# SPATIO-TEMPORAL ANALYSIS OF THE CHANGES IN ROOFTOP GARDENING IN DHAKA METROPOLITAN AREA

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**Abstract**

Urban Rooftop gardening (RTG) as a possible solution to food insecurity gets popularised due to the reduction of urban agricultural land and regarded as an effective climate change impact mitigation strategy. This paper identified the spatio-temporal changes of RTG practices in Dhaka Metropolitan Area (DMA) between 2016 and 2021. This evidence-based study was conducted based on manually extracted build-up (building rooftop) areas of DMA for 2021 and RTG areas of DMA for 2016 and 2021 through digitization from Google earth images using Google Earth Pro software. It is identified that the different zones of DMA experience changes in RTG differently based on their zonal development stages. The DMA received moderate increase (i.e. 15 percent) in RTG between 2016 and 2021 where the western part has greater RTG area than the eastern part. The study also reveals that planned residential areas have higher RTG areas than any other landuse whereas most Government/ Non-Government buildings have less RTG throughout the 20 zones of DMA and the Dhaka Cantonment area.

**Keywords:** Rooftop Gardening, Dhaka Metropolitan Area, Spatio-temporal Changes

## Introduction

Cities are considered as the engines of development of a country. It is estimated that 54 percent people of the world live in urban areas (i.e. cities and towns) and it

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would be 66% by 2050 (UN, 2014) because of rural urban migration. In this era of urban booming, urban space absorbs about 55 percent population of the world and expected to increase to 68 percent by 2050 (United Nations, 2019, p. 19). Cities occupy only 3 percent of the global land cover but consume 80 percent of the global food produced (FAO, 2022) and emits 80 percent of global greenhouse gas and produce 36.3 billion tons of global average carbon footprint, contributing to global warming-induced climate change (Pang et al., 2020; IEA, 2021). Moreover, expansion of urban centres creates pressure on urban agricultural land, causes food insecurity and increases the urge to practice agriculture in an urban environment.

Rapid and unplanned urbanization is bringing great demand of urban food supply. However, urban people fail to control over the production of basic commodities i.e. foods (Roseland, 2005) due to the reduction of green space and increase of urban heat island effect (Smit et al., 2001). As a result, idea of urban rooftop garden (RTG) is emerged as a possible solution of urban food problem. Urban rooftop gardens can contribute to food and nutrition of urban households (Baudoin et al., 2017). Moreover, urban rooftop gardens can reduce the use of fossil fuel by the reduction of travel for food and these gardens can reduce the temperature of the roofs and adjacent air, which contribute to cooling local climate as well (RIES, 2014).

Ancient Etrurians and Romans were first evident to practice rooftop gardening (RTG) (Barreca, 2016, p. 721), mostly due to aesthetic purposes. In modern times, RTG provides a diverse range of financial and non-financial ecosystem services from food supply to social and mental well-being (Thapa et al., 2021, pp. 2-3) To be self-reliant, urban people need to grow daily foods inside the urban areas. Rooftop gardening would be a way for the production of several foods. The choice of production techniques can vary from citizen to citizen. Urban agriculture can provide healthy and nutritious food, improve environment and strengthen local economy. It is found that rooftop gardening brings dietary changes and leading to raise vegetable intake (Blaine et al., 2010; Flores, 2006). A rooftop garden can partially or fully fulfil a family's vegetables needs as well as nutritional requirements (e.g. vitamin-A, B, C and iron). As hunger and obesity are increasing day by day so, supply of nutritious food to them is more important (Brown & Jameton, 2000).

Dhaka, the capital of Bangladesh, is one of the world fastest-growing urban centres with the fourth highest urban population (United Nations, 2019). Agricultural land in and around Dhaka reduced by 12.32 percent while residential area increased by 9.2 percent from 2006 to 2013 (Mahmud, 2014, p. 1). The food demand of Dhaka

city dwellers is unable to meet from inside of the city rather meet from nearby or distant places outside the city (Etzold et al., 2009, pp. 14). Therefore, RTG would be a possible solution to urban food and nutrient insecurity problem. In this circumstance, it is urgent to identify the existing condition of the RTG in Dhaka Metropolitan Area (DMA). To identify the full potential benefits of RTG based on particular context from cities of developing countries, RTG practice of Dhaka could be a useful study. Therefore, present study (I) identified the ratio of building roof and rooftop garden area of DMA for 2016 and 2021 and (II) determined the zone-wise spatio-temporal change in RTG in DMA between 2016 and 2021. Such type of study would be useful for the policy makers, urban planners, environmentalists as well as the urban dwellers. Assessment of such potential urban renewable resources help to design future policy frameworks, incentives programs, awareness and training facilities that further promotes achieving urban sustainability. This study explores the status of RTG in DMA (including Dhaka Cantonment) in 2016 and 2021 and their spatio-temporal change.

The first section contains background, statement of the research problem, importance of the study and the objectives of the study. The second section deals with review of literature. The third section describes the methods of the study including the study area and accuracy assessment. The fourth section of the paper highlights the results of the study. Section five deals with a discussion on the results of the study and the final section summarizes the study.

**Review of literature**

The practice of RTG influenced by the process of urban transformation. The concept of urban transformation emphasized the need and opportunity for fundamental changes to sustainable and resilient cities. Some theories of urban transformation postulate that cities are continuously experiencing transformations or changes (Haase et al., 2018). Chicago school proposed the theory of urban ecology that deals with the structure and function of urban ecosystem. Moreover, it focuses on the mechanism of social structures and environmental conditions in shaping human behaviour. The theory assumes that the changes in neighbourhood (i.e. surrounding urban area) occur due to human interactions and human needs. On the other hand, L. Lefebvre proposed the theory of sustainable urbanism in 1970 and production of urban space in 1974 (Wiedmann & Salama, 2019). The theory discussed about urbanism, its production, evolution and key conflicts. The theory emphasized on human-induced spatial development by considering physical and spatial settings of an area (Wiedmann & Salama, 2019).

The idea of RTG could be connected with the theory of the production of urban space proposed by David Harvey. The theory postulated six theses such as spatial concentration thesis, spatial dispersal thesis, spatial fix thesis, uneven geographical development-as-ideology thesis, the uneven geographical development and state connection thesis, and uneven geographical development interconnected political thesis (Das, 2017). The theory more focuses on the uneven geographical development which is an important part of David Harvey's large theory of production of urban space. The RTG practice in an urban area could also be explained by the ideas of Gottdiener and Wirth. In 1985 Mark Gottdiener introduced a new spatial form based on the social production of urban space. The new spatial form is sprawling, unbounded, and multi-centred metropolitan region which is the consequence of several processes. For instance, the growth of agri-business is one of the processes. Gottdiener showed that the use of space or real estate or property value can produce the additional value or production (Ruddick & Gottdiener, 1987). However, Louis Wirth stated about the interaction of urban people with the built environment in his theory of 'urbanism as a way of life' (Laskar, 2018). The theory denoted that the size and density of cities change the way of people and their relationship. Urban people do not interact with others as individuals but they interact with others in particular roles. For instance, urban dwellers interact with the gate keeper of the particular building only because of particular purposes but they do not develop personal connections with them (ASA, 2023).

Besides the role of RTG to urban transformation, gardening could be a way to rest and release pressure. Thus, rooftops gardening can improve psychological health of urban citizens (Minnich, 1983; Malakoff, 1995). Practice of rooftop gardening can increase the rate of carbon sequestration and decrease the climate change impacts. For instance, it is estimated that if United Kingdom produce and consume foods locally then the level of $CO_2$ would be decreased by 22% (Doron, 2005). This type of gardening can reduce local economic leakage, increase green space and reduce effect of urban heat island. For example, if rooftop gardening is practiced in Singapore over the public states housing, it would be possible to meet 35.5% vegetables demand and country's carbon footprint would decrease by 9052 tons emissions annually (Astee & Kishnani, 2010). It can create job opportunity in food sectors such as production, processing and marketing. In addition, waste of kitchen can be reused as fertilizer. As a result, cost of waste management for city dwellers can be reduced (Malakoff, 1995).

The DMA however, is highly dominated by residential, commercial and industrial land uses. These types of land uses are increasing day by day. Therefore, current

practices of land use within the DMA bring potential threat to agricultural activities (Mahmud, 2014, p. 1). Thus, agricultural production in DMA is decreasing day by day and hence, the agricultural products including fruits and vegetables need to bring from outside the DMA to meet the daily food demand of the residents in the area. Consequently, the price of the agricultural products is becoming costly. Besides, in most of the times, inhabitants of DMA do not get fresh vegetables and fruits. To get green vegetables and fruits the DMA residents started to practice RTG.

Dhaka with enormous potentiality of RTG could be a suitable study area for research. About 10,000 ha area of Dhaka city can be brought under RTG and local dwellers can get fresh vegetables while meeting over 10 percent of the consumption (Bhuiyan & Ferdous, 2021). In different parts of Dhaka, annual production from RTG is valued from US$ 2,676 to US$ 60,202 depending on the type and size of RTG (Safayet et al., 2017, p. 61). The lakeside residents of Korail slum in Dhaka supplement their food demand from RTG by 35 percent along with secondary income sources, women entrepreneurship and empowerment (Kaizer, 2020, pp. 21-22). However, previous studies (Shariful Islam, 2002; Asad et al., 2014; Safayet et al., 2017, Islam et al., 2019; Shahidullah et al., 2022) focused more on the current practices, potentiality, perceptions, institutional settings, barriers as well as future prospects of RTG in Dhaka. Moreover, studies identified that RTG could be an alternative strategy for promoting food security in Dhaka (Chowdhury et al., 2020), and a source of environment conservation (Islam et al., 2020). On the other hand, previous studies emphasized on climate change and carbon sequestration, health conditions of urban people, job opportunities from RTG, carbon heat island, and waste management system (Minnich, 1983; Malakoff, 1995; Doron, 2005; Astee & Kishnani, 2010). Although having a number of studies on RTG of Dhaka city, literature suggests that there is no study conducted on spatio-temporal changes of RTG for the entire DMA.

**Method of the study**

The present research is an empirical way of investigation where data were obtained from both primary and secondary sources. To assess the existing situation of rooftop gardening in DMA it was needed to identify the total number of space as a continuous roof and then to identify the proportion of rooftop space used for gardening. This evidence-based study was conducted based on manually extracted built-up (building rooftop) areas of DMA for 2021 and RTG areas of DMA for 2016 and 2021 through digitization from Google earth images using Google Earth

Pro software. During the digitization process, the study utilized similar seasonal imageries (mostly Jan-May, Nov-Dec) from 2016 and 2021 for better visualization and comparison. The researchers use Google earth images from 2016 for knowing the recent RTG practices of DMA inhabitants. Consequently, out-dated Google earth images from 1990 or 2000 are not more suitable for this purpose. Besides, present study also think about the impact of lock down (i.e. Covid-19) on RTG practices because local newspapers published the news of increasing RTG during Covid-19. Therefore, to evaluate the present status of RTG in DMA and provide some suggestions it was necessary to evaluate recent data. After the preparation of built-up and RTG areal datasets of DMA, all the geo- processing, editing, area calculation, map preparation has been prepared using Arc Map (version 10.6) and all the graph, table and charts has been prepared using Microsoft Excel.

The study prepared a dataset on built-up area (i.e. building with roof) of DMA and hence, excludes other land covers of urban environments, for example, paved surfaces, commercial and industrial sites as well as urban green spaces. About 5,59,153 building rooftops have been detected where building structure was only "Pacca" and exclude all possible types of Semi-pacca" and Tin-shed/Kacha. About 51,915 RTGs occupy over 22, 35, 042.98 Sq. m. in 2016 and about 65,139 RTGs occupy over 25,79,477.098 Sq. m. in 2021 has been identified. To identify the zonal changes of RTG practices from 2016 to 2021 the study classified the changes into four categories including reduced, minor increase, moderate increase, and high increase.

***Accuracy Assessment***

An accuracy assessment was carried-out for the present study conducted of the feature extraction and digitization process. It compares the newly prepared dataset to the dataset having accurate or ground truth data collected from the field. A total number of 105 random sample points have been justified against the field-based ground truth point's dataset (Fig. 1). For this, a combination of high-density built-up area and the existence of RTG practices were selected. The samples were distributed proportionately among 20 zones (10 zones of DNCC and 10 zones of DSCC) and the Dhaka Cantonment of Dhaka Metropolitan Area (DMA), which represents at least one (01) rooftop garden in one zone (Fig.1). The zonal and overall accuracy assessments have been conducted using the following formula:

$$\text{Accuracy Assessment} = \frac{\text{Number of Total Corrected Sample Points}}{\text{Number of Total Sample Points}} * 100$$

Moreover, the study identified some relevant information such as why RTG occur in the DMA, who usually does RTG (e.g. upper/middle/lower classes; house owners/ landlords), why do people do it (e.g. for economic, social, aesthetic, or health purposes), when and by whom do they do so, who can afford the time/resources to do so, and so on. These data were collected by conducting a questionnaire survey on the RTG practitioners of 105 sample households that were selected for ground verification of the areas identified as RTGs.

### *Study area*

The present study was conducted in the Dhaka Metropolitan Area (Fig. 1). The reason to choose DMA as the study area is one of the fastest-growing cities in the world where most of the building's rooftop spaces of DMA is highly suitable for rooftop gardening (RTG) due to its flat structure and additionally blessed with favorable climate and available water, fertile soil and other resources but historical literature-based evidence revealed less RTG practices in the DMA (Chowdhury et al., 2020).


**Figure 1:** The Dhaka Metropolitan Area including Dhaka Cantonment. (Source: Authors, 2022)

## Results of the study

### *Accuracy of feature extraction and digitization*

The study identified 95 percent overall accuracy on the detection of RTGs for 2016 and 97 percent overall accuracy for 2021 (Table 1). As the 2016 historical images of Google Earth Pro have more cloud coverage with low-resolution images than that of 2021 during digitization, the 2016 RTG dataset might have lesser overall accuracy than 2021 RTG dataset.

**Table 1: Zone wise and overall accuracy assessment of RTG in the study area.**

| | Accuracy Assessment (Percent) | | | Accuracy Assessment (Percent) | |
|---|---|---|---|---|---|
| **Name of the Zone** | **2016** | **2021** | **Name of the Zone** | **2016** | **2021** |
| Dhaka Cantonment | 100 | 100 | DCC South 1 | 80 | 100 |
| DCC North 1 | 100 | 100 | DCC South 2 | 100 | 100 |
| DCC North 2 | 100 | 80 | DCC South 3 | 100 | 100 |
| DCC North 3 | 100 | 100 | DCC South 4 | 100 | 100 |
| DCC North 4 | 80 | 100 | DCC South 5 | 80 | 100 |
| DCC North 5 | 100 | 100 | DCC South 6 | 100 | 80 |
| DCC North 6 | 100 | 100 | DCC South 7 | 100 | 100 |
| DCC North 7 | 100 | 100 | DCC South 8 | 100 | 100 |
| DCC North 8 | 80 | 100 | DCC South 9 | 80 | 100 |
| DCC North 9 | 100 | 100 | DCC South 10 | 100 | 100 |
| DCC North 10 | 100 | 80 | **Overall Accuracy** | **95** | **97** |

(Source: Authors, 2022)

### *Rooftop gardening practices in the Dhaka Cantonment Area*

The entire Dhaka Cantonment is one of the well-planned areas in DMA. Although having planned residential, administrative, commercial, recreational and other institutional infrastructure, the study identified a very few building roofs that are used for gardening. Dhaka Cantonment has a building area of 26,46,091.76 sq.m. whereas, only 2.91 percent area in 2016 and 3.10 percent area in 2021 were used for RTG. Dhaka Cantonment area experienced a minor increase (i.e. 6 percent) in RTG from 2016 to 2021 (Fig. 2 and Table 2).

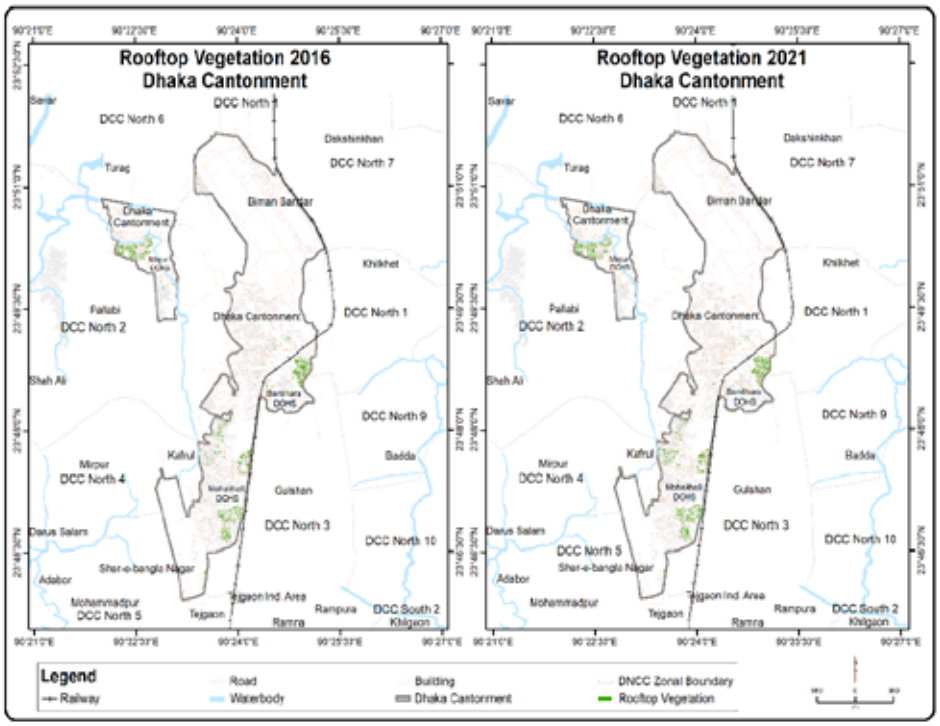


Figure 2: Rooftop gardening practices in the Dhaka Cantonment Area. (Source: Authors, 2022)

### *Rooftop gardening practices in the Dhaka North City Corporation (DNCC)*

The results of the study reveal noticeable spatial (zonal) and temporal changes in RTG practices. For instance, DNCC Zone 1 experienced an increase (i.e. 6 percent) in RTG from 2016 to 2021 (Table 2). Most of the RTGs homogenously increased in the pre-existing hotspots such as Uttara sector- 7, 9 and 4, Nikunja-2 residential area and Bashundhara residential area etc. (Fig. 3). The DNCC Zone 2 experienced the highest observed increase (i.e. 22 percent) in RTG from 2016 to 2021 (Fig. 5, Table 2). Most RTGs homogenously increased in the pre-existing hotspots like Mirpur DOHS, Mirpur (section-1, 2, 6, 7, 10, 12 and 13), Lalmatia, Pallabi, Bawnia etc. (Fig. 3). The DNCC Zone 3 experienced a moderate increase (i.e. 16 percent) in RTG from 2016 to 2021 (Table 2). Most RTGs homogenously increased in the pre-existing hotspots like Baridhara DOHS (partial), Badda (North & South), Gulshan-1&2, Banani, Mohakhali, West Nakhalpara, New Eskaton, East Rampura, Tejgaon industrial area etc. (Fig. 3). The DNCC Zone 4 experienced the second-highest increase (i.e. 21 percent) in RTG from 2016 to 2021(Table 2).

Most RTGs homogenously increased in the pre-existing hotspots like Ibrahimpur, Monipur, Shewrapara (East and West), Paikpara (Mid and south), Borobag, Shah Alibag, Lalkuthi,Gabtoli, etc.(Fig. 3). The DNCC Zone 5 also experienced the second-highest increase (i.e. 21 percent) in RTG from 2016 to 2021 (Fig. 3 and Table 2). Most RTGs homogenously increased in the pre-existing hotspots like Agargaon, Lalmatia, Mohammadpur, Shyamoli, Tejgaon, Mohammadia residential area and other housing societies such as Baitul Aman, Chandmia, Dhaka Uddan, PC Culture, Nabi Nagar, as well as Nobodoy Housing Society.

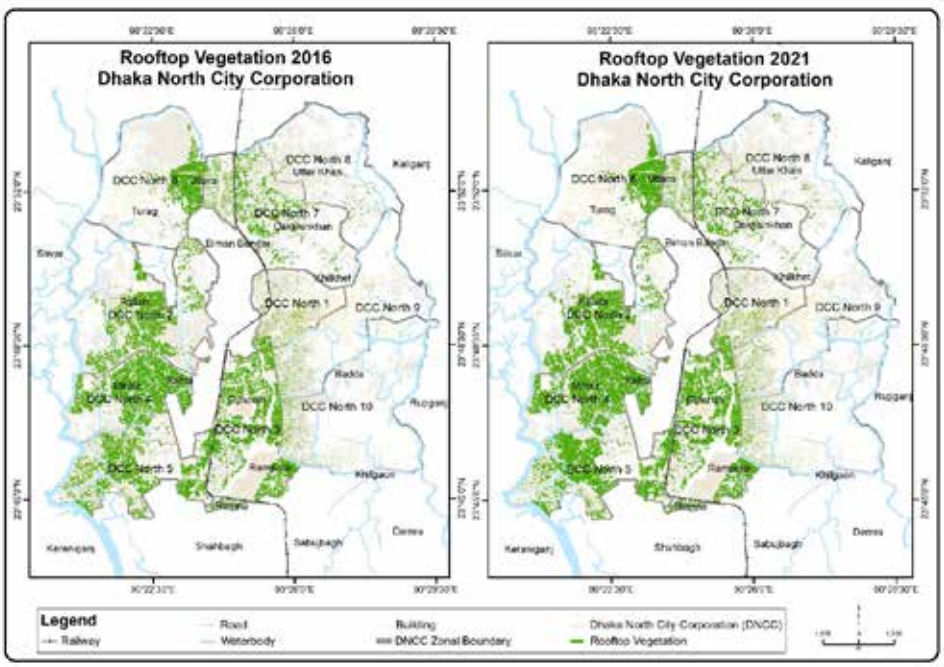


**Figure 3: Rooftop gardening practices in the DNCC. (Source: Authors, 2022)**

The DNCC Zone 6 experienced the third-highest increase (20 percent) in RTG from 2016 to 2021(Table 2). Most RTGs homogenously increased in the pre-existing hotspots like Uttara sector- 5, 10, 11, 12, 13 and 14 etc. Some portions of this zone is still under development, especially Uttara sector-15, 16, 17 and 18 under Uttara Residential Model Town (3rd phase) and the current trend predicts that many new RTGs will take place in these areas in the near future (Fig. 3). The DNCC Zone 7 experienced a minor increase (3 percent) in RTG from 2016 to 2021(Table 2). Although many new buildings have been constructed during the last 5 years but most RTGs homogenously increased in the pre-existing hotspots like Ajampur,

Ashkona, Chalaban, Mollapara, Naddapara, Nowapara and Prembagan. Some portions of this zone are still under development and the current trend predicts that many new RTGs might take place in the near future (Fig. 3). On the other hand, the DNCC Zone 8 experienced a slight decrease (1 percent) in RTG from 2016 to 2021(Table 2). Although many new buildings have been constructed within 5 years, existing RTG hotspots rather show decreasing trends among the RTG practitioners. The current trend might be a fallacy with reference to findings from other zones and additionally as some portion of this zone is still under development, especially the eastern Turag Riverbank, many new RTGs might take place in the near future (Fig. 3). The DNCC Zone 9 experienced a moderate increase (15 percent) in RTG from 2016 to 2021(Table 2). Most RTGs homogenously increased in the pre-existing hotspots like Vatara, Nurer Chala and Bashundhara residential area. As some portion of this zone is still under development, especially the eastern part of Bashundhara residential area and the current trend predicts that many new RTGs might take place in the near future (Fig. 3). The DNCC Zone 10 also experienced a minor increase (8 percent) in RTG from 2016 to 2021(Table 2). Although many new buildings have been constructed within 5 years, most RTGs increased in the pre-existing hotspots such as Adarsha Nagar, Tekpara, Merul Badda, Aftabnagar etc. (Fig. 3).

***Rooftop gardening practices in the Dhaka South City Corporation (DSCC)***

Similar to DNCC, the study identified spatio-temporal changes in RTG areas in Dhaka South City Corporation (DSCC). For instance, DSCC Zone 1 has experienced the third-highest increase (i.e. 20 percent) in RTG in the study area from 2016 to 2021(Table 2). Most RTGs homogenously increased in the pre-existing hotspots like Dhanmondi residential area, Kalabagan, Banglamotor, Kataban etc. (Fig. 4). The DSCC Zone 2 experienced a moderate increase (13 percent) in RTG from 2016 to 2021 (Fig. 5, Table 2). Most RTGs homogenously increased in the pre-existing hotspots like Banasree residential area, Bashabo, Goran, Khilgaon, Paltan, Shanti Nagar, Shahidbag, Rajarbagh, South Mugdapara etc. (Fig. 4). The DSCC Zone 3 experienced a minor increase (i.e. 5 percent) in RTG from 2016 to 2021 (Table 2). Although many new buildings have been constructed within 5 years, most RTGs homogenously increased in the pre-existing hotspots like Bosila, Hazaribagh, Munshihati, Kashmiri Tola, Khaje Dewan etc. (Fig. 4). The DSCC Zone 4 experienced a moderate increase (14 percent) in RTG from 2016 to 2021(Table 2). Most RTGs homogenously increased in the pre-existing hotspots such as Babu Bazaar, SaatRawza, Sikkatuli, Siddique Bazar, and Bangshal etc.

(Fig. 4). The DSCC Zone 5 experienced a moderate increase (16 percent) in RTG from 2016 to 2021 (Table 2). Most RTGs homogenously increased in the pre-existing hotspots such as Dhupkhola, Dhalpur, Jatrabari, Tikatuli, Golapbagh, Maniknagar, Niketan, Gendaria etc. (Fig. 4).

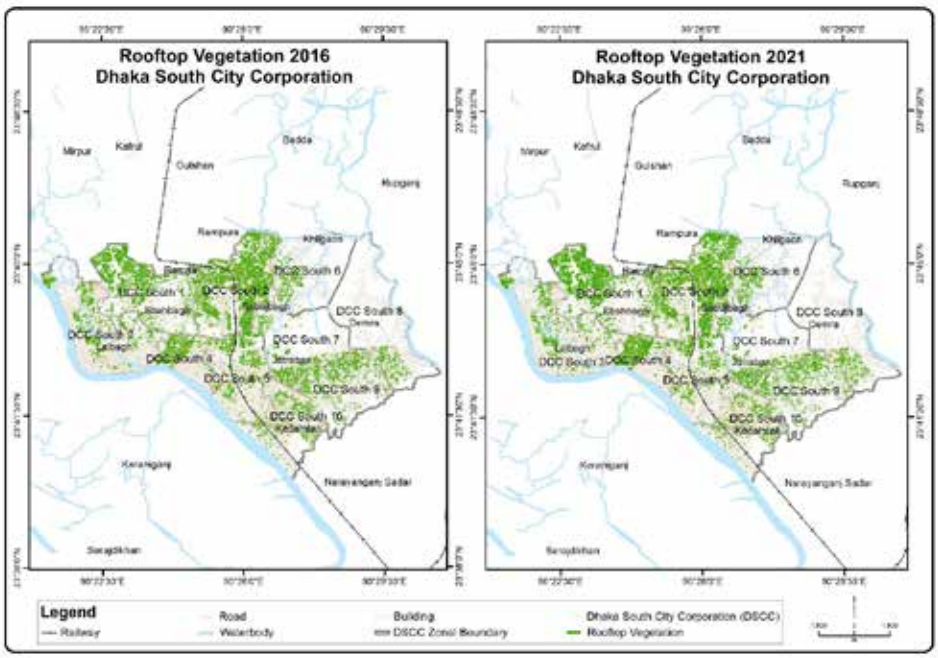


**Figure 4: Rooftop gardening practices in the DSCC. (Source: Authors, 2022)**

The DSCC Zone 6 experienced a minor increase (i.e. 6 percent) in RTG from 2016 to 2021 (Fig. 4 and Table 2). Most RTGs homogenously increased in the pre-existing hotspots such as Rosulbag, Nandipara, Sabujbagh etc. Significant portion of this zone still remained undeveloped, especially the eastern part, and has the potential to develop and occupy more RTGs in the near future. The DSCC Zone 7 experienced a moderate increase (i.e. 16 percent) in RTG from 2016 to 2021(Table 2). Most RTGs homogenously increased in the pre-existing hotspots like Konapara, Manda, Mridhapara etc. Major portion of this zone remained undeveloped, especially the east-central part, and has the greater potential to develop and occupy more RTGs in the near future (Fig. 4). The DSCC Zone 8 experienced a moderate increase (i.e. 11 percent) in RTG from 2016 to 2021(Table 2). Most RTGs homogenously increased in the pre-existing hotspots like BahirTangra, Sarulia,Rasul Nagar etc. Some portion of this zone is still under development, especially the north-western

part, and current trend predicts that many new RTGs might take place in the near future (Fig. 4). On the other hand, DSCC Zone 9 has experienced a slight decrease (i.e. 1 percent) in RTG from 2016 to 2021 (Table 2). Although many new buildings have been constructed within 5 years, existing RTG hotspots dominated by mixed land use rather show decreasing trends among the RTG practitioners (Fig. 4). The DSCC Zone 10 experienced a minor increase (i.e. 9 percent) in RTG from 2016 to 2021 (Fig. 5, Table 2). Most RTGs homogenously increased in the pre-existing hotspots like Doniya, Japani Bazar, Shanir Akhra, Rayerbagh, Meraj Nagar, Mohammadbag, Shyampur etc. (Fig. 4).

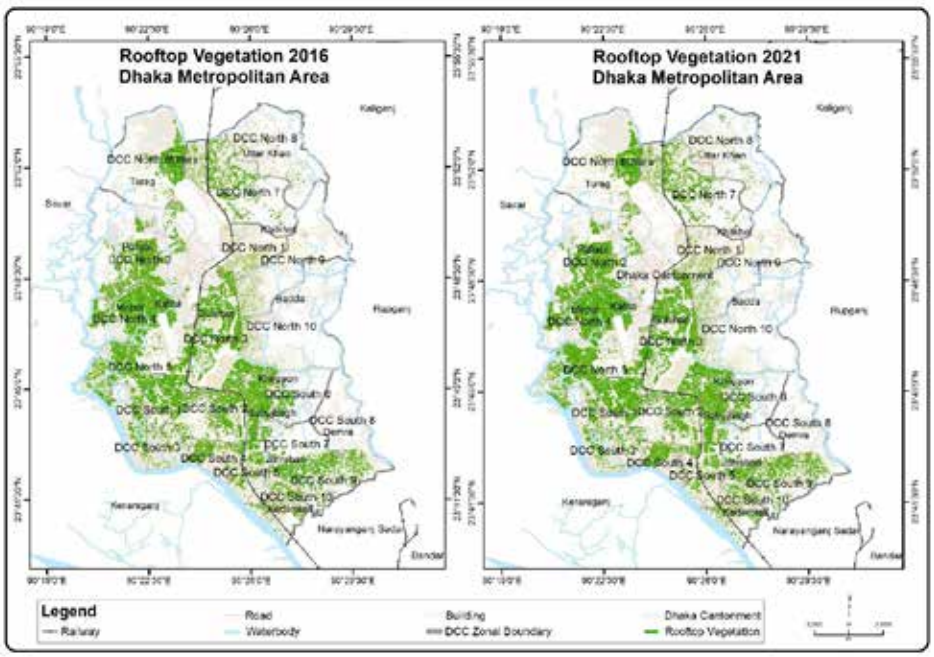


**Figure 5:** The overall changing scenario of RTG practices in the DMA from 2016 to 2021. (Source: Authors, 2022)

**Table 2: The spatio-temporal changes of RTG practices in the DMA from 2016 to 2021.**

| Name of the Zone | RTG in 2016 (sq. m) | RTG in 2021 (sq. m) | Net Area Change (sq. m) | Net Area Change (Percent) |
|---|---|---|---|---|
| Dhaka Cantonment | 76992.81 | 81927.84 | 4935.03 | 6 |
| DNCC Zone 1 | 190074.92 | 200627.36 | 10552.44 | 6 |
| DNCC Zone 2 | 186250.76 | 226512.15 | 40261.39 | 22 |

| | | | | |
|---|---|---|---|---|
| DNCC Zone 3 | 313662.06 | 364825.49 | 51163.43 | 16 |
| DNCC Zone 4 | 232698.30 | 281549.39 | 48851.09 | 21 |
| DNCC Zone 5 | 241014.66 | 292553.41 | 51538.76 | 21 |
| DNCC Zone 6 | 128261.71 | 154176.61 | 25914.89 | 20 |
| DNCC Zone 7 | 54729.08 | 56550.43 | 1821.36 | 3 |
| DNCC Zone 8 | 2638.41 | 2609.87 | -28.54 | -1 |
| DNCC Zone 9 | 60019.77 | 69244.82 | 9225.06 | 15 |
| DNCC Zone 10 | 60783.73 | 65587.71 | 4803.98 | 8 |
| DSCC Zone 1 | 144134.21 | 173101.83 | 28967.62 | 20 |
| DSCC Zone 2 | 231313.75 | 260606.93 | 29293.18 | 13 |
| DSCC Zone 3 | 50754.15 | 53129.53 | 2375.37 | 5 |
| DSCC Zone 4 | 47217.74 | 53610.22 | 6392.48 | 14 |
| DSCC Zone 5 | 70143.97 | 81049.47 | 10905.49 | 16 |
| DSCC Zone 6 | 23593.05 | 24957.02 | 1363.97 | 6 |
| DSCC Zone 7 | 27664.66 | 32085.35 | 4420.69 | 16 |
| DSCC Zone 8 | 9642.71 | 10706.79 | 1064.08 | 11 |
| DSCC Zone 9 | 59005.96 | 58237.28 | -768.68 | -1 |
| DSSC Zone 10 | 32802.35 | 35827.59 | 3025.24 | 9 |
| **Total** | **2235042.985** | **2579477.099** | **344434.114** | **15** |

(Source: Authors, 2022)

**Discussion**

The physical environment of DMA is changing mainly due to over population. Uneven distribution of population brings some challenges to the sustainability of natural environment. Hence, there is a decreasing trend of agricultural areas exists in DMA. However, to alive in the city areas, it is very perquisite to have some livelihood supports from urban ecology. Urban transformation in DMA highlights the fundamental changes in urban area. There are number of transformations occur in the DMA due to the practice of RTG which include the improvement of food security, enabling sustainable environment, decreasing the rate of climate change, minimizing the urban heat island, improving psychological health conditions of the practitioners, increasing employment opportunity and enhancing waste management system. Since, cultivable land is shrinking in the study area, residents gradually brought some changes in the urban territory through RTG practices which could be denoted as a transformation in urban area recognized by the urban

transformation theories. The residents of DMA are using rooftop area for the cultivation of vegetables and fruits since they do not have enough agricultural lands.

Rooftop gardening practices in the DMA get momentum during the last decade. It is identified that area of RTG in the DMA is increasing from 2016 to 2021(Table 3). The DMA experience a moderate positive change (i.e. 15% increases) in RTG between 2016 and 2021. However, there is also a decreasing trend of RTG practices in the some zones including the DNCC Zone 8 and the DSCC Zone 9 (Fig. 5, Table 2).

**Table 3: The categories of RTG practices in the different zones of DMA from 2016 to 2021.**

| Legend | Range of Change (Per cent) | Label | Number of Zones |
|---|---|---|---|
| | <0 | Reduced | 2 |
| | 0-10 | Minor Increase | 7 |
| | 11-20 | Moderate Increase | 9 |
| | 21-30 | High Increase | 3 |

(Source: Authors, 2022)

The study identified that among the diverse types of land use, renowned planned residential areas have higher RTG practitioners than any other land use such as commercial area or residential-commercial land use. Most Government/ Non-Government administrative, educational buildings have less RTG practices throughout the zones. However, RTG practice in the residential buildings of the area mostly driven by non-economic purpose such as recreation, relaxation, aesthetic or subsistence production whereas, the commercial buildings serve both economic or non-economic purposes such as aesthetic beauty, refreshment, municipal tax rebate, business promotion etc.

The western part of DMA has greater RTG area than that of eastern part, especially the entire Mirpur incorporating DNCC Zone-2, 4, 5 (Figure 6). The probable explanation might be these zones of western part is now at a stable stage after land development and although currently serves for residential-commercial mixed purposes, it has a history of well-planned fully residential area where most building owners are economically wealthy and led a posh lifestyle. As a result, along with posh lifestyle, individual rather than corporate ownership greatly promotes RTG. Most of the zones of DMA (the DNCC Zone 3, 6, 9 and the DSCC Zone 1, 2, 4, 5, 7, 8) that show moderate increase of RTG are either serve for residential or residential-commercial purposes and either at the end of the development or under

development process which clearly projects that there might be increase in RTG in these zones in the near future.

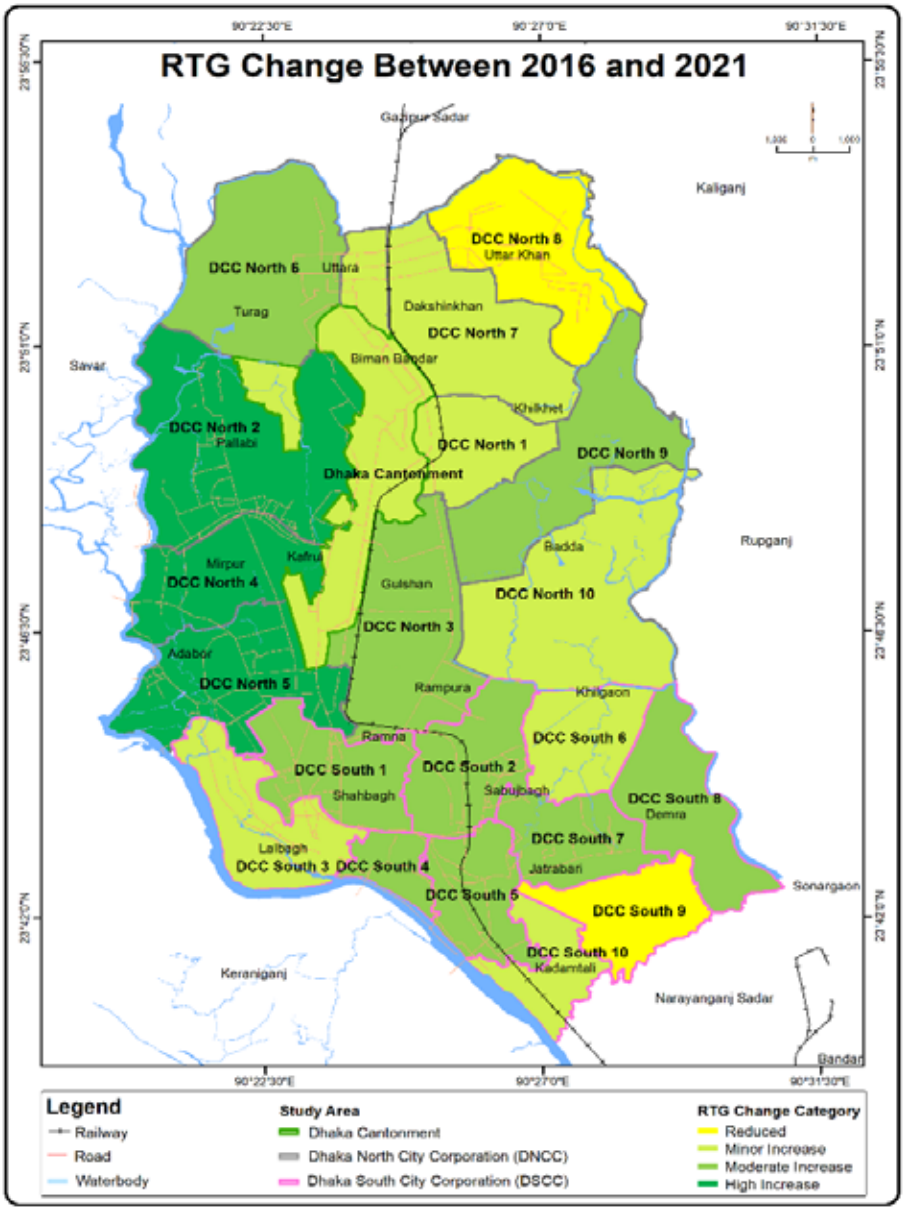


**Figure 6: The spatial distribution of rooftop gardening in the DMA. (Source: Authors, 2022)**

However, most of the zones of DMA (Dhaka Cantonment, the DNCC Zone 1, 7, 10 and the DSCC Zone 3, 6, 10), which show minor increase in RTG, cannot be uniformly explained. These zones incorporate well-planned residential areas like the Dhaka cantonment or the DNCC zone 1 area that might be at a stable stage of development as well as unplanned residential or residential-commercial mixed areas like the DNCC zone 7, 10 or DSCC 8. The Zones (i.e. the DNCC Zone 8 and the DSCC zone 9) showing negative growth of RTG are still at the developing stage and have the possibility to show positive increase in the future as more and more building owners will engage in RTG with time. No possible explanation can be drawn for the DSCC zone 3 and 10, which have highly mixed, landuse and are already at the stable stage but show minor increase in roofs. However, there is a potentiality for the inhabitants of Dhaka Cantonment area to adapt RTG as local dwellers are economically solvent, building roofs are suitable for RTG with favourable climate and available resources, but due to lack of time or administrative permission it might be difficult to practice RTG. Although many new buildings have been constructed within 5 years, most RTGs increased in the pre-existing hotspots like Mirpur DOHS (partial); Mohakhali DOHS and Baridhara DOHS (partial) etc. (Figure 2).

The study shows that there is an uneven distribution of RTG in the DMA. The capital is more or less accountable for the urban production space. The residents of DMA those who have more capital they have more tendency to use more space for the practices of RTG. Therefore, RTG of rich people is healthier and the healthier RTGs provide more production of fruits and vegetables. On the other hand, middle income or lower income people do not use more space so they have found lesser amount of fruits and vegetables. Further, the DMA is occupied by more unused rooftop space. Presently, these extra spaces have been used for the practices of RTG getting fresh vegetables and fruits. Thus, unused open space brings additional production or values by the dint of RTG.

Availability of suitable roofs and shortage of agricultural lands together force inhabitants (particularly house owners or landlords) of DMA to go for RTG practice. Tenants of the house have very few chances to practice RTG. Members of an upper or middle income family (i.e. about 95.5%) play a key role in RTG development whereas, very few cases (only 4.5%), people of lower classes are involved in the development of RTG in the DMA (Table 4). It is found that upper and middle income family use more space and resources for RTG. Therefore, RTG of higher and middle income family are healthier compared to lower income family's RTG. Consequently, healthier RTG provides more vegetables and fruits.

**Table 4: Practices of RTG in the DMA by different socio-economic classes.**

| Socio-economic class | Percentage |
|---|---|
| Upper class | 78.5 |
| Middle class | 17.0 |
| Lower class | 4.5 |

(Source: Authors, 2022)

In most of the cases, head of the household (i.e. about 80% male) setting up RTG, aiming to pass quality time at their leisure ( i.e. about 85%) and get some fresh vegetables and fruits ( e.g. about 10%) to eat and give to the relatives, neighbours, and friends (Figure 7). On the other hand, very few people of the DMA establish RTG because of health purposes (i.e. about 3%) and for aesthetic view (e.g. nearly 2%). On the other hand, about 20% female members of the certain family setting up and maintain the RTG with the help of gate keeper or caretaker of the house. There is an increasing trend of conversion of vegetated area into a barren land or open space for the development of residential, industrial and commercial structures. With the shortage of green spaces people of DMA are trying to bring back green area through RTG.

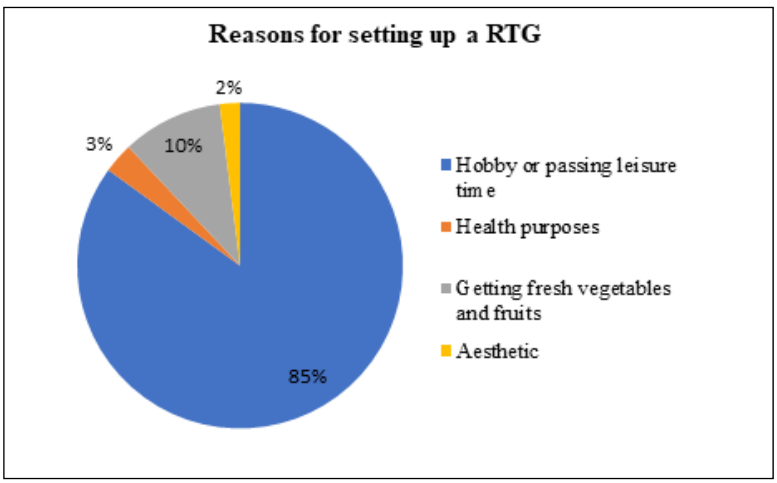


**Figure 7: Different reasons for setting up RTG in the DMA. Source: Authors, 2022)**

The practitioners spent an average 1.5-2.0 hours in a day for rooftop gardening. Of them, care taker or the gatekeeper or the wife of the gate keeper is the key labour force as he or she spend more time for gardening activities such as cultivation of

fruits and vegetables, watering the plants, collecting soil and fertilizers, spraying insecticides and pesticides as well as cleaning unwanted weeds (Table 5).

**Table 5: Engagement of people in different stages of in RTG activities.**

| Before setting up of RTG | | During setting up of RTG | | After setting up of RTG | |
|---|---|---|---|---|---|
| Type of people engaged | Activities | Type of people engaged | Activities | Type of people engaged | Activities |
| Male member of the family | Provide directions and bringing few small trees of fruits and seeds of vegetables from his native village | Male member of the family | Provide directions how to setting up RTG | Male member of the family | Sometimes visit to see the RTG and collect the mature fruits and vegetables |
| Female member of the family | Provide directions and suggestions | Female member of the family | Select particular places for particular fruits and vegetables | Female member of the family | Sometimes visit to see the RTG and collect the mature fruits and vegetables |
| Son or daughter of the particular family | Express their choice for the selection of different types of fruits and vegetable plants | Son or daughter of the particular family | Help to select different locations for different plants of fruits and vegetables | Son or daughter of the particular family | Sometimes visit to see the RTG and collect the mature fruits and vegetables |
| Gate keeper or care taker of the house | Bringing all components (i.e. seeds, small plants, soil, cow-dung, chemical fertilizers, drums etc.) for establishing RTG | Gate keeper or care taker of the house | Cultivating plants of fruits and vegetables in the RTG by the directions of RTG owner | Gate keeper or care taker of the house and his wife and son | Watering the plants and spray insecticides and pesticides as well as clean the extra or unwanted trees. |

(Source: Authors, 2022)

## Conclusion

The practice of rooftop gardening in the DMA are increasing day by day especially during the last few years. It is observed that the DMA experience a total of 15 percent increases in RTG practices between 2016 and 2021. The western part of DMA has greater RTG area than that of eastern part, especially the entire Mirpur incorporating DNCC Zone-2, 4, 5. Most of the zones of DMA (the DNCC Zone 3, 6, 9 and the DSCC Zone 1, 2, 4, 5, 7, 8) that show moderate RTG increase. Most of the zones of DMA (Dhaka Cantonment, the DNCC Zone 1, 7, 10 and the DSCC Zone 3, 6, 10), which show minor increase in RTG, cannot be uniformly explained. There is also a decreasing trend of RTG practices noticed in the few zones including the DNCC Zone 8 and the DSCC Zone 9. However, the study might broaden the scope of further in-depth micro-scale research such as the assessment of benefits of RTG in local, national and global contexts, establishment of an effective RTG model etc. Dhaka has great potential to scale up RTG to its optimum capacity which many developed countries already set exemplary milestones. Public initiation along with government and NGOs intervention are much needed to popularise such eco-beneficiary practice. Government should impose more interactive effective policy interventions such as municipal tax rebate for both DNCC and DSCC, income tax exemption for green business etc.

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