Evaluating the Socio-economic Benefits of Rooftop Gardening and the Influence of Government Tax Incentives on Urban Sustainability.

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Abstract: Increasing food demands along with shrinkage of agricultural lands make urban dwellers vulnerable to food insecurity. This leads to practicing rooftop gardening (RTG) by dwellers living in an urban area. The present study shows that the contribution to household-level resilience for vegetables and fruits produced from RTG is about 6% and 18%, respectively. The RTG practitioners consume about 75% cultivated fruits and vegetables. Utilization of rooftop spaces for gardening could be a potential solution to household food and nutrition insecurity in Dhaka Metropolitan Area (DMA). The study was conducted at four selected areas are Dhanmondi, Mirpur, Mohammadpur and Uttara. Data were collected by using interview schedule (Questionnaire) and multiple linear regression was used to analyze the data. The result showed that 38% old aged (above 50 years) respondents involved in RTG from Dhanmondi, Mirpur and Uttara areas and the majority of the respondent was female. All the factors cooperatively contribute 52.7% of the variance of rooftop production (R^2 = 0.527). The production level per rooftop was medium (71-100) kg/year in Dhaka city but it had maximum small family (up to 3 members) to consume. There will be an opportunity to sell the surplus. Mirpur region had the highest production of fruits and vegetables among the four selected areas. The daily average concentrations of CO_2 is 5500 ppm, $PM_{2.5}$ 120.4 µg/m³, PM_{10} 107.5 µg/m³ and TVOC 20.4 mg/m³ which exceed the recommended limits according to the World Health Organization (WHO, 2021, 2022). Long-term exposure to CO_2, $PM_{2.5}$, PM_{10}, and TVOC can cause chronic health problems, including permanent damage to internal organs and an increased risk of cancer. The merits including urban heat reduction and community engagement are discussed alongside constraints such as structural limitations and environmental challenges. The multifaceted aspects of rooftop gardening, emphasizing its potential to address urban challenges sustainably.

Keywords: Rooftop Gardening, Sustainable Practice, Food and Nutrition Security, CO_2 Concentration, Physical and Mental Health, Air Quality, Rebate Tax.

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Introduction:

Numerous issues affect urban regions, such as a lack of available space, environmental damage and food instability. As a result, cutting-edge methods like rooftop gardening have come to light as a contemporary response to these problems that also encourages sustainable production in urban settings [2, 4]. By growing plants on building rooftops, rooftop gardening turns unused space into useful green space. This study addresses the significance of rooftop gardening its advantages and its application methods in urban contexts. It is difficult to supply the food needs of urban populations due to the tendency towards increased urbanization which has resulted in the loss of agricultural land and green spaces. Rooftop agriculture has the potential to reduce food poverty. Green roofs will provide a rare opportunity to grow food efficiently in often underutilized locations assisting in the support and sustainability of food for urban people. Alternative agricultural production systems, such as green roof technologies will become increasingly important as human populations get more urbanized and urban customers become more interested in local food for their families. Green roofs provide an area for vegetable crop cultivation allowing agriculture to become more integrated into urban neighborhoods. The majority of homemakers will engage in agribusiness with their rooftop cultivation which will boost a family's income while also ensuring organic food sourcing and nutritional security. Our building's roof will be used to raise vegetables and fruits for family consumption and also for selling purposes. So, rooftop production can give health security to produce organic fruits and vegetables ensure food security scope of agribusiness and employment opportunity by agribusiness. Rapid urbanization and expansion are putting pressure on city food supply systems. Rapid urbanization and urban growth are placing massive demand on urban food supply systems. Moreover, many cities in the world are facing problems like a rapid decrease in green space and an increase in heat island effects. Urban agriculture or farming is promoted as a potential solution to these problems. For city dwellers urban agriculture can provide a source of fresh produce a healthier diet and significant financial savings. Vegetated surfaces offer important sound-insulating capabilities and are frequently employed in urban contexts for noise reduction. Green roofs can help buildings reduce noise pollution significantly[1, 2]. Through its backward and forward relations, it can lso provide jobs and economic opportunities. Implementing rooftop farming can be a possible solution to reduce food supply problems, make urban living amore self-sufficient and make fresh vegetables more accessible to urban individuals. A survey shows that most of the roofs of Dhaka city are suitable for gardening and do not require major improvement work sometimes only

need some modifications. A rooftop garden can supplement diets of a community as it supplies with fresh produce and provides tangible benefits tied to food production. With rapid and unplanned urbanization the incidence of urban poverty and food insecurity has been also increasing alarmingly in Dhaka[3, 12].

Global climate change and rapid urbanization have emerged as two of the most pressing challenges to sustainable development particularly in developing countries such as Bangladesh. Due to its geographical location and socio-economic conditions. Bangladesh is highly vulnerable to the adverse impacts of climate change which continue to threaten environmental sustainability and place increasing pressure on natural resources. At the same time rapid population growth and unplanned urban expansion have accelerated the conversion of open spaces into built-up areas. Dhaka, the capital city of Bangladesh has already exceeded its carrying capacity because of continuous rural-to-urban migration and increasing population density[17,20]. A rooftop garden can be the primary way of our urban agriculture to keep the environment calm and cool. It can be a great source of our local food system, employment and daily engagement with nature[4,5]. Rooftop gardening can be an effective way to provide food security and meet people's nutritional needs. Understanding the problems and opportunities associated with policy of insurance adoption will go a long way towards improving the city's food supply[5,12]. The current study looks at the production of rooftop gardening in Dhaka and tries to figure out the scope and possibility of agribusiness. The goal of this research is to find out the scope and possibility of agribusiness by rooftop production and figure out the significant factors that affecting most in rooftop gardening production. It highlights rooftop gardening's role in urban agriculture, contributing to local food production. The Local Government Division announced a 10% holding tax rebate for city corporations and municipal homeowners who develop and maintain functional rooftop gardens to reduce urban heat and increase green cover[7,8]. The merits, including urban heat reduction and community engagement are discussed alongside constraints such as structural limitations and environmental challenges. The multifaceted aspects of rooftop gardening emphasizing its potential to address urban challenges sustainably[3].

Gardening has a positive impact on both physical and mental health by reducing stress, anxiety, depression and improving overall mood even after a short period of gardening. According to the Attention restoration exposure to natural environments helps restore mental focus and reduce attention fatigue. Gardening also promotes social interaction, strengthens community relationships and enhances the sense of belonging[24]. These benefits are particularly important in urban areas where access to ground-level green

spaces is often limited. In such settings rooftop gardens provide an accessible way for people to experience nature while engaging in moderate physical activity and relaxation. As a result, rooftop gardening can help reduce depression, stress and social isolation, ultimately improving overall psychological well-being and reducing depressive symptoms[23].

Objectives:

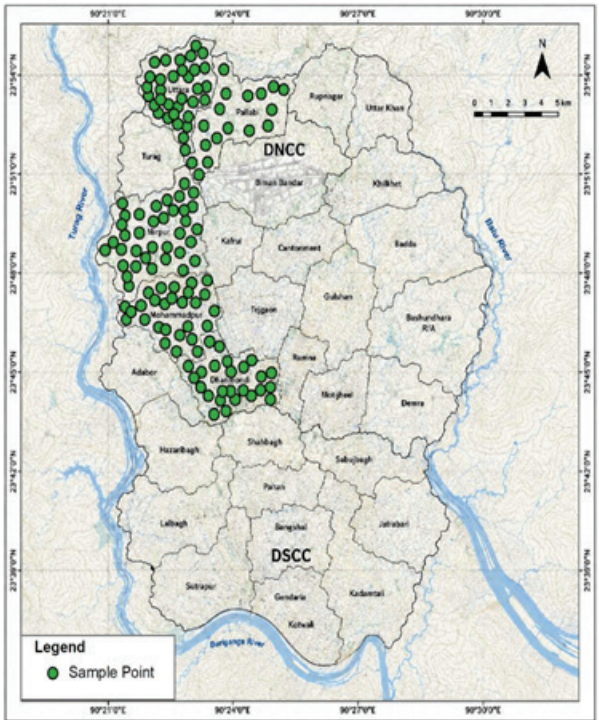
The present study has been taken under consideration to achieve the following:

1. To analyze socio economic status of rooftop gardeners in Dhaka city.
2. To determine the factors that affect rooftop production in Dhaka city.
3. To find out the scope and possibility of improving mental and physical health through rooftop gardening production in selected regions of Dhaka city.

Methodology:

The study was conducted in four areas, of Dhaka City—Mirpur, Dhanmondi, Mohammadpur and Uttara - to capture variations in rooftop gardening. These areas were intentionally characteristics allowing a meaningful comparison among different urban settings. A total of 300 households were surveyed across the selected study areas. Among the selected areas Mirpur was considered particularly suitable for comparison because it contains both buildings with rooftop gardens and buildings without rooftop gardens within densely populated residential neighborhoods. This study adopted a quantitative cross-sectional research design which was deemed most suitable for assessing the impacts of rooftop gardening on mental well-being economic benefits and air quality (Concentrations of CO_2, TVOC, $PM_{2.5}$, PM_{10}) at a single point in time. Air quality measurements were conducted using an air Quality Detector (Model: JSM-131 SE). The device was used to measure the concentrations of CO_2, $PM_{2.5}$, PM_{10} and TVOC at the selected study locations. Primary data were collected through a structured questionnaire survey administered to respondents to capture their perceptions and experiences regarding the mental health and economic benefits of rooftop gardening

Figure 1: The Locations of the Rooftop Gardens Selected for Household.



Source: Field survey, 2025-26.

The distribution of the respondents from the selected area in accordance with their Age, Family size, Professions are presented in the following tables:

Table 3.1. Distribution of the respondents according to their age is presented in Mirpur, Mohammadpur, Uttara and Dhanmondi.

Category	Range (Year)		Respondent	
	Year	Observed Age	Number	Percent (%)
Young aged	Up to 30	24-75	75	25%
Middle aged	31-50		112	37%
Old aged	Above 50		113	38%
Total			300	100%

Source: Field survey 2025-2026.

Table 3.1 shows the age distribution of the respondents from selected study areas of Mirpur, Mohammadpur, Uttara and Dhanmondi. Out of the total respondents of 300, (25%) were of the young age group (up to 30 years) while (37%) were classified as middle-aged (31–50 years). The remaining 38% of the respondents were categorized as old-aged (above 50 years). The results suggest that the sample was predominantly middle-aged and older adults making up approximately three-quarters of the total respondents. Again according to the survey older respondents said that rooftop gardening improved both their physical and mental well-being.

Table 3.2. Distribution of the respondents according to their Family size is presented in Mirpur, Mohammadpur, Uttara, and Dhanmondi.

Category	Members	Respondents	
		Number	Percentage (%)
Small Family	Up to 4	135	44%
Medium Family	5-6	110	37%
Large Family	Above 6	55	19%
Total		300	100%

Source: Field survey 2025-2026.

Table 3.2 presents the distribution of the respondents by family size in the selected study areas of Mirpur, Mohammadpur, Uttara and Dhanmondi. Among the 300 respondents, (44%) were from small families, (37%) were from medium-sized families and (19%) were from large families. The results showed that the majority of the respondents were from small families. The survey revealed that the elderly people in their families are more likely to be interested in this RTG activity and thus their physical and mental health both are getting better.

Table 3.3. Distribution of the respondents according to their professions is presented in Mirpur, Mohammadpur, Uttara and Dhanmondi.

Category	Respondent	
	Number	Percent (%)
Government	85	28%
Private	76	25%
Business	68	23%
other	71	24%
Total	300	100%

Source: Field survey 2025-2026.

Table 3.3 presents the occupational distribution of the respondents in the selected study areas of Mirpur, Mohammadpur, Uttara and Dhanmondi. Of the 300 respondents (28%) were employed in the government sector (25%) were working in the private sector (23%) were engaged in business activities and (24%) belonged to other occupational categories. The results indicated that government employees constituted the largest occupational group followed by private sector employees. In general, the distribution shows a wide range of occupations among the respondents and hence a representative socio-economic profile of the study population.

Table 3.4. The contribution of Different Classes of People in Urban RTG.

Socio-Economic Classes of urban People in RTG	RTG annual vegetable production (Kg)	RTG annual Fruits Production (Kg)
Income class 1	16-20 Kg	15-25 Kg
Income class 2	20-30 Kg	25-35 Kg
Income Class 3	30-40 Kg	35-45Kg
Income Class 4	40-50 Kg	45-55 Kg

Source: Field survey 2025-2026.

Table 3.4 presents the annual production of vegetables and fruits from rooftop gardening (RTG) in different income classes of urban areas. The results indicate that with the increase of income production increases gradually. Income Class 1 had the lowest production of vegetables (16-20 kg) and fruits (15-25 kg) indicating a limited production capacity. However, Income Class 2 and Income Class 3 showed a moderate level of production, which might be due to better practices of rooftop gardening and availability of resources. Annual production of vegetables was 40–50 kg and fruits 45–55 kg, highest in Income Class 4. This shows that the higher income group can afford more investment in rooftop gardening which gives higher productivity in return.

3.5 Table: Average Air Quality Parameter in Study Area.

Parameter	Daily Average
CO_2 (ppm)	5500
$PM_{2.5}$(µg/m³)	120.4
PM_{10} (µg/m³)	107.5
TVOC (mg/m^3)	20.4

Source: Field survey 2025-2026.

The daily average measured CO_2 concentration is 5500 ppm (Standard value 1000 ppm; WHO, 2022) indicating that the daily average concentration was very high above the level associated with outdoor air quality. Similarly the daily average $PM_{2.5}$ concentration is 120.4 µg/m³ (standard value 25 µg/m³; WHO, 2021) and PM_{10} concentration is 107.5 µg/m³ (standard value 50 µg/m³; WHO, 2021). The measured TVOC concentration is 20.4 mg/m³ (standard value 05mg/m³; WHO, 2021). Overall, the measured values indicate relatively bad outdoor air quality in the study areas (Mirpur, Mohammadpur, Uttara and Dhanmondi). Long-term exposure to elevated carbon dioxide (CO_2) levels can lead to chronic hypercapnia, metabolic adjustments and persistent neurological symptoms like headaches and fatigue. Long-term exposure to $PM_{2.5}$, PM_{10} can cause chronic respiratory diseases, lung function decline and increased risk of cardiovascular mortality. Long-term exposure to total volatile organic compounds (TVOCs) can cause chronic health problems including permanent damage to internal organs and an increased risk of cancer.

Table 3.6. Name of Common Vegetables and Fruits in the Rooftop Gardening of Dhaka City.

Name of Vegetables	Name of Fruits
Papaya, Eggplant, Taro, Sponge Gourd, Okra, Bottle Gourd, Beans, Leafy Greens, Spinach, Bitter Gourd, Coriander, Mint, Lemon, Green Banana, Snake Gourd, Green Chili, Tomato.	Dragon, Mango, Star Fruit, Sweet Orange, Rose Apple, Sugar Apple, Guava, Hog Plum, Black Ebony Fruit, Sweet Potato, Sugarcane, Aloe vera, Strawberry, Papaya, Banana, Banana Mango, Miyazaki Mango.

Source: Field survey 2025-2026.

Figure 2: Vegetables and Fruits grown in Rooftop Gardening.



Source: Field survey, 2025-26.

1. Rooftop gardening (RTG) for vegetables and fruits production:

2. The table 3.6 shows that the respondents commonly cultivate a variety of vegetables and fruits through a rooftop gardening in Dhaka city with vegetables and fruits such as including tomato, guava, papaya, mango, eggplant being among the commonly grown products. According to the survey respondents produce approximately 6-7 kg vegetables per month and seasonal fruits contribute around 15-20 kg annually. The practice of rooftop gardening has gained popularity, particularly in urban areas, as a means to promote sustainability in urban agriculture. It can enhance resource sustainability, contribute to food security and provide fresh food locally produced food for urban communities. Also, through the survey we analyzed that a large number of senior citizens are getting benefits both mentally and physically because of rooftop gardening. However, rooftop gardening should complement rather than replace large-scale rural vegetable production. Green roofs, including rooftop agriculture emerge as a viable option to restore lost green areas and expand localized urban agriculture particularly in the form of green roof production systems. *(Field survey, 25-26).*

3. Merits of rooftop gardening:

4. Urban Heat Island Reduction: Rooftop gardens act as insulation, mitigating heat absorption and radiation from buildings. This helps reduce the urban heat island effect leading to lower surface and air temperatures in metropolitan areas creating a more comfortable and cooler microclimate[4].

5. Stormwater Management: Plants on rooftops serve as natural stormwater management solutions by capturing and absorbing rainwater. This reduces the quantity and intensity of stormwater runoff alleviating pressure on drainage systems and lowering the risk of floods[11].

6. Improved Air Quality: Rooftop Garden plants play a role in filtering and capturing airborne contaminants including gases and particulates. This contributes to improved air quality in urban environments as plants produce oxygen and absorb carbon dioxide[13,14].

7. Community Engagement: Rooftop gardens provide opportunities for social interaction and community participation. They serve as social hubs, educational platforms and catalysts for neighborhood engagement and empowerment.

8. Local Food Production: Urban rooftop gardens enable the production of food in close proximity to homes, enhancing food security and

reducing dependence on long-distance transportation. Residents can cultivate fresh products, fostering a connection with nature and supporting sustainable food systems.

9. Tax Incentives for Rooftop Gardening in Bangladesh:
   Bangladesh has recently introduced a local government tax incentive to encourage rooftop gardening as part of its urban greening and environmental sustainability initiatives approved a 5% holding tax rebate for homeowners who maintain rooftop gardens or gardens within their residential premises.[8,19].

10. Major Findings

11. From the above discussion here author summarized all the findings together. The major findings of the study are given below:

12. In Dhaka city, it reveals that the old-aged respondents comprised the highest proportion in every region which is 38%.

13. The study found that the daily average concentrations of CO_2, $PM_{2.5}$, PM_{10} and TVOC exceeded their respective recommended standards indicating elevated levels of outdoor air pollutants. Overall, the findings suggest relatively poor indoor air quality in the study areas.

14. In all the regions, most of the respondents involved in rooftop gardening belong to small-sized families (3 members or less). In Uttara, the contribution of both medium (4-6 members) and large (more than 6 members) families are same while in Mohammadpur, Dhanmondi and Mirpur has the least respondents from large-sized families.

15. Education, Age, family size, gender, access to training giving time in rooftop growing season and production technology were statistically insignificant. So, there was no relationship with rooftop production.

16. 80 percent of respondents agreed that rooftop production is sustainable in Mohammadpur that was the highest portion among the five selected areas.

17. The majority of the respondents agreed that rooftop production gives more nutrition than buying from the market.

18. In this research, it is found that among all the regions, Mirpur respondents collect the highest portion of production per day and per month.

19. Among all the regions, Mirpur area respondents had training experience on rooftop gardening and they wanted to access training also.

20. From the study, it was seen that the majority of rooftop owners wanted to do a vertical garden. Maximum respondents already implemented a vertical garden in their rooftop.
21. Five common fruits (Mango, Dragon, Guava, Banana, Papaya) and vegetables (Tomato, Bitter gourd, Eggplant, Green Chilli, Snake gourd) were selected from respondent rooftop by the basis of highest production and sales was calculated by the average market price.
22. In Mirpur the benefit-cost ratio was 1.345 which was highest among all regions which means the result was economically satisfactory. So, the rooftop owners from Mirpur can do agribusiness with the extra production on a small scale.
23. In this research, it is found that gardening positively influences both physical and mental health by reducing stress, anxiety and depression while improving overall well-being.

Recommendation:

1. Vegetables and fruits yields in current RTGs could be enhanced with careful management. So, proper training facilities on both online and offline platforms will be required. Benefit-cost ratio is higher in every region in Dhaka city. So, rooftop production has agribusiness scope and opportunity.
2. To improve RTG in the individual areas, proper crop, technical knowledge and training facility is required.
3. Rooftop gardening production will make employment opportunities if the agribusiness platform will be made.
4. The government tax rebate policy is not known among most of the respondents. The government must take some initiatives to spread this information among all the residents in Dhaka city.

Conclusion

Dhaka is one of the world's fastest-growing megacities open and cultivable land has been unlawfully changed to built-up area resulting in an alarming loss of agricultural land. Rooted in ancient practices and evolving into modern green roofs is not only addresses spatial constraints but also fosters ecological well-being. Today, rooftop gardening offers a versatile approach incorporating diverse systems like green roofs and hydroponics. Despite structural, maintenance and policy challenges the merits including heat island reduction, stormwater management, improved air quality, community engagement and local food production underscore its significance[9, 13]. Advocacy, innovation and strategic planning will ensure the continued growth of rooftop gardens contributing to vibrant and eco-friendly urban landscapes. The researcher drew the following conclusions based on the findings and relevant facts of the research work. Rooftop gardening in particular, helps to the construction of a healthy environment and food security. It improves the quality of perishable goods reaching urban customers by increasing the supply of fresh food[20,21]. There is no explicit policy provision or regulation in Bangladesh that promotes urban agriculture in general or rooftop gardens in particular. In Dhaka, there is no special city strategy that promotes urban agriculture. This is critical as several countries such as Switzerland and Germany have demonstrated and rooftop gardening has enormous potential. Maximum old aged people cultivate on rooftops because they have leisure time after retirement or they enjoy this work as well. Those rooftop owners have training experience their production level was high from this research. Rooftop owners wanted to improve their technical knowledge to increase production. It was also found that it has a regional impact because Bengali people want to do the same to see others so it has a positive effect. On the other hand, rooftop production secures organic food there is minor chemical use for ripening fruits also. The findings of this study indicate that rooftop gardening provides significant environmental and health benefits making it an effective nature-based solution for sustainable urban development. The study indicates that rooftop gardening has the potential to improve urban air quality by contributing to lower CO_2 concentrations in areas with greater rooftop garden coverage. The findings suggest that increased rooftop vegetation can enhance carbon absorption reduce the urban heat island effect and create a healthier urban environment. Gardening positively influences both physical and mental health by reducing stress, anxiety and

1. depression while improving overall well-being. In urban areas with limited green spaces, rooftop gardening provides access to nature, promotes social interaction and physical activity and contributes to better psychological health and quality of life[23,24] .Therefore, promoting rooftop gardening across Dhaka city can serve as an effective nature-based solution for reducing carbon emissions improving environmental quality supporting mental well-being and ensuring long-term urban sustainability.

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