shaping attitudes toward urban agriculture.

Experience in rooftop gardening also shows a moderately strong and significant positive correlation ($r = 0.410$, $p < 0.01$), suggesting that those with more hands-on involvement or practical engagement in rooftop gardening are more likely to perceive it positively. Similarly, the initial cost of roof gardening has a significant and positive correlation ($r = 0.438$), which might seem counterintuitive at first. However, it could be interpreted as those who have made financial investments in rooftop gardening tend to value the practice more, likely because of their commitment and perceived return on investment, whether in terms of food, aesthetics, or satisfaction.

The number of plant species cultivated in the rooftop garden is also significantly and positively associated ($r = 0.431$, $p < 0.01$) with perception, which implies that biodiversity in rooftop gardens may enhance interest, satisfaction, and perceived benefits, reinforcing positive views toward the practice. Furthermore, contact with information sources—such as extension services, NGOs, community groups, or media—has a moderate and significant relationship ($r = 0.263$, $p < 0.05$), indicating that access to relevant and reliable information can enhance perceptions by improving understanding and motivation.

In Table 4, several variables were found to have non-significant correlations with perception toward rooftop gardening, indicating that their influence on shaping perception is either weak or inconsistent in the study context. Age showed a low positive correlation ($r = 0.150$), but it was not statistically significant, suggesting that older or younger individuals do not necessarily differ much in how they perceive rooftop gardening. This may imply that age alone does not shape perception unless it is linked with other factors like interest, knowledge, or experience.

Family size was negatively correlated ($r = -0.074$) with perception, though also not significant. This suggests that larger families do not necessarily have a better or worse perception of rooftop gardening. It's possible

Table 4. Co-efficient of correlation (r) between socio-demographic characters and perception on rooftop gardening

Independent variable	Dependent variable	Coefficient (r)
Age	Perception on rooftop gardening	0.150
Family size		-0.074
Experience on rooftop gardening		0.410**
Extent of agricultural utilization of rooftop space		0.139
Time spent in roof gardening		-0.054
Initial cost of roof gardening		0.438**
Contact with information sources		0.263*
Knowledge of rooftop agriculture		0.656**
Total species cultivated in the rooftop garden		0.431**

(*Significant at 0.05 level of probability, ** Significant at 0.01 level of probability, NS= Not significant)

that other household dynamics—such as income, available labor, or space—may mediate the impact of family size. The extent of agricultural utilization of rooftop space had a small, positive but non-significant correlation (r = 0.139). This implies that even if people use more of their rooftop for gardening, it may not always translate into a more favorable perception, possibly due to challenges like maintenance burden or limited perceived benefits.

Interestingly, time spent in rooftop gardening showed a slight negative correlation (r = -0.054), though not significant. This might indicate that spending more time on gardening tasks doesn't always equate to higher satisfaction or better perception—especially if the gardening is labor-intensive, poorly planned, or doesn't yield expected benefits. Overall, the non-significant results highlight that quantitative or demographic attributes alone—such as age, family size, space, or time—do not strongly influence perception unless they are coupled with qualitative factors like motivation, knowledge, and satisfaction. This further reinforces the need to focus on awareness, training, and support services rather than assuming that basic demographic traits or gardening extent directly shape perception.

Challenge Confrontation in Rooftop Gardening

Focus group discussion was conducted to identify the challenge faced in rooftop gardening. From the results of the focus group discussion, the top 10 most severe challenges were identified and individual opinions on these challenge statements were collected through interviews (Table 5).

Data presented in Table 5 indicated the extent of different challenges faced by the respondents in rooftop gardening. The most severe challenges listed as 1st, 2nd, 3rd were 'due to lack of adequate open space and playgrounds in cities,

Table 5. Challenge Confrontation Index (CCI) in rooftop gardening

Sl#	Problem statements	% respondents (N=63)				CCI	Rank
		ES	MS	SS	NS		
01	The shadow of the adjoining building hampers the production of the roof garden	54.0	30.2	7.9	7.9	145.1	7th
02	Difficult to collect quality seeds and seedlings	77.8	6.3	7.9	7.9	160.0	2nd
03	The fallen leaves of the tree make the roof dirty so the roof has to be cleaned regularly	63.5	22.2	7.9	6.3	153.0	4th
04	Different kinds of birds eats and damage small vegetables and fruit trees	50.8	42.9	-	6.3	150.1	6th
05	Lack of proper training and technical guidance	71.4	12.7	7.9	7.9	155.9	3rd
06	Lack of proper marketing facilities	55.6	28.6	15.9	-	151.1	5th
07	Due to lack of adequate open space and playgrounds in cities, the conversion of roofs into gardens have made children and adolescents more dependent on technology than sports which is alarming for their physical and mental growth	71.4	22.2	6.3	-	166.9	1st
08	Outbreaks of insects, pests, and diseases	41.3	23.8	19	15.9	120.0	9th
09	Lack of timely supply of required fertilizers, pesticides, compost, and credit	41.3	14.3	23.8	20.6	111.1	10 th
10	Management of gardens and carrying of soils and other inputs to the rooftop is difficult for the aged person due to lack of experienced labor	28.6	44.4	20.6	6.3	123.0	8th

ES =Extremely severe (3), MS =Moderately severe (2), SS =Somewhat severe (1), NS = Not severe at all (0)

the conversion of roofs into gardens have made children and adolescents more dependent on technology than sports that is alarming for their physical and mental growth'; 'Difficult to collect quality seeds and seedlings, and 'lack of proper training and technical guidance' with the CCI score of 166.9, 160.0 and 155.9 respectively. Statements 3, 6, 4 ranked 4th, 5th, and 6th position by obtaining CCI scores 152, 151.1, and 150.1. Statements 1,10,8, and 9 ranked 7th, 8th, 9th, and 10th position by gaining CCI scores 145.1, 123.0, 120.0, and 111.1, respectively. Islam *et al.* (2017) concluded that the drip irrigation system is an efficient water management technology for rooftop vegetable production in urban areas of Bangladesh.

Discussion

The findings of this study provide valuable insights into the socio-economic and practical aspects of rooftop gardening in the Dhaka

Metropolitan Area (DMA), particularly focusing on the profiles, practices, benefits, and challenges faced by respondents.

Firstly, the majority of respondents were older, retired professionals with postgraduate education (Table 1). This demographic profile reflects findings that rooftop gardening is more prevalent among individuals with higher education levels, likely due to their greater access to information and capacity to apply urban agriculture techniques (Khan & Ahmed, 2009). The moderate gardening experience among respondents aligns with Uddin *et al.* (2021), who observed that participants in urban agriculture often demonstrate an openness to learning and adapting despite limited prior knowledge. This highlights the potential for capacity-building programs to enhance rooftop gardening practices further.

The reliance on friends, Facebook, and extension agents (Fig. 2) as primary information sources underscores the growing influence of social networks and digital platforms, as also noted by Ahmed *et al*. (2023) and Shahidullah *et al.* (2023). While these channels provide accessibility, their informal nature raises concern about the accuracy and comprehensiveness of the information disseminated. Extension agents, in particular, could play a more significant role in bridging the gap between informal advice and expert technical support, ensuring that gardening practices are both sustainable and effective.

The study also revealed a high level of engagement among participants, with 40-80% of rooftop space utilized for diverse gardening activities and 2-3 hours spent daily (Fig. 3; Table 2). This practice mirrors findings that highlight the multifunctionality of rooftop gardening in urban contexts, addressing food security, aesthetic enrichment, and health benefits (Partha *et al.*, 2023; Nur *et al*., 2022). The cultivation of vegetables, fruits, flowers, and medicinal plants demonstrates the potential of rooftop gardening to simultaneously address these goals.

The positive relationship between respondents' perceptions and factors such as experience, initial costs, access to information sources, knowledge, and species diversity (Table 4) aligns with observations emphasizing the importance of individual engagement and external support in shaping successful urban gardening practices (Nahar *et al.*, 2024). This highlights the need for targeted interventions to enhance knowledge dissemination, reduce costs, and increase species availability, thereby fostering more positive perceptions and sustained participation in rooftop gardening.

A critical challenge identified is the limited participation of tenants, despite their dominance in the urban housing landscape (Table 5). This issue resonates with findings by Hossain *et al*. (2023), who emphasized the need for inclusive policies and collaborative frameworks between landlords and tenants. Encouraging such partnerships could address structural barriers and expand the reach

of rooftop gardening. Policymakers could introduce incentives for shared gardening initiatives to promote broader community participation.

Another significant concern is that only about 20% of respondents cited environmental and economic reasons as motivations for rooftop gardening. This finding aligns with Rashid and Ahmed (2010), who stressed the need to raise awareness about the broader ecological and economic benefits of green roofs. Without understanding the long-term environmental and economic contributions, participants may lose interest once immediate cultural or aesthetic benefits are achieved. Promoting education about the role of rooftop gardening in mitigating the urban heat island effect, improving air quality, and enhancing food security, as highlighted by Sultana *et al*. (2024), is essential to sustaining engagement.

The concern about losing open spaces for children's play due to rooftop gardening could be addressed by designing multi-functional spaces that accommodate both recreational and gardening activities, as suggested by Uddin *et al.* (2021). This approach ensures that the diverse needs of urban families are met, particularly in space-constrained environments like Dhaka.

Finally, the lack of access to quality seeds and seedlings, as well as the need for structured training, reflects the findings of Shahidullah *et al.* (2023), who highlighted the importance of robust supply chains and technical guidance. Addressing these gaps through partnerships between government agencies, NGOs, and private stakeholders could significantly enhance the viability and sustainability of rooftop gardening practices in Dhaka.

Conclusions

This study highlights the growing significance of rooftop gardening in the Dhaka Metropolitan Area (DMA) as a multifaceted urban practice with recreational, nutritional, educational, economic, and environmental dimensions. The rooftop gardening is predominantly practiced by educated, retired professionals who dedicated significant time and space in cultivating diverse plant species. While the primary motivations are recreational and nutritional, the practice also offers substantial educational and economic benefits, though environmental considerations remain underemphasized. Rooftop gardening contributes to personal well-being, improved air quality, and access to safe, nutritious food, showcasing its potential as a sustainable urban practice. However, challenges such as limited tenant participation, misconceptions about structural feasibility, and inadequate access to quality seeds and training hinder its broader adoption. Addressing these challenges through awareness campaigns, technical guidance, and inclusive policies could unlock its full potential. Moreover, fostering a stronger focus on the environmental and economic benefits could ensure the continuity of rooftop gardening practices, aligning them with urban sustainability goals. GO and NGO supports are essential to generate the awareness and

innovative technologies as smart approach for the massive implementation of rooftop farming in different cities of Bangladesh including Dhaka.

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Conflict of Interest

The authors affirm that no financial or commercial relationships that might be construed as a potential conflict of interest existed during the course of the research.

Author Contributions

Conceptualization, M.Z.H; methodology, M.Z.H. and M.M.H.; software, M.Z.H.; validation, M.Z.H; resources, M.Z.H.; data curation, M.Z.H. and M.M.H.; writing—preparation of the initial draft, M.Z.H. and M.M.H.; writing, review and editing, M.Z.H., M.M.H., M.R., M.S.I.A., M.S.H., M.F.H., and F.A.P.; visualization, M.Z.H. and M.M.H.; supervision, M.Z.H.; project administration, M.Z.H and M.S.I.A.; revenue acquisition, M.Z.H. All authors have reviewed the manuscript in its current form and given their approval.

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