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Rooftop Gardening in Chattogram City Areas of Bangladesh- An Empirical Study

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***Abstract*—The study was carried out in three selected metro areas of Chattogram city of Bangladesh covering 90 sample households. Proportionate random sampling technique was followed. Results revealed that the average rooftop space per household was recorded as 2248.23 sq. feet; whereas 1268.4 sq. feet (56.42%) was under rooftop garden (RTG), 588.5 sq. feet (26.17%) was remained as open and 391.3 sq. feet (17.41%) was identified as potential space for expanding the garden. All of the gardens were installed at 2-10th stories of the buildings. As crop diversity 26 types of vegetables, 39 types of fruits, 11 types spices and 22 types of flower/ornamental and medicinal plants were found to be grown in the current RTG's. But the number of crops varies significantly among the garden and locations. About 16 types of containers were used for growing plants. The total yield was recorded to be 135.38 kg per garden from 22 types of vegetables in the year of 2019. Among them, the highest yield was received from bottle gourd, 17.98 kg followed by tomato, 9.33 kg and country bean, 8.99 kg. In the case of fruits, the total yield was recorded as 77.24 kg per garden from 18 types of fruits in the same year. Among these, mango gave the highest yield (8.57 kg), followed by papaya (8.38 kg) and guava (7.52 kg). Research should be carried out on crop selection, fertilizer and irrigation management under different container systems and to develop a suitable RTG model for greening city of Bangladesh**.

***Keywords*—Rooftop Gardening; Chattogram; City Areas, Empirical Study**

I. INTRODUCTION

Rooftop garden plays an important role in the mental well-being of the gardeners as well as in amelioration of the physical environment. The production of fresh fruits and vegetables of the rooftop garden can increase the nutritional status of the household members of the urban citizens and it will make a positive contribution to the environment. JhaRitesh Kumar [1]claimed that rooftop gardens are gaining relevance as they have the potential to meet the growing demand for food in cities and enhance the ecosystem along with the conservation of biodiversity. Baudoin [2] viewed that an idea of roof gardening in towns could be contributed to supply fresh food for the increasing urban population.MasturaSafayet [3] reported that rooftop farming can provide local fresh and safe food. It can support environment by improving air quality, reducing carbon in the atmosphere and can benefit society by reducing storm water management cost..

Choguill [4] stated with rapid and unplanned urbanization, augmentations of urban poverty and food insecurity have been also observed alarmingly in Dhaka. Islam [5] viewed that Urban agriculture (UA) contributes to food security by increasing the supply of food and by enhancing the quality of perishable foods reaching urban consumers. He also suggested that strong political commitment and solid policy guidelines are the preconditions for creating supportive environment for RTG. Esther Sanyé-Mengual[6] observed that urban rooftop farming favours local food production. Although rooftop farming is perceived as a sustainable system, there is a lack of quantitative studies. Mohammad Hasan Chowdhury [7] reported that the rooftop agriculture can improve various ecosystem services, enhance the biodiversity of urban areas and reduce food insecurity. They also mentioned that food production from green roofs will help support and sustain food for urban communities and provide a rare opportunity to grow food efficiently in typically unused spaces but vegetable production activities on rooftops are limited due to multiple challenges that need to be addressed before widespread implementation takes place. Humayon Kabir [8]showed that the influential variables viz; roof top area, media contact and knowledge were significant contributors on using roof top for gardening.

In 2015, a project was initiated entitled *"Enhancing Urban Horticulture Production to Improve Food and Nutrition Security"* by FAO with the Government counterpart of the Department of Agricultural Extension (DAE), Ministry of Agriculture, Bangladesh to promote urban horticulture/rooftop garden for increasing the production of fresh-nutritious vegetables and fruits and also creating a positive impact on environment in Dhaka and Chattogram city areas. As a associate personnel of the project, Uddin [9], conducted a baseline study on rooftop gardening in Dhaka and Chittagong city areas for realizing the potential of RTG in terms of benefits to policy making. Under this project, a remarkable number of RTG were established in the Chattogram and Dhaka metro areas which supposedly would have a highly significant impact on city dwellers in terms of supplement of fresh produces as well as uplifting nutritional status to the family members and great impact on environment as well. This is why, it is necessary to have an understanding of the actual situation of Rooftop Gardening in Dhaka and Chattogram city areas. Considering the propriety of the above mentioned points it can

surely be said the study is important and realistic with the objectives (i) to document basic information of the respondent and RTG's; (ii) to identify the crop diversity and their container used in the RTG; (iii) to estimate the yield of different crops, benefits and problem associated with the RTG and (iv) to derive suggestion and policy implications for future intervention on RTG.

II. Materials and Method

Selection of study areas:

For ensuring proper representation of location, three metropolitan areas namely Panchlaish, Doublemooring and Patenga were selected purposively from Chattogram city areas. Before selecting the areas, one discussion meeting was held with the Additional Director of DAE, Agrabad, Chattogram along with three Metropolitan Agriculture Officers. A half-day long discussion was made and finalized the locations based on availability of rooftop garden.

Selection criteria of the respondents:

Selection procedure for the respondents is very important for collecting authentic information. After long discussion with the DAE personnel, the following criteria were fixed for selecting the respondents. These are: (i) willingness of the respondents (ii) cooperative motive (iii) easily accessible to the garden and (iv) having potential space on rooftop for future intervention.

Sample size and sampling techniques:

Sampling, there are no strict rules to follow, and the researcher had to rely on logic and judgment. Cochran [10] suggested that there is no safe general rule as to how large sample size must be for use of the normal approximation in computing confidence limit.Freund and Williams [11] viewed that when the population size is known or roughly so and the researchers are careful of the heterogeneity problem, any number (equal to or) greater than the statistically large sample (of 30 sample units) may be appropriate. Proportionate random sampling technique was adopted for selecting the sample size in each location. In this process, a sampling frame was constructed by 100 rooftop gardener for each location. After that, the proportionate sampling (30%) was done considering the minimum number of 30 households required for statistical analysis in each location. By applying this technique, due to resource limitations a total of 90 sample households were selected for the study. Uddin [12] selected the sample size with the same procedures for their study.

Data collection procedure:

Mainly primary data were used in the study. The extensive literature review, relevant documents/reports and secondary information were collected for the study. Primary data were collected from sample households using the semi-structured questionnaire. In total 10 well experienced Sub-Assistance Agriculture Officers from each Metropolitan Agriculture Offices (3-4 SAAO's for each location) were engaged for data collection. Before starting data collection, a discussion meeting on the questionnaire was held in each metropolitan agriculture office. The data collection period was from January to March 2020. Researcher himself and three Metropolitan Agriculture Officers monitored the data collection time to time and cross-checked the collected data at field level.

Analytical techniques:

In the study, the primary data were analyzed. Descriptive statistics i.e. mean, standard deviation, percentage were used to analyze the data. The mean comparison and significance test was done by One-Way ANOVA using SPSS. In ANOVA technique, the F-value was used to judge whether there is a significance difference or not among the locations and samples.

III. Results and Discussions

Basic information of the respondents

Age: The younger respondents are technically more efficient than the older one and can easily adopt new technology and thereby increase efficiency. The average age of the respondents was recorded as 49.5 years in all areas which implied that they reached at mid-level age (Table 1). Analytical results revealed that the mean differences of the age of respondents varied insignificantly among the locations. Uddin [9]found that the average age to be 48.18 years in the same locations.

Education: Education of the respondents can play a vital role in efficient management and operations as well as in successful production. Results revealed that the average educational level of the respondents were recorded 38% as the highest as found to be graduate and the lowest were primary level (3.2%) irrespective of all locations (Table 1). Uddin [9] found that 54% respondent's belonged graduation as the highest in the same locations.

Occupation: A good number of diversified respondents were involved in various occupations. The highest number of respondents (38.8%) were found be involved as businessmen followed by housewives (33.4%) irrespective to all locations (Table 1). *Uddin* [9] found 38.8% respondents was business man as the highest and 26.7% housewives in the same locations.

Household size: Results revealed that the average size of household (person per family) of the respondent was recorded as 4.82 which were higher than the national average (urban) (4.41), BBS [13]. It was found to be the highest (5.12) in Potenga and the lowest in Doublemooring areas (4.43). The mean differences of household size varied insignificantly among the locations (Table 1). Uddin [9] found that the household size was 5.3 for the same areas.

Basic Information of the RTG's

In the RTG's, basic information includes size of rooftop, area under garden, open space, potential space, current uses of open space at the roof, types of house, ways of motivation for establishing RTG and willingness to expand current RTG's. The results are discussed below:

Size of RTG, Open Space and Potential Area: Size of rooftop is an utmost important for improving or expanding the garden. In the study, results revealed that per household total rooftops space was recorded as 2248.2 sq. feet irrespective of all areas; of them 1268.4 sq. feet (56.42%) was under garden, 588.5 sq. feet was open space (26.17%) and 391.3 sq. feet

Table 1: Basic information of the respondents

Sl. No.	Particulars	Locations			All
		Panchlaish	Doublemooring	Potenga	
1	Average age (years) of the respondents	49.9	51.86	46.80	49.5($F=1.164^{ns}$)
2	Education level (%):				
	- Primary	3.0	-	3.4	3.2
	- Secondary	27.0	6.7	40.0	24.6
	- Higher secondary	10.0	10.0	26.7	15.5
	- Graduate	57.0	36.6	23.3	38.0
	- Post graduate	3.0	46.6	6.6	18.7
3	Occupation (%):				
	- Govt. job	3.0	10.0	-	6.5
	- Private job	17.0	13.3	13.3	14.5
	- Business	30.0	36.7	46.7	37.7
	- Retired	13.0	-	16.7	14.8
	- Housewife	37.0	40.0	23.3	33.4
4	Household size (person per family):				$4.82(F=1.831^{ns})$
	- Total	4.90	4.43	5.12	2.49
	- Male	2.57	2.03	2.86	2.33
	- Female	2.33	2.40	2.26	1.1
	Below 18 years	1.00	1.00	1.30	

(17.41%) was considered as potential space for expanding the garden. But presently the open space are being used in different purposes by the owner of the building (Table 2). Analytical results implied that the mean differences in the total rooftop space, open spaceand potential space was found to be highly significant at 1% and 5% level of probability but the size of garden was found to be insignificant among the locations. Uddin [9] reported that the total rooftops space per household was 2190 sq. feet in the same areas. Of them 1607 sq. feet was considered as potential space for gardening and 583 sq. feet was remained as open. MasturaSafayet [3] reported that maximum people are willing to practice rooftop farming and want to provide at least 50% of roof space for rooftop farming in Dhaka city areas.

Types of House:The highest 77.8% RTG were established in own house/building followed by flat system 20.1% *and rest in the* Government *Banglo* or in rent house.

Ways of motivation for establishing RTG:It was reported that the RTG owner motivated by own-self to observe the neighbors' garden, watching TV program on RTG, and through DAE personnel. Among these, the highest 39.8% of the respondents was motivated by watching TV program on RTG followed by self-interest 27.7% (Table 2).

Willingness to expand current RTG:The highest 66.1% respondents agreed on expanding their existing RTG using available open space on the rooftop and rest of didn't agree to expand the RTG.

Current uses of open space at the roof: Presently, the open space is being used in different purposes by the owner of the building. The highest 79% of the respondent is being used open space for drying clothes and raw materials like chilli, turmeric or any others and rest of are using for recreation purposes irrespective to all locations (Table 2).

Diversity of crops grown in the RTG:

Crop diversity is fundamental to agricultural growth. Crop diversity enables growers to develop higher yielding, more productive varieties that have the improved quality characteristics required by growers and desired by consumers. With growing population in the urban areas, the demand of fresh produces is increasing day by day. In order to mitigate this, crop diversification maximizes the use of rooftop space and optimizes productivity and incomes also. Reducing environmental degradation, the crop diversity can contribute significantly to protecting the environment. It was observed in the study areas, mainly vegetables, fruits, spices, flowers, ornamental and medicinal plants were grown in the current RTG's.

As crop diversity, about 26 types vegetables, 39 types fruits, 11 types species & others plant and 22 types flowers/ornamental and medicinal plants were grown in the sample RTG's. But the number of crops per households varied significantly among the locations. In the case of vegetable, the highest 90.1% of the respondents were grown tomato followed by brinjal 85.4% and bottle gourd 73.4%. On the other hand, by fruits, the highest 92.2% of the respondents were grown lemon followed by mango 91.1% and guava 78.9%. In the case of spices, the highest 85.6% of the respondents were grown to be green chilli followed by coriander 63.3% and capsicum 44.5% in the RTG. Among the flowers, the highest 46.7% of the respondents were grown as favorite to be rose followed by marigold 38.9% and Jasmine-plants 33.3% in the current RTG (Table-3). Tania Hossain [14] found that 35 species were fruit and 10 species

Table2: Basic information of the sample RTG.

Sl. No.	Particulars	Locations			All
		Panchlaish	Double mooring	Potenga	
1.	Total area of roof (sq. feet)	2056.6	2692.4	1995.7	2248.2($F=6.792^{***}$)
	- Area under garden (sq. feet)	1246.7	1376.6	1182.0	1268.4 ($F=1.343^{ns}$)
	- Open space (sq. feet)	536.6	759.2	469.6	588.5 ($F=9.101^{***}$)
	- Potential space to expand RTG	273.3	556.6	344.1	391.3 ($F=2.463^{**}$)
2.	Types of house where RTG established (%):				
	- Own house	90.0	76.7	66.7	77.8
	- Flat system	7.0	23.3	30.0	20.1
	- Govt. *Banglo*/Rent house	3.0	-	3.3	3.15
3.	Way of motivation for establishing RTG (%)				
	- Self Interest	30.0	27.5	25.6	27.7
	- Media (TV Program on RTG)	33.7	39.3	46.4	39.8
	- Neighbors	13.0	13.7	6.7	11.1
	- DAE+FAO (project)	23.3	19.5	21.3	21.4
4.	Willingness to expand RTG (%):				
	- Yes	60.0	73.3	65.0	66.1
	- No	40.0	26.7	35.0	33.9
5.	Current uses of open space in the roof (%):				
	- for drying clothes and raw materials (i.e.chilli, turmeric, spices and others)	87.0	93.3	56.7	79.0
	- for recreation	13.0	7.7	43.3	21.0

*Note: *** indicates 1% level of significance, ** at 5% level of significance and * at 10% level of significance*

Table 3: Diversity of crop grown in the current RTG

Sl. No.	Types of crop	In % of respondents by crops in all locations (n=90) (as per priority basis)
1.	Vegetable	Tomato 90.1%, Brinjal 85.4%, Bottle gourd 73.4%, Spinach 65.5%, Red amaranth 62.3%, Okra 61%, Country bean 58.9%, Yard long bean 56,6%, Sweet gourd 54.4%, ,Danta 35.7%, Bitter gourd 43.3%, Teasle gourd 32.3%, Kangkong 26.7%, Cucumber 25.6%, Lettuce 25.4%, Ridge gourd 24.6%, Snake gourd 20.1%, Drum stick 17.8%, Ash gourd 17.8%, Cauliflower 16.6%, Cabbage 9%, Sponge gourd 7.9%, Radish 7.8%, Broccoli 7.8%, Aroid 5.4%, Squash 2.5%, (In total 26).
2.	Fruits	Lemon 92.2%, Mango 91.1%, Guava 78.9%, Ber 76.7%, Pomegranate 73.3%, Malta 66.7%, Sapota 54.4%, Papaya 51.1%, Palmary Plum 46.7%, Orange 42.2%, Dragon fruit 38.9%, Custard Apple 36.7%, Pomelo 32.2%, Bilimb 25.6%, Carambola 22.2%, Banana 21.1%, Grape 18.9%, Karonda 17.8%, Strawberry 14.4%, *Sharifa* 8.9%, Stae-apple 7.8%, Olive 7.8%, Apple 5.5%, Pear 4.4%, Litchi 3.3%, Sweet Tamarind 3.3%, Exotic Date Palm 3.3%, Gooseberry (Orbaroi) 3.3%, Blackberry 2.2%, Mulberry 2.2%, Avocado 2.2%, Jackfruit 2.2%, Pineapple 2.2%, Burmese grape (Lotkon) 2.2%, Cashew-nut 1.1%, Indian goosberry (Amalki) 1.1%, Wood Apple and Persimmon 1.1%, Cherry 1.1%, 3.3%. (In total 39).
3.	Spices & Others plants	Green Chilli 85.6%, Coriander 63.3%, Capsicum 44.5%, Onion 26.7%, Long Coriander (*Bilati Dhania)* 25.6%, Mint (Pudina) 17.7%, Ginger 13.3%, Turmeric 12.2%, Sugarcane 11.1%, Common Plum (Alubokhara) 5.5% and Bay leaves 3.3%, (In total 11),
4.	Flower/Ornamental/ Medicinal plants	Rose 46.7%, Marigold 38.9%, Jasmine-plants 33.3%, Dahlia flowers 25.6, Tuber rose 24.4%, Night-blooming Arabian jasmine-plants 20%, China rose 16.7%, Arabian jasmine (*Bely*) 12.2%, Bougainvillea 8.8%, Crotons 8.7%, Cactus 6.7%, Aloe vera 6.7%. Petunia flowers 6.7%, Night queen flowers 5.5%, Jasmine flowers 5.5%, Dianthus flowers 5.4%, Gladiolus flower 4.4%, Euphorbia flowers 3.3%, Lily flowers 3.3%, Nayantara flowers 3.3%, Orchid flowers 2.2% and Jungle geranium plants1.1% (In total plant types-22)

were medicinal which encompasses 84 families. She also reported that 65% of the garden owners have higher plant species diversity and 62.5% gardeners were interested in rising of roof top garden because they think that gardening products consumption are healthy.

Source of Seedling/Sapling:The RTG owners collected seeds/seedlings and saplings from different sources. In the

study, ten sources were identified from where the seeds, seedling and sapling were collected. The same RTG owners used different sources for collecting their necessary inputs. Among them, the highest 82.3% respondent reported that they collected the necessary materials from local nurseries followed by agricultural fairs (56.7%) and local or near markets (38.0%) (Table 4).

Types of Container Used: Container is one of the important input materials for growing plant in the rooftop. Selection of suitable containers is important factor for raising the plants well. Bienz[15] reported that suitable growing medium must be prepared ensuring sufficient water and mineral elements. In the study, it was observed that the various types of containers were used by the rooftop gardeners. The choices of containers depended on availability, preferences and nature of the growing plants. It can be seen in the selected areas, 16 types containers were used for the plants grown. Among them, the highest 95.6% respondents used half plastic drum followed by earthen made tubs 78,9% and plastic bucket, 76.7% (Table 5). Differences of used containers were found to be significant among the locations. Rahman [16] found that for rooftop gardening 77% gardeners used earthen containers, 8% cemented beds, 7% drums, 5% brass made pots and 3% others. Uddin [9] found that 42% gardeners used concreted drum, 40% half-drums made by GI sheet, 31% plastic and earthen pot, 27% half plastic drum, 16% plastic bucket, 7% concrete made bed and 5% plastic tray.

Table 4: Source of seeds, seedlings and saplings for RTG.

Sl. No.	Sources	Locations			
		Panchlaish	Double mooring	Potenga	All
		In % of respondents			
1.	Local Nursery	90.3	93.3	63.3	82.3
2.	Local *Bazar*/Market	40.7	26.7	46.7	38.0
3.	Research Institute	20.0	33.3	33.3	28.9
4.	Metropolitan Agricultural Offices	16.7	26.7	6.7	16.7
5.	Horticulture Center	23.3	23.3	30.0	25.5
6.	BADC	10.0	-	-	3.3
7.	Agriculture Fair	50.0	50.0	70.0	56.7
8.	NGO	6.7	-	-	2.2
9.	Relative/Neighbors	13.3	46.4	30.0	29.9
10.	From Abroad	6.7	-	-	2.2

Table 5: Types of containers used in the sample RTG.

Sl. No.	Types of container	Locations			
		Panchlaish	Double mooring	Potenga	All
		In % of respondents			
1.	Half plastic drum***	100.0	96.7	90.0	95.6
2.	Concreted drum	30.0	13.3	13.3	18.9
3.	Earthen made tob	66.7	100.0	70.0	78.9
4.	Half drum made by GI sheet	13.3	13.3	36.7	21.1
5.	Plastic tray***	46.7	33.3	30.0	36.7
6.	Plastic tub	60.0	90.0	30.0	60.0
7.	Plastic Pot	-	73.3	43.3	38.9
8.	Plastic bucket	83.3	96.7	50.0	76.7
9.	Earthen made pot	30.0	50.0	16.7	32.2
10.	concrete made bed**	53.3	30.0	20.0	34.4
11.	Sac	3.3	-	-	1.1
12.	Vehicle Tiar	3.3	3.3	3.3	3.3
13.	Old Bath tub	-	13.3	-	4.4
15.	Plastic crates	-	-	40.0	13.3
16.	Fruit basket	-	-	10.0	3.3

Input Used:Input includes organic or inorganic/chemical fertilizers and plant protection measures etc. Irrespective of all locations, most of the respondents were used chemical fertilizers (Triple Super Phosphate (TSP), Muriate of Potash

(MoP) and Zypsum) and composts in the rooftop garden. But most of them didn't know the recommended doses of fertilizers and compost in different container systems and plants. Results revealed that about 95.5% of the respondents used compost (Kitchen compost &Vermicompost , urea, 96.7%, TSP, 94.4%, MoP, 87.8%, Zypsum, 50.0% and netting, 35.6% irrespective of all locations (Table 6). Besides these, they used pesticides, IPM technology, sticky yellow trap, bagging technology for fruits in controlling pests and diseases. Uddin [9] found that 62% of the gardeners used compost, urea, 49%, TSP, 49% and MoP, 33% in the rooftop garden but only 10% used netting for controlling birds and insect in the same locations.

Table 6: Input used in the sample RTG.

Sl. No.	Inputs	Input used by locations			
		Panchlaise	Double mooring	Potenga	All
		In % of respondents			
1.	Compost	100.0	93.3	93.3	95.5
2.	Urea	100.0	93.3	96.7	96.7
3.	TSP	100.0	90.0	93.3	94.4
4.	MoP	96.7	86.7	80.0	87.8
5.	Zypsum	83.3	36.7	30.0	50.0
	Boron		6.7	10.0	8.4
6.	Pesticide	93.3	70.0	70.0	77.8
7.	IPM	46.7	83.3	36.7	55.6
8.	Netting	36.7	50.0	20.0	35.6
9.	Trail	3.3	3.3	-	3.3
10.	Sticky trap	-	16.7	-	16.7
11.	Feroman trap	-	6.7	6.7	6.7
12.	Bagging	-	3.33	-	3.3

Table7: Average yield of vegetables grown in the sample RTG

Sl. No.	Crops	Locations				
		Panchlaish	Double mooring	Potenga	All	F-Value
		Yield (Kg)				
1.	Bottle gourd	13.6	16.11	6.25	11.98	2.745^{*}
2.	Sweet gourd	13.0	7.50	2.75	7.75	3.848^{**}
3.	Broccoli	2.50	2.40	-	2.45	3.323^{*}
4.	Brinjal	9.20	4.83	9.38	7.80	0.672^{ns}
5.	Tomato	10.7	9.36	7.85	9.30	0.819^{ns}
6.	Yard long bean	6.20	2.30	3.67	4.06	3.646^{**}
7.	Country bean	12.8	7.67	6.50	8.99	2.890^{**}
8.	Red amaranth	8.19	4.00	5.78	5.99	0.591^{ns}
9.	Spinach	9.08	4.75	4.00	5.94	1.414^{ns}
10.	Danta	7.67	2.29	3.00	4.32	2.029^{ns}
11.	Cauliflower	6.50	7.75	8.33	7.53	3.353^{**}
12.	Cabbage	4.26	9.33	-	6.80	2.311^{**}
13.	Okra	7.22	4.74	6.45	6.14	0.523^{ns}
14.	Bitter gourd	7.50	2.81	2.67	4.33	0.125^{ns}
15.	Teasle gourd	7.67	15.00	3.33	8.67	6.066^{***}
16.	Snake gourd	-	2.08	-	2.08	0.715^{ns}
17.	Ridge gourd	-	2.10	3.67	2.89	1.261^{ns}
18.	Sponge gourd	-	-	8.25	8.25	0.184^{ns}
19	Ash gourd	-	5.50	-	5.50	1.471^{ns}
20	Aroid	5.00	4.23	-	4.62	1.206^{ns}
21	Radish	-	4.78	-	4.78	1.024^{ns}
22	Kankong	-	2.08	8.33	5.21	6.240^{***}
	Total	131.09	121.61	90.21	135.38	3.543^{**}

Estimated yield of different crop grown in the RTG: The yield of different crops was estimated as the total harvest from per household in the year of 2019. The average yield was recorded from 22 vegetables, 18 fruits and 6 spices in the sample households. In total of 135.38 kg vegetables per household were harvested in the year of 2019. Of them, the highest amount was recorded from Panchlaish, 131.09 kg and the lowest was from Potenga, 90.1 kg. Considering the types of vegetables, the highest yield was obtained from bottle gourd11.98 kg followed by tomato, 9.33 kg and country bean, 8.99 kg irrespective to all locations. The mean differences of yield of teasle gourd, kankong, was found to be highly significant at 1% level of probability and sweet gourd, yard long bean, country bean, cauliflower, cabbage was found significant at 5% level of probability but the other two vegetables bottle gourd and broccoli was found to be significant at 10% level of probability. On the other hand, the yield of others vegetables were found to be insignificant among the locations (Table 7). Uddin [9] found that the highest yield 9.25 kg was found from gourds (all types) followed by tomato, 8.47 kg in the same locations.

In the case of fruits, in total of 77.24 kg fruits per RTG's were harvested in the year of 2019. By locations, the highest yield was recorded to be 79.73 kg in Panchlaish and the lowest 64.51 kg in Potenga. By fruits, the highest yield was obtained from mango 8.57 kg per household followed by papaya 8.38 kg and guava 7.52 kg irrespective of all locations. Mean differences of yield of mango, lemon, malta, ber and pomegranate was found to be highly significant at 1% level of probability and guava, papaya, palmary plum, orange was found to be significant at 5% level of probability but the yield of others fruits were found to be insignificant among the locations (Table 8). Uddin [9] reported that the highest yield was obtained from papaya, 7.1 kg followed by lemon, 5.4 kg, wax apple, 4.1kg, guava, 3.2 kg and mango, 2.7 kg in the same locations.

In the case of spices, in total of 10.69 kg different types of spices were harvested per RTG in 2019 irrespective of all locations. Of them, the highest total yield 8.25 kg was found in Doublemooring and the lowest 7.60 kg in Panchlaish. By types of spices, the highest yield was recorded to be 2.89 kg from green chilli followed by onion 2.00 kg and capsicum 1.92 kg per RTG in 2019. Analytical results shows that the mean differences of yield of green chilly was found to be significant at 5% level of probability but the yield of others spices were found to be insignificant among the locations (Table 9).

Table 8: Average yield of fruits grown in the sample RTG

Sl. No.	Crops	Locations				
		Panchlaish	Double mooring	Potenga	All	F-Value
		Yield (Kg)				
1.	Mango	10.61	8.22	6.87	8.57	11.652***
2.	Guava	9.30	5.72	7.55	7.52	2.821**
3.	Lemon	5.21	5.66	7.08	5.98	5.753***
4.	Papaya	10.73	5.25	9.17	8.38	3.367**
5.	Malta	5.00	2.50	5.00	4.17	4.927***
6.	Ber	10.58	8.33	3.42	7.44	5.570***
7.	Pomegranate	1.21	3.00	2.00	2.07	23.495***
8.	Dragon	1.53	6.75	3.75	4.01	0.198ns
9.	*Sharifa*	1.33	2.00	-	1.67	0.985ns
10.	Sapota	6.83	3.38	3.67	4.63	1.746ns
11.	Pomelo	4.43	5.00	5.00	4.81	0.293ns
12.	Custard Apple	1.42	1.85	-	1.64	2.059ns
13.	Palmary Plum	5.20	2.00	4.25	3.82	2.805**
14.	Orange	1.60	1.50	-	1.55	2.343**
15.	Karambola *(Kamranga)*	3.50	4.16	2.75	3.47	0.229ns
16.	Strawberry	1.25	-	-	1.25	1.495ns
17.	Olive	-	2.26	-	2.26	1.941ns
18.	Star-apple	-	-	4.00	4.00	1.000ns
	Total	79.73	67.58	64.51	77.24	7.531***

Table 9: Average yield of spices crop grown in the sample RTG

Sl. No.	Crops	Locations				F-Value
		Panchlaish	Double mooring	Potenga	All	
		Yield (Kg)				
1.	Green Chilli	4.35	2.82	1.50	2.89	2.676^{**}
2.	Capsicum	-	1.58	2.25	1.92	1.333^{ns}
3.	Coriander *(Dhania)*	2.25	1.40	1.83	1.83	1.341^{ns}
4.	Long Coriander *(Bilati Dhania)*	1.00	1.25	1.67	1.30	1.032^{ns}
5.	Onion	-	2.00	-	2.00	1.845^{ns}
6.	Mint *(Pudina)*	-	0.50	1.00	0.75	1.579^{ns}
	Total	7.60	9.55	8.25	10.69	1.0132^{ns}

Crop-wise Problem faced by the RTG Owners: In the study, it was observed that all most all the gardener were faced by12 types problems for crop production in their RTG. Pest and diseases were occurred in all common crops. Besides, all crops were slightly damaged due to hot temperature when watering was not applied regularly. Flower and fruit dropping occurred in mango, pomegranate and malta at early stage. But in the case of Chilli, flower dropping seriously happened due to minor pest attacks and hot temperature. In the case of cucurbits like bottle gourd, sweet gourd, cucumber, ridge gourd etc. was faced fruits missed as desired though the flower was enhanced sufficiently. It might be happened due to sufficient pollination or attack of fruit fly. The others problems associated with the mentioned crops are shown in the (Table 10).

Measures Taken for Controlling Pest and Diseases: It can be seen in the (Table 11) that six measures were taken for controlling the pest and disease prevalence of the plants. Among them, the highest 87.8% respondents sprayed insecticide/pesticide followed by herbal method (i.e.*neem* oil. koko dust), 41.1% and used sticky trap, 20.0%. Only 6.7 % respondents did not take any measures for controlling the pest and diseases due to ignorance and lack of awareness.

Training Received by the RTG Owners: Skilled manpower is essential for ensuring the success of RTG at household level.

Table 10: Crop-wise problem encountered for major vegetable and fruits in the RTG in all locations.

Sl. No.	Problems/Constraints	Crops (Yes indicates 'X')									
		Tamato	Brinjal	Yard long bean	Cucurbits	Chilli	Mango	Guava	Lemon	Pomegranate	Malta
1	Pest attack	X	X	X	X	X	X	X	X	X	X
2	Disease prevalence	X	X	X	X	X	X	X	X	X	X
3	Fruit dropping						X			X	X
4	Flower dropping					X	X			X	
5	Flower enhanced but fruit missed				X	X	X			X	
6	Rotten the fruit	X			X		X			X	
7	The tree dies/die back						X	X		X	X
8	The leaves of the plants curled	X			X	X					
9	The plants weakens and falls (wilting)	X	X			X					
10	Lack of regular watering	X	X	X	X	X	X	X	X	X	X
11	Crop damaged due to heavy shower	X			X	X					X
12	Crop damaged due to hot temperature	X	X	X	X	X	X	X	X	X	X

Skills can be improved by technical trainings and it could have a role to play in the food production process Uddin [12] In the study areas, more than 57.8% of the respondents received training on roof top gardening irrespective of all locations. The training was provided by different institutes like BARI, DAE and NGO's. Of them, the highest number of respondents 77.2% received training from DAE followed by BARI, 17.3% and NGO, 5.5%, irrespective of all locations (Table 12). Uddin [9] reported that more than 56% of the respondents in Dhaka city areas received training on rooftop gardening whereas in Chattogram areas no respondents found who received training on RTG. It can be seen from the (Table 13) that 90.0% of the respondents got necessary advised on RTG from DAE followed by BARI, 42.2% and electronic media, 36.4% irrespective of all locations.

Table 11: Measures taken for controlling pest and diseases by the RTG owner.

Sl. No.	Measures used	Locations			
		Panchlaise	Double mooring	Potenga	All
		In % of respondent			
1.	Spraying insecticide/pesticide	93.3	90.0	80.0	87.8
2.	Applying herbal method	53.3	36.7	33.3	41.1
3.	Bagging	-	13.3	-	13.3
4.	Sticky trap	-	20.0	-	20.0
5.	Feruman trap	-	6.7	6.7	6.7
6.	Spraying detergent mixed water	-	-	3.3	3.3
7.	None	-	3.3	10.0	6.7

Table 12: Training received on RTG by the RTG owner

Sl. No.	Locations	Training received (%)		Training received from whom (%)		
		Yes	No	BARI	DAE	NGO
1.	Panchlaise	53.3	46.7	16.7	76.6	6.7
2.	Double mooring	63.3	36.7	23.5	72.2	4.3
3.	Potenga	56.7	43.3	13.3	86.7	-
	All	57.8	42.2	17.3	77.2	5.5

Table 13: From whom do you get the necessary advice on RTG?

Sl. No.	Locations	From whom?					
		BARI	DAE	NGO	Media	Nursery man/ Dealer	Experienced gardener
		In % of respondents					
1.	Panchlaise	23.3	93.3	3.3	43.3	6.7	10.0
2.	Double mooring	56.7	96.7	6.7	33.3	13.7	6.7
3.	Potenga	46.7	80.0	3.3	32.7	3.3	3.3
	All	42.2	90.0	4.4	36.4	7.9	6.7

Table 14: Respondent's responses to the benefit of RTG

Sl. No.	Benefits	In% of respondents by locations			All
		Panchlaise	Double mooring	Potenga	
	i. Social and economic benefits				
1.	Increase social reputation	60.0	73.3	63.3	65.5
2.	Getting economic support	63.3	56.7	43.3	54.4
3.	Getting safe food	93.3	96.7	96.7	95.6
4..	Increase nutritional benefits for family members	90.0	86.7	93.3	90.0
5.	Increase cultural value in the community	50.0	60.0	16.7	42.2
	ii. Environmental benefits:				0.0
1.	Increase oxygen level	83.3	73.3	90.0	82.2
2.	Decrease the discharge of CO2	83.3	73.3	90.0	82.2
3.	Maintain environmental balance	86.6	96.7	93.3	92.2
4.	Keep cold the house	93.3	83.3	73.3	83.3
5.	Increase aesthetic value	60.0	76.7	83.3	73.3
6.	Increase mental health	86.7	93.3	83.3	87.8

Table 15: Perception of the RTG owners about the Dengue disease spreads due to rooftop gardening

Sl. No.	Q. Do you think rooftop gardening spreads dengue?	In% of respondents by locations			All
		Pacnchlaise	Double mooring	Potenga	
1.	Yes	10.0	3.3	6.7	6.7
2.	No	90.0	96.7	93.3	93.3

Respondents' responses to the Benefit of RTG: Many benefits are not readily measurable and their values are difficult to estimate such as the health benefits of a rooftop garden. According to the responds of the interviewees in the study, 11 types of common benefits came up to mentioning. Those were categorized into two sections as, (i) social and economic benefits and (ii) environmental benefits. Only the benefits the respondent's responded to are shown in the (Table 14). Sajjaduzzaman[17] reported that the major purposes of roof gardening are passing leisure time (100%), creating aesthetic values (100%), contributing in environmental amelioration (45%) and financial gain being a very minor concern (4% only) in Dhaka Metropolitan city of Bangladesh.

Respondents' responses about the Dengue Spreads due to RTG: At the end of the questionnaire, one question was thrown to the respondents on Dengue issue. The answers derived from the respondents was closed ones; likely ''Yes'' or ''No'' basis. More than 93% respondents opined that dengue diseases do not spreads due to gardening at the rooftop of the house if it is cleaned regularly (Table 15).

IV. Conclusion

Urban agriculture (UA) particularly rooftop gardening contributes significantly to creation of healthy environment and food security. It ensures supply of fresh food by enhancing the quality of perishable foods reaching urban consumers. Though the Government of Bangladesh has projected great progress in agricultural sectors but most of them are of traditional ones. The government yet does not have any specific policy, provision or legislation that promotes urban agriculture. Governmental guidance and encouragement is urgently needed to spread out the concept of RTG and make it popular among urban people. In order to realize the potential that RTG can offer, major changes of thinking at the policy making level is required. Conduction of some fundamental researches and experimentations /demonstration is required. This could be successful with required political commitment and concerted actions, underpinned by scientific researches, technical expertise and good design of RTG model suited for the urban areas.

V. Recommendation

Based on the research findings it can be recommended that crop diversity can be increased through introducing high yielding varieties of vegetables and fruits developed by BARI. Plant composition need to be re-arranged in an economic point of view and capacity of the roof. High performance crop varieties have to be assured for the RTG through proper confirmation. Yield of existing vegetables and fruits could be increased through proper management and ensuring regular visit by the respective personal of BARI, DAE and NGO's. Selection of crops and its container should be done carefully for better management of RTG. Hands on training on container preparation for planting, fertilizer application, irrigation method, pest and disease management is essential for quality and safe production. All inputs has to be made available through establish linkage with the service providers. Finally, a technically feasible, socially acceptable, economically viable and environment friendly RTG model should be developed for better outcome from RTG in Chattogram city areas.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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