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Present scenario and problem confrontation of rooftop gardening and its efficacy in ambient environment reclamation in Khulna City of Bangladesh

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ABSTRACT

In the urban area there is scarce space for planting trees and cultivating agricultural plants. Rooftop gardening might be an alternative to overcome this land scarcity. The present study analyzes the scenario of rooftop gardening, its problem confrontation and its effects on the surroundings. Nirala and Sonadanga area of Khulna city of Bangladesh were purposively selected for the study from where a total of 60 rooftop gardens were randomly selected for face-to-face interview with a pre-tested interview schedule during the period of 15 March to 20 April, 2018. Results showed that majority of the rooftop gardeners belonged to the group of old age (40%), undergrad and above level of education (61.6%) and small family size (55%) with high annual income (41.7%). Majority of them had low experience (40%), but high knowledge (76.7%) on rooftop gardening. Besides, 58.3% respondents had no organizational participation along with seldom extension contact (66.7%) and seldom cosmopoliteness (81.7%). More than half of the respondents (65%) had small size ($\leq$1000 ft^2) roof area suitable for gardening. The rooftop gardeners earned very poor economic benefit from the garden compared to bearing large expenditure for it. Most of the respondents preferred rooftop garden as a hobby (98.3%) and aesthetics (90%). Again, 51.7% respondents considered it as an aspect of ecological balance. Vegetables (16.6%) and flowers (12.5%) were the most dominating plants in the study area for rooftop gardens. Main intercultural operations included irrigation, weeding, training/pruning and control of insects and diseases. Commonly faced insects were ant, mealy bug and green leaf hopper with the diseases of die back, viral disease, leaf curling and leaf scorching. Common fertilizers used in the study area were cow dung, compost, urea, muriate of potash and sesame cake. Excessive heat (91.7%), lack of proper nourishment (87.1%) and roof load (72.9%) were the most severe problems. Among the 9 selected characteristics only age of the respondents showed significant positive relationship with problem confrontation. Besides, weather parameters showed positive impacts in case of green roof than empty roof. Thus, the overall results indicate great contributions of rooftop gardening in urban areas in terms of environmental reclamation.

Keywords: Rooftop gardening, present scenario, prospect, environment

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1 Introduction

Rooftop gardening or rooftop farming is an art and science of growing plants on the fallow spaces within the surrounding and/or adjacent to the residence. In other words, a roof of a building that is fully or partially covered with a layer of vegetation is known as a green roof or a rooftop garden. Rooftop farming is usually done by using green roof, aeroponics, hydroponics, air-dynaponics or container gardens. Furthermore, rooftop gardens not only include the rooftop of a building; but also other places such as balcony, corridor and other open places. Existence of green roof is over 3000 yr; whereas green roof technology was widely popular and established in Europe and in 1960s it enhanced in many countries (Bass and Baskaran, 2003; Doncean, 2014).

After 1980s, green roofs were constructed with the idea of bringing vegetation back into urban areas. At present, rooftop garden is a modification of modern landscape that can be a part of urban green space in the city. Now, ecological functions of green roofs become more important than their aesthetical properties. Rapid and high rates of urbanization and industrialization have resulted in drastic demographic, economic, land use and climate change and that already threatened the agricultural sector of the world. In that case, rooftop gardens are smart solutions for ecological, technical, economic and aesthetic qualities in urban areas. It is a specific urban agriculture niche set within a broader system of city gardens, which have a set of distinctive benefits. Considering few detrimental impacts, rooftop agriculture is becoming popular particularly in developing countries.

The vegetation and waterproof membrane of green roofs alleviate the temperature of the roof and extend its life by more than 20 yr (USEPA, 2000). Rooftop gardens are most suitable solution for the reduction of the external surface temperature in any climate (Costanzo et al., 2016). In Singapore, green roofs reduce cooling load by 10% of the usual building with a conventional roof (Wong et al., 2003). Through rooftop gardening the roof environment might be made better. Different low-cost light media such as, coconut coir, rotten water hyacinth, etc., could also be utilized for roof-top plant production. In this way the roof physical weight bearing capacity could also be minimized and stabilized.

Total land area of Bangladesh is about 14.3 million hectare and of which about 59.8% is available for cultivation. On the other hand, Khulna City Corporation constitutes the land area of about 45.65 km^2 of which about 18% occupied for agriculture (KDA, 2002). Agricultural land in the country is declining at an alarming rate mainly for the increase of population. During the last 12 yr, agricultural land has been declining on an average rate of about 1%. In Khulna city, conversion of agricultural land to non-agricultural land is at the rate of 0.26% (2001—08) (Quasem, 2011). Due to decline in agricultural land, overall national production is declined and problem of food insecurity is becoming more intense. In that case, rooftop agriculture is one way in which urban areas could attempt to be more balanced and sustainable in their resource consumption. There is a great possibility to produce fruits, grains, vegetables, flowers, ornamental plants etc. on rooftops. Roof Garden Association in Bangladesh is playing an important role on focusing technical and financial aspects of rooftop gardening (Sajjaduzzaman et al., 2005). But the technical aspects of rooftop gardening and commonly faced problems are not well studied yet.

In this situation, the research was explored to find out the answers of the following questions: (i) what is the present status of rooftop gardening in Khulna city? (ii) what types of problems faced by the gardeners? and (iii) can rooftop garden influences the weather parameters of the surroundings? Therefore, the study was mainly focused on the following objectives: (i) to identify the present scenario of rooftop garden in Khulna city, (ii) to determine the problem confrontation in rooftop gardening, (iii) to explore relationship between the selected characteristics of rooftop gardeners and the problem confrontation and (iv) to assess the effects of rooftop garden on the surrounding environment.

2 Methodology

The study was conducted in two purposively selected area of Khulna city named by Nirala and Sonadanga of Bangladesh. The householders who belongs rooftop garden were considered as the sample of population for the research work. The areas constituted a number of 600 rooftop gardens. Among those, a total of 60 rooftop gardens (10%) were randomly selected for research purpose. Face-to-face interview was conducted among the households of the rooftop gardeners (i.e. 30 rooftop gardens) from each of the area. Primary data were collected during the period of 15 March to 20 April of 2018. The study included a total of 9 selected personal socio-economic characteristics of the respondents *viz.* age, educational qualification, family size, experience in rooftop gardening, organizational participation, annual income, extension contact, cosmopoliteness and knowledge on rooftop gardening. Besides, the study constituted one focus variable i.e. problem confrontation. Data on present scenario of rooftop gardening was collected based on the parameters of year of initiation of rooftop gardening, total roof area, suitable roof area for gardening, actual roof area under gardening, total

production, total income, total expenditure, net income, purpose of rooftop gardening, plant types and number, intercultural operations, insect infestation and control, disease infestation and control and fertilizers used by the gardeners. A total of 12 problems were appeared as more or less severe problem for the rooftop gardeners. A five point rating scale *viz*. no, less severe, medium severe, severe and highly severe problem was assigned against each of the problem to determine the extent of severity of the problem. Besides, the score of 0, 1, 2, 3 and 4 was used against the rating scale, respectively. Problem confrontation index (PCI) in rooftop gardening was calculated by using the observed score of the respondents against all of the problems and the potential score of all the problems. The following formula was used to calculate the PCI score.

$$\text{PCI} = \frac{\text{Observed Score}}{\text{Potential Score}} \times 100 \qquad (1)$$

The observed score of the respondents was varied from 0 (= 0×12) to 48 (= 4×12). Where, 0 means one did not face any problem and 48 mean one faced the highest problem. On the other hand, the PCI score was ranged from 0 (= 0×60) to 240 (= 4×60); where 0 indicated no problem and 240 indicated the highest problem.

Three weather parameters i.e. temperature, relative humidity and light intensity were selected for measuring the efficacy of rooftop gardening in its surrounding environment. Green roof and empty roof were compared in respect of those three parameters by using appropriate measuring devices. Temperature and relative humidity were measured in '°C' and '%' units using a Fisherbrand 'Hygrothermometer'; and light intensity was measured in 'lux' unit using a Lutron 'Lux meter' (Model LX-101, made in Taiwan). All the instruments used for the mentioned purposes were hand-held and were used to measure the intended weather parameters during the time of interview of the respondents. The survey duration was kept confined within 10.00 am to 5.00 pm. At the time of data recording for the weather parameters, the researcher recorded data of three places of the roofs, both for green roofs and empty roofs. The roof heights were also maintained the same, i.e., if the green roof was at 3rd floor the control data were collected from an empty 3rd floor roof. For this purpose the researcher immediately found an adjacent empty roof just after completion of the green roof survey.

To facilitate the research work, each of the variable was divided into categories or rating scales as per demand. The descriptive statistics such as the mean, standard deviation (Sd), range, frequency and percent were used to interpret data. Relationship among the variables was explored by using Spearman's Rank Order Coefficient of Correlation (ρ). Data analysis was performed by using Microsoft Excel and the Computer Package SPSS (Statistical Package for Social Science).

3 Results and Discussion

3.1 Socio-economic characteristics of the gardeners

Findings on personal and socio-economic characteristics of the respondents have been presented in Table 1. It is evident from Table 1 that the highest 40% rooftop gardeners were from old aged (>50 yr) with the second highest 38.3% from middle aged followed by 21.7% young aged. Most (33.3%) of the respondents had above level (>16 yr) educational qualification followed by bachelor, secondary and higher secondary (28.3%, 18.3% and 18.3% respectively). There were only 1.7% respondents with no educational qualification i.e. illiterate. The highest proportion (55%) of people belonged to small family (≤4) and the rest 40% and 5% to medium and large, respectively. Findings (Table 1) indicate that majority (40%) of the rooftop gardeners had low experience in rooftop gardening, while 33.3% had high experience and 26.7% medium experience. Most (58.3%) of the respondents were not involved in any organization followed by 40% low and 1.7% medium organizational participation.

The proportion of 41.7% respondents had high annual income (>1,80,000 Tk), whereas 38.3% low and 20% medium. There were the highest 66.7% respondents who had seldom extent of extension contact compared to 23.3% sometimes, 8.3% often and 1.7% never (Table 1). Besides, 81.7% respondents belong to seldom cosmopoliteness with the least 1.7% never cosmopoliteness. Furthermore, majority (76.7%) of the respondents had high knowledge on rooftop gardening with the rest 23.3% medium knowledge. The survey reflected that all most all of the respondents had more or less knowledge on gardening. Table 1 showed that 40% of the respondents had low experience (i.e., ≤5 yr) and none of the respondents (0%) had poor knowledge regarding roof-top gardening. Despite their low experience, they possess medium to high knowledge, because at the beginning of the roof-top gardening they study about it, consult with friends and family about it, contact with DAE about it, and so on. Thus, they possess good amount of knowledge on roof-top gardening. A large number of people bear submissive experience in cultivation due to agricultural background. Islam (2004) found 50% families having knowledge on rooftop gardening.

3.2 Present scenario of rooftop gardening

Summarized results of present scenario of rooftop gardening in Khulna city have been presented in Table 2. Results indicated that medium size roof area (1001–2000 ft^2) owners were the major respondents (56.7%)

Table 1. Distribution of the respondents according to the personal socio-economic characteristics

Variables	Categories	Score	Respondents (N=60)		Range	Mean	Sd
			Frequency	Percent			
Age (year)	Young	≤35	13	21.7	12–86	47.83	14.45
	Middle	36–50	23	38.3			
	Old	>50	24	40.0			
Educational qualification (year of schooling)	Illiterate	0	1	1.7	0–16	13.28	2.99
	Primary	1–5	0	0.0			
	Secondary	6–10	11	18.3			
	Higher secondary	11–12	11	18.3			
	Bachelor	13–16	17	28.3			
	Above	>16	20	33.3			
Family size (number)	Small	≤4	33	55.0	2–13	4.53	1.97
	Medium	5–7	24	40.0			
	Large	>7	3	5.0			
Experience in RG† (year)	Low	≤5	24	40.0	0.5–30	9.28	6.99
	Medium	6–10	16	26.7			
	High	>10	20	33.3			
Organizational participation (score)	No	0	35	58.3	0–8	1.07	1.84
	Low	1–6	24	40.0			
	Medium	7–12	1	1.7			
	High	13–18	0	0.0			
Annual income ('000' Tk)	Low	≤120	23	38.3	15–800	199.92	149.42
	Medium	120-180	12	20.0			
	High	>180	25	41.7			
Extension contact (score)	Never	0	1	1.7	0–14	5.75	3.39
	Seldom	1–6	40	66.7			
	Sometimes	7–12	14	23.3			
	Often	13–18	5	8.3			
Cosmopoliteness (score)	Never	0	1	1.7	0–8	4.87	1.89
	Seldom	1–6	49	81.7			
	Sometimes	7–12	10	16.7			
	Often	13–18	0	0.0			
Knowledge on RG (score)	Poor	≤6	0	0.0	8–20	14.25	2.62
	Medium	7–12	14	23.3			
	High	>12	46	76.7			

† RG = rooftop gardening

followed by small and large as 33.3% and 10%, respectively. The highest 65% respondents owned small roof area that is suitable for gardening. The rest 31.7% and 3.3% respondents respectively belonged to medium and large suitable roof area for gardening. In case of actual roof area for gardening, maximum 56.7% belonged to small area (≤500 ft^2) followed by 33.3% medium and 10% large. Total production obtained from the garden includes the year round products from all types of plants as like as flowers, vegetables, fruits, medicinal plants and all others that the gardeners used to grow in their rooftop garden. Results revealed out that maximum 45% gardener had low production (≤10 kg yr^{-1}) from the garden. Among the rest, 43.3% and 11.7% respondents had medium (11–30 kg yr^{-1}) and high production (>30 yr^{-1}), respectively from the rooftop garden (Table 2). In the question of total income from rooftop garden, both the low (≤500 Tk) and the high (>1000 Tk) category of the respondents constituted 45% with 10% medium income. Findings on Table 2 also shows that the major proportion (56.7%) of the rooftop gardeners expend highly for the rooftop garden compare to net return or net income from the garden. Besides, 33.3% rooftop gardeners had medium expenditure followed by 10% of low. Whereas, 2013–2015 was the period when the largest number of people took initiation for rooftop gardening.

Table 2. Distribution of the respondents according to present scenario of rooftop gardening

Parameters	Categories	Score	Respondents (N = 60)		Range	Mean	Sd
			Frequency	Percent			
Total roof area (ft^2)	Small	≤1000	20	33.3	100–3000	1305	628
	Medium	1001–2000	34	56.7			
	Large	>2000	6	10.0			
Suitable roof area (ft^2)	Small	≤1000	39	65.0	100–3000	949.17	572.72
	Medium	1001–2000	19	31.7			
	Large	>2000	2	3.3			
Roof area under RG† (ft^2)	Small	≤500	34	56.67	30–2400	582.67	504.38
	Medium	501–1000	20	33.33			
	Large	>1000	6	10.0			
Total production (kg yr^{-1})	Low	≤10	27	45.0	0.025–100	18.53	23.09
	Medium	11–30	26	43.3			
	Large	>30	7	11.7			
Total income (Tk yr^{-1})	Low	≤500	27	45.0	25–7500	2144	2345.89
	Medium	501–1000	6	10.0			
	Large	>1000	27	45			
Total expenditure ('000' Tk)	Low	≤1	6	10.0	0.65–99.90	11.58	16.41
	Medium	2–5	20	33.3			
	Large	>5	34	56.7			
Net income ('000' Tk yr^{-1})	Low	≤–1	15	25.0	–84.9∼–0.76	8.92	14.2
	Medium	–2 ∼–5	16	26.7			
	Large	<–5	29	48.3			

† RG = rooftop gardening

Table 3. Distribution of the respondent based on the purpose of rooftop gardening

Purposes	Citation frequency	Percent	Rank
Hobby	59	98.3	1
Aesthetic	54	90.0	2
Ecological balance	31	51.7	3
Fruit production	29	48.3	4
Vegetable production	28	46.7	5
Others	6	10.0	6
Income generation	1	1.7	7
Production and distribution of plantlets	1	1.7	7

In case of purpose of rooftop gardening (Table 3), hobby (98.3%) and aesthetic value (90%) was taking respectively the 1st and 2nd position along with ecological balance (51.7%), fruit production (48.3%) and vegetable production (46.7%) as 3rd, 4th and 5th position, respectively. In contrast of those, there were only 1.7% people who considered rooftop garden for income generation and as a source of production and distribution of plantlets. Again, 10% of the respondents had variety of purposes in carrying out rooftop garden. Though rooftop garden can be considered as a small business and it provides an additional income to a family, people actually are not interested to take it as a source of income and commercially to get profit.

Rahman et al. (2013) also found the same result and they observed that 95.3% people carried out rooftop garden for mental satisfaction, 87.8% for leisure activity and 54.9% for environmental amelioration. Though vegetables ($\bar{x}$=16.57) were the most dominating plants (81.7%); flower plants ($\bar{x}$=12.53) taken the first preference (83.3%) of the gardeners. Besides, 76.7% respondents prefer fruits ($\bar{x}$=6.8), 73.3% medicinal plants ($\bar{x}$=5.97) and 61.7% some other plants ($\bar{x}$=5.78) (i.e. ornamental plants, bonsai, exotic plants etc.). Rahman et al. (2013) in their study categorized rooftop gardeners into the categories of agri-crops (36%), flower species (30%), fruit species (21%) and medicinal plants (13%). Hossain and Hos-

sain (2016) found that 100% respondents were mainly interested on flower and vegetable cultivation. Nira (2006) found flower and ornamental plants as the most dominating plants followed by fruits, vegetables and medicinal plants. The name of most common flowers, vegetables, fruits, medicinal plants and other types of plants grown in rooftop garden in the study area have been presented in Table 4.

Results on Table 5 indicate that 100% of the rooftop gardeners used to practice the intercultural operations of irrigation and weeding along with training/pruning (81.7%), control of insects-pests (75%), decoration (70%) and thinning (51.7%). But, most of the intercultural operations were conducted as per demand and in that case the respondents did not follow any regular frequency. Ant (65%), mealy bug (36.7%) and green leaf hopper (13.3%) were reported as the major insects by the rooftop gardeners (Table 6). There were also some minor insects named by whitefly, lemon butterfly, red pumpkin beetle, aphid, termite, fruit borer etc. On the other hand, majority (23.3%) of the rooftop gardeners mentioned about die back; whereas viral diseases, leaf curling, leaf scorching and fungal diseases constituted 21.7%, 18.3%, 15% and 13.3%, respectively (Table 6). As Table 6 indicated, there were 21.7% respondents who did not face any insect problem; while 35% respondents reported that there is no disease infestation in their rooftop garden.

To protect plants from different insects-pests and diseases, rooftop farmers carried out a number of control measures. Most commonly used practices against insects-pests were finish, removal of infested part, hand killing of insects, washing with water, wheel powder + water, Ripcord, neem + mehagani juice, tobacco + water, kerosene, Nitro, Green tonic, Sevin etc. On the other hand, the most common protection methods against diseases was removal of the infected part compared to Tilt, Malathion, Vertimex, Noin powder, Aora, Mancozeb, Flora, Uromil etc. There were a number of respondents who did not take any action against insects-pests and diseases infestation rather facing the problems in different extent. Insect problem was found as a year round problem; whereas winter season was revealed as the main disease infestation time. Table 6 evident the main fertilizers viz. cow dung (51.7%), compost (43.3%), urea (36.7%), MoP (25%), sesame cake (23.3%) and TSP (21.7%) used by the rooftop gardeners. Besides, there were some minor fertilizers such as DAP, vermi-compost, birds litter, bio-salary, egg shell etc. Almost all of the rooftop gardener did not follow any regular pattern in case of insects-pests control, diseases control and in fertilizer application dose and stage.

3.3 Problem confrontation of rooftop gardening

Results presented in Table 7 shows that severity of problem confrontation of the rooftop gardeners was ranged from 12 to 29 with the mean and standard deviation of 18.15 and 3.61, respectively. As Table 7 indicated, majority (78.3%) of the respondents marked out medium severe problem confrontation in rooftop gardening and the rest, 21.7% rated problems as highly severe. The respondents of the areas were faced as much as 12 problems in different extent. Where, the most severe problems were listed as excessive heat, lack of proper nourishment and roof load with the PCI percentage of 91.7%, 87.1% and 72.9%, respectively (Table 8). Other main problems included lack of proper sunlight and shade (45%), insect-pest and disease infestation (43.8%) and lack of proper training, skill and experience (40%). On the other hand, the least severe problems were appeared as the transportation problem (2.1%), lack of proper marketing facilities (5.4%), lack of suitable planting materials (7.5%) and so on (Table 8). There were a few people who talked about the problem of lack of time and scarcity of water; whereas a large number of people consider rooftop gardening as a laborious work. Islam et al. (2017) concluded that drip irrigation system is an efficient water management technology for rooftop vegetable production in urban areas of Bangladesh.

3.4 Relationship between the selected characteristics and problem confrontation

Spearman's Rank Order Co-efficient of Correlation (ρ) was used to explore relationship among the variables. Table 9 furnished the relationship between the 9 selected personal socio-economic characteristics and the problem confrontation. Among the 9 selected personal characteristics only age of the respondents showed a significant positive relationship with the problem confrontation at 5% level (Table 9). As Table 1 indicated the majority of the respondents from the age group of old (>50 yr); so it can be explained in such a way, the higher the age of the respondents the higher they experienced about rooftop gardening. Thus, they are able to identify more problems related to the sector. Other eight variables i.e. family size, organizational participation, annual income, extension contact and their knowledge on rooftop gardening had non-significant and positive relationship with problem confrontation. Besides, respondents educational qualification, experience in rooftop gardening and cosmopoliteness showed inverse relationship with the problem confrontation.

Table 4. Distribution of the respondents depending on the types of plant grown in rooftop garden

Plant types	Major plants	Avg. plant number	Respondents (N=60)		Rank
			Number	Percent	
Flowers	Rose, marigold, bougainvillea, Arabian jasmine, chrysanthemum, Cape jasmine, Chinese rose, periwinkle, zinnia, night jasmine, dahlia, gardenia	12.53	50	83.3	1
Vegetables	Chili, brinjal, Indian spinach, tomato, bottle gourd, bitter gourd, lady's finger, coriander	16.57	49	81.7	2
Fruits	Lemon, mango, guava, sapota, jujube, pomegranate, wax jumbo, lime, orange, malta, hog palm, litchi, papaya	6.8	46	76.7	3
Medicinal plants	Aloe, basil, air plant, diabetic plant, centella	5.97	44	73.3	4
Others	Cactus, bonsai, dracaena, palm, henna, croton	5.78	37	61.7	5

Table 5. Distribution of the respondents based on the practiced intercultural operations

Intercultural operations	Respondents (N = 60)		Rank
	Frequency	Percent	
Irrigation pattern	60	100	1
Weeding	60	100	1
Training/Pruning	49	81.7	2
Insect & disease control	45	75.0	3
Decoration	42	70.0	4
Thinning	31	51.7	5
Shading	6	10.0	6
Others	5	8.3	7
Drainage system	3	5.0	8

Table 6. Distribution of respondents based on insect infestation, disease infestation and fertilizer use

Items	Major findings	Respondents (N=60)		Rank
		Frequency	Percent	
Insects name	Ant	39	65.0	1
	Mealy bug	22	36.7	2
	Not at al	13	21.7	3
	Green Leaf Hopper (GLH)	8	13.3	4
	Whitefly	5	8.3	5
Diseases name	Not at al	21	35.0	1
	Die back	14	23.3	2
	Viral disease	13	21.7	3
	Leaf curling	11	18.3	4
	Leaf scorching	9	15.0	5
	Fungal disease	8	13.3	6
Fertilizer name	Cow dung	31	51.7	1
	Compost	26	43.3	2
	Urea	22	36.7	3
	Muriate of potash (MoP)	15	25.0	4
	Sesame cake	14	23.3	5
	Triple super phosphate (TSP)	13	21.7	6

Table 7. Distribution of the respondents according to the severity of problem confrontation

Problem	Score	Respondents (N=60)		Range	Mean	Sd
		Frequency	Percent			
Low	≤10	0	0			
Medium	10–20	47	78.3	12–29	18.15	3.61
High	>20	13	21.7			

Table 8. Severity of different problem confrontation in rooftop gardening

Problems	Severity of Problems†					PCI		Rank
	N (0)	LS (1)	MS (2)	S (3)	HS (4)	Score	Percentage	
Problem of excessive heat	0	1	1	15	43	220	91.7	1
Lack of proper nourishment	0	0	2	27	31	209	87.1	2
Problem of roof load	1	2	15	25	17	175	72.9	3
Lack of proper sunlight and shade	3	16	31	10	0	108	45.0	4
Insect, pest and disease infestation	5	15	31	8	1	105	43.7	5
Lack of proper training, skill & experience	11	17	20	9	3	96	40.0	6
Lack of sufficient area	35	5	10	5	5	60	25.0	7
Lack of proper management	37	6	11	6	0	46	19.2	8
Disturbed by child, pet animals & thieves	35	18	5	2	0	34	14.2	9
Lack of suitable planting materials	49	6	3	2	0	18	7.5	10
Lack of proper marketing facilities	53	3	2	2	0	13	5.4	11
Transportation problem	58	0	1	1	0	5	2.1	12

† N= no problem, LS= less severe problem, MS= medium severe problem, S= severe problem, HS= highly severe problem

Table 9. Relationship between the selected characteristics of the respondents and the problem confrontation

Selected characteristics (independent variables)	Dependent variable	Correlation of coefficient (ρ)
Age	Problem confrontation of RG†	0.289*
Educational qualification		–0.071 NS
Family size		0.015 NS
Experience in rooftop gardening		–0.003 NS
Organizational participation		0.073 NS
Annual income		0.030 NS
Extension contact		0.097 NS
Cosmopoliteness		–0.024 NS
Knowledge on rooftop gardening		0.206 NS

† RG = rooftop gardening; NS = Non-significant, *Correlation is significant at the 0.05 level (2–tailed)

3.5 Efficacy of rooftop vegetation on ambient environment reclamation

Roofs with plants and roofs without plants were compared based on the weather parameters of temperature (°C), relative humidity (%) and light intensity (lux) to determine the efficacy of rooftop gardening on its surroundings. For that purpose, 32 green roofs and empty roofs were selected purposively from study area and the findings have been presented in Fig. 1. Results on Fig. 1a represented temperature in green roof of 32.78 °C in case of empty roof of 32.93 °C. Again, relative humidity in green roof is of 64.1%; whereas 63.3% in empty roof (Fig. 1b). An average of 1204 lux and 1677 lux were light intensity from green roof and empty roof, respectively (Fig. 1c). As the results indicate, temperature (difference is not so big) and light intensity are high in empty roof than green roof; where relative humidity is much higher in green roof compare to empty roof. Speak (2013) also found the same result. The reason behind these might be that, traditional buildings soak up direct

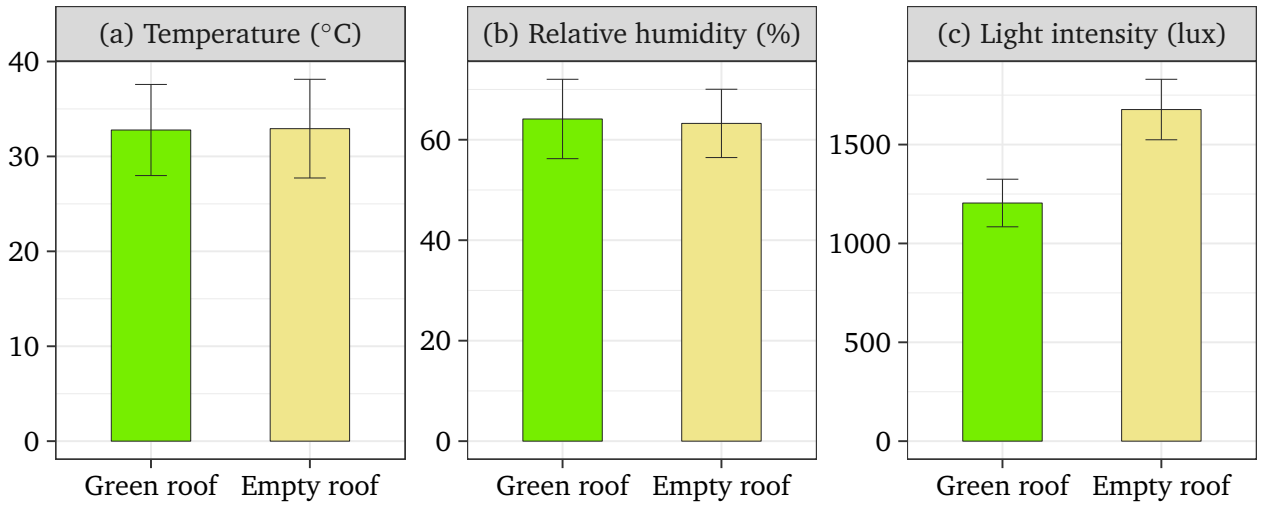

Figure 1. Temperature, relative humidity (RH) and light intenisty as affected by rooftop vegetation

solar radiation or light intensity. On the other hand, plants on rooftop absorb and transform sunlight and regulate ambient temperatures through evapotranspiration. Again, plants act as a solar filter and have the ability to prevent the absorption of heat radiation into the materials of the building (Perini et al., 2011). Furthermore, implementation of green roofs shows potential temperature reductions of about 0.3 to 3.0 °C (Santamouris, 2014).

4 Conclusions

Reviewing the overall results, the conclusion can be made that rooftop gardening is becoming popular among all aged and all classes of people in urban areas. All most all of the respondents had more or less experience and knowledge on rooftop gardening. Most of the people consider rooftop gardening as a hobby with next importance of its aesthetic appeal. Flower plants were the first choice followed by vegetables, fruits and medicinal plants. According to the cost return analysis, most of the rooftop gardeners were not economically viable from the garden. However, rooftop gardening have a significant impact on food security, income and meeting nutritional deficiency to the gardeners. It has the possibility to generate employment and economic facilities through its backward and forward linkages. Lack of proper nourishment, excessive heat and roof load were exposed as the most common and severe problems. It requires adequate training and motivation to encourage people to cultivate plants on rooftop with sustainable management. In that case, Government and NGOs could play a vital role by providing training and motivate people with technical aspects of rooftop gardening. Furthermore, it can be concluded that rooftop garden has the aspects of social, recreational, economical and environmental benefits.

Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

References

Bass B, Baskaran B. 2003. Evaluating Rooftop and Vertical Gardens as an Adaptation Strategy for Urban Areas. Institute for Research in Construction National Research Council, NRC-IRC-46737. National Research Council, Canada.

Costanzo V, Evola G, Marletta L. 2016. Energy savings in buildings or UHI mitigation? Comparison between green roofs and cool roofs. Energy and Buildings 114:247–255. doi: 10.1016/j.enbuild.2015.04.053.

Doncean M. 2014. Strategic solutions for pollution: Reduction and restoring the rural environment – Green roofs. Lucrari Stiintifice 57:263–266.

Hossain T, Hossain MA. 2016. Present Scenario and Problem Confrontation of Rooftop Gardening in Khulna City of Bangladesh. Khulna University, Khulna, Bangladesh.

Islam KMS. 2004. Rooftop gardening as a strategy of urban agriculture for food security: The case of Dhaka city, Bangladesh. Acta Horticulturae 643:241–247.

Islam MR, Alam MAH, Yasmin N. 2017. Evaluation of a novel semi-automatic drip irrigation system for water management in rooftop garden. Fundamental and Applied Agriculture 2:178–182.

KDA. 2002. Khulna Urban Structure Plan 2000–2020. Khulna Development Authority, Khulna, Bangladesh.

Nira KN. 2006. Adoption of Roof Gardening at Mirpur-10 Area under Dhaka City. MS Thesis, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh.

Perini K, Ottele M, Fraaij A, Haas E, Raiteri R. 2011. Vertical greening systems and the effect on air flow and temperature on the building envelope. Building and Environment 46:2287–2294. doi: 10.1016/j.buildenv.2011.05.009.

Quasem MA. 2011. Conversion of agricultural land to non-agricultural uses in Bangladesh: Extent and determinants. The Bangladesh Development Studies 34:59–85.

Rahman MH, Rahman M, Kamal MM, Uddin MJ, Fardusi MJ, Roy B. 2013. Present status of rooftop gardening in Sylhet City Corporation of Bangladesh: an assessment based on ecological and economic perspectives. Journal of Forest and Environmental Science 29:71–80. doi: 0.7747/JFS.2013.29.1.71.

Sajjaduzzaman M, Koike M, Muhammed N. 2005. An analytical study on cultural and financial aspects of roof gardening in Dhaka metropolitan city of Bangladesh. International Journal of Agricultural and Biological Engineering 7:184–187.

Santamouris M. 2014. Cooling the cities – A review of reflective and green roof mitigation technologies to fight heat island and improve comfort in urban environments. Solar Energy 103:682–703. doi: 10.1016/j.solener.2012.07.003.

Speak AF. 2013. Quantification of the Environmental Impacts of Urban Green Roofs. PhD Thesis, School of Environment and Development, The University of Manchester, UK.

USEPA. 2000. Vegetated Roof Cover: Philadelphia, Pennsylvania. Washington (DC): USEPA. Report no. EPA 841-B-00-005D. US Environmental Protection Agency, USA.

Wong NH, Chen Y, Ong CL, Sia A. 2003. Investigation of thermal benefits of rooftop garden in the tropical environment. Building and Environment 38:261–270. doi: 10.1016/S0360-1323(02)00066-5.

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