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Article

Urban agriculture for environmental sustainability: Perception of city dwellers

Md. Maruf Billah[1,2*], Al Muzahid[3], Md. Nasrul Millat[4], Mohammad Mahmudur Rahman[1]

[1]Global Center for Environmental Remediation (GCER), The University of Newcastle, Callaghan, 2308, NSW, Australia
[2]Agrotechnology Discipline, Khulna University, Khulna-9208, Bangladesh
[3]Jashore University of Science and Technology (JUST), Jashore, Bangladesh
[4]Upazila Agriculture Office, Department of Agriculture Extension, Fakirhat, Khamarbari, Bangladesh

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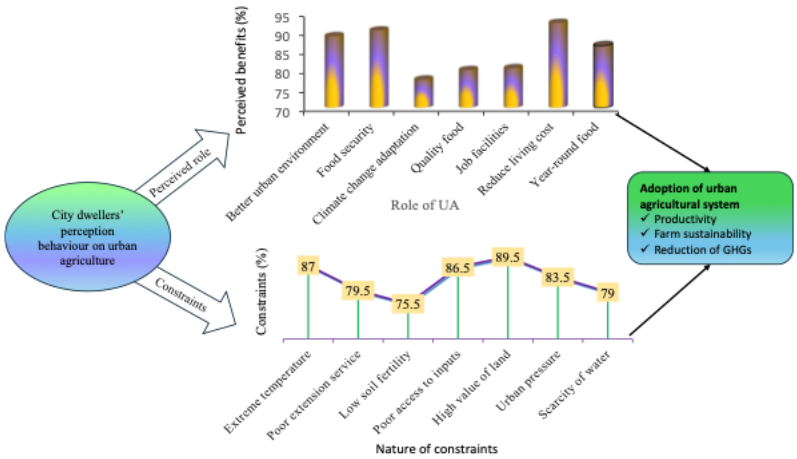

Highlights

- Rooftop gardens, homestead gardens, and container gardens are widely adopted in urban agriculture.
- The majority (94.5%) of city dwellers perceived medium to high role of urban agriculture.
- High value of land, extreme temperature, and lack of input are major constraints.
- Well-planned and feasible strategies are highly advised to support urban agriculture.

Abstract

Urban agriculture (UA) is the part and parcel of modern farming system which plays a pivotal role in underpinning food security for the global population. This study investigated the perception of city dwellers on the role of urban agricultural system for environmental sustainability. Data were collected from 200 randomly selected respondents from Bangladesh by face-to-face interview method utilizing structured questionnaire in 2024. Statistical analysis was performed employing statistical package for social science (SPSS), version 29. Findings reveal that the majority (34.5%) of respondents belonged to early adopter categories in adopting urban agricultural practices. It was also found that the most adopted urban farming practice is rooftop gardening (93.5%) followed by homestead gardens (80%), container gardens (66.5%) and so forth. Results explored that most (94.5%) of city dwellers perceived a medium to high role of UA on environmental sustainability. Conversely, reducing the cost of living (92.5%) was perceived as the most potential role of these interventions. However, innovativeness, training exposure, access to extension services, media contact, education, group membership, and access to market were identified as the potential factors in adoption of UA. Surprisingly, a significant portion (89%) of respondents confronted medium to high constraints in adopting this innovation. The outcomes explore the present scenario of urban agriculture to the concerned authorities, policymakers, researchers and city dwellers. Therefore, well-planned, and appropriate

Correspondence: md.billah@uon.edu.au (MMB)

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strategies such as awareness and motivational programs, capacity building initiatives, subsidies for innovations and integration of UA in city master plan can strengthen adoption of urban agricultural interventions.

Keywords: Environmental sustainability; Urban agriculture; City dwellers; Perception; Climate change; Bangladesh.

1. Introduction

Globally, around 54% of the populations are dwelling in the urban regions and it is anticipated to be increased up to 66% by 2050 alongside rapid urbanization (UN, 2014; Knorr et al., 2018). It has been reported that over 900 million people depends on food grown in cities (FAO, 2015). According to United Nations report, food insecurity has increased by 22.4% since 2014 whereas about 2 billion people are suffering from severe food crisis (UN, 2020). The scenario will be more complex and challenging in the coming epochs. Moreover, population is increasing very quickly while the cultivable agricultural land is declining at an alarming rate (UN, 2022).

It is projected that by 2050 the world's population will be around 9.8 billion while the proportion of urban population at the same time will be 16.8% and 83.2%, respectively in developed and developing nations (UN, 2018). Although, urban area covers only 2 to 3% of the total land surface but consumed approximately 75% of the world's energy, emit 60% of the greenhouse gases and produce large quantities of waste which is the burning question for urban sustainability (Churkina, 2016; UN, 2018). So, to feed the upcoming generation, the overall agricultural production needs to be increased up to 60% by 2050 which is a matter of concern (Badami and Ramankutty, 2015; FAO, 2015).

Furthermore, producing food in a sustainable manner and maintaining environmental sustainability is a challenging issue as farming practices are highly sensitive and vulnerable to both anthropogenic and natural phenomena (FAO, 2016). Moreover, many metropolitans are suffering from various crises like massive population pressure, prompt decline in green areas, rise in temperature, environmental degradation, and infrastructure development (Veen, 2015; Miccoli et al., 2016; Oh and Lu, 2023). On the contrary, urban soil is extremely contaminated with heavy metals like lead (Pb), cadmium (Cd), arsenic (As) as well as organic pollutants such as polycyclic aromatic hydrocarbons (PAHs), petroleum products, antibiotics etc. which limiting the use of urban land for farming practices (Menefee and Hettiarachichi, 2017).

Scholars (Schwab et al., 2018; Tomatis et al., 2023) agreed that adjacent to traditional farming practices, urban agriculture (UA), the foundation of food security for the global urban people, could be a feasible solution to the aforesaid problems. Urban agricultural system is a type of farming practices that is conducted in urban or peri-urban areas utilizing small plot of lands, adopting innovations, and employing climate smart technologies, though there are significant differences with respect to extent, location, actions, and goals (Padgham et al., 2015; Poulsen et al., 2015; FAO, 2019).

Generally, UA is often practiced as a means to moderate the effects of climate change faced by the city dwellers and concurrently offer multidimensional and multifunctional benefits which enhance urban sustainability and resilience (Gómez-Villarino et al., 2021; Newell et al., 2022). Such benefits encompass the enhancement of food security and resilience of farming system, mitigation and adaptation to climate risks, conservation of biodiversity, expansion of social capital, and promotion of health and well-being of city dwellers (Vitiello and Wolf-Powers, 2014; Lin et al., 2015; Royer et al., 2023).

According to Van der Heijden (2014) a sustainable urban city is one which meets the requirements of the existing people without sacrificing the potential of imminent generations to confront their own demands. In addition, Grebitus et al. (2020) stated that urban agricultural practices are constructed as a domain of productive system to confirm the daily basic needs within a city while D'Alessandro et al. (2018) exposed that most of the cities should have specific land area and plans for conducting farming activities which will increase the sustainability of the urban environment.

The study was conducted in Bangladesh which is densely populated along with huge food deficit (UN, 2010). This country is very small in size (147,570 km^2) having a massive population (around 200 million) where a large portion of them live in urban areas (BBS, 2022). In Bangladesh, there are eight mega cities called divisional cities such as Dhaka, Chittagong, Khulna, Barisal, Rajshahi, Sylhet, Rangpur and Mymensingh characterizing diversified geographic features (BBS, 2020). These mega cities are extremely polluted, and city dwellers are consistently fighting against food scarcity (Akhtar and Rahman, 2015).

City dwellers perceived severe constraints and prospects of adoption of urban agricultural systems in Bangladesh (Ferdous et al., 2021). Urbanization is very rapid in divisional cities whereas agricultural land is declining sharply which is a threat for environmental sustainability (Tomatis et al., 2023). Moreover, this low-lying deltaic country are more unprotected and vulnerable to climate variabilities compared to many developing nations of the globe and would likely be the first and firmest hit by the effects of climate extremes and food shortage (IPCC, 2019). In this situation, establishing well-planned urbanization is highly essential to support environmental sustainability.

Beside natural calamities, various anthropogenic activities like development of infrastructure, unplanned throwing of wastage are creating barriers concerning the establishment and expansion of UA (Abdillah et al., 2023; Thornbush, 2015). So, with a view to making the earth habitable for future generations, environmental sustainability is a big concern, which is widely accepted concept of sequence of social, environmental, economic and policy aspects (Olumba et al., 2024). Existing literature suggests that it is indispensable to explore city dwellers' perceptions and preferences concerning urban farming practices, so that urban planners and policymakers uphold, manage, and further expand urban farming effectively (Ackerman et al., 2014; Kyoi, 2021).

Though UA can be a potential solution to ensure food security, environmental sustainability, self-sufficiency along with access to fresh and quality products, there is a clear knowledge gap about the perception of city dwellers regarding the role of UA in building environmental sustainability for human welfare. Considering the current consequences and imminent prerequisite, this research was conducted keeping in mind the following aspects: i) socio-economic attributes of the city dwellers, ii) adoption behavior of city dwellers concerning adaptation to UA, iii) perceived role of UA in supporting environmental sustainability, iv) factors affecting city dwellers' ability to adopt urban agriculture, and v) constraints confronted by city dwellers in adopting UA.

2. Materials and methods

2.1 Study area, sampling design and data collection

The research was attempted to all divisional cities of Bangladesh, viz. Dhaka, Chittagong, Khulna, Barisal, Rajshahi, Sylhet, Rangpur and Mymensingh (**Fig. 1**). The reason of selecting Bangladesh as the study area is that the low-lying deltaic country are more exposed and susceptible to climate extremes compared to many developed nations and will likely be the first and hardest hit by the impacts of climate change and food scarcity (Eckstein et al., 2019; IPCC, 2019). These mega cities were purposively selected because the surroundings of these metropolitan areas are highly polluted and becoming unsuitable for living. On the contrary, people of these cities are trying largely to get involved in various urban farming practices (BBS, 2020).

Before selecting these divisional cities, a comprehensive conversation with the related departments such as

Figure 1. Map showing the study area.

Department of Agriculture Extension (DAE) was carried out by the researcher with a view to communicating with the targeted clientele groups. Moreover, purposive random sampling techniques were employed in selecting the respondents for the study and collecting research data.

Farm household heads, who are dedicatedly engaged in various urban agricultural activities comprised the sample size. From each divisional city, a total number of 25 respondents were selected purposively. So, the total sample size was 200. Before collecting data with personal interview methods, eight key informant interviews (KIIs) with upazila agriculture officers were conducted to collect in depth information. The qualitative data obtained from KIIs were utilized in designing the interview schedule for the investigation. Prior to collecting survey data, ethical approval was obtained from Department of Agriculture Extension offices (approval number H-2024-035) and participant consent form was employed accordingly. Finally, a face-to-face interview was accomplished with the sampled (200) participants using structured questionnaire between January and February 2024.

2.2 Measurement of variables and analysis of data

Perceived role of urban agriculture on environmental sustainability was considered as focus variable while the socio-economic attributes of the respondents like age, sex, education, access to market, farm size, training exposure, credit received, annual income, access to extension services, media contact, group membership, knowledge, innovativeness, and awareness were treated as explanatory variables. For measuring the focus variable, a total number of 25 statements (role of UA) were included investigating existing literature and performing KIIs.

A 5-point Likert type rating scale such as very strongly agree, strongly agree, moderately agree, somewhat agree and not all agree was utilized against the rating scale correspondingly. The scores allocated against the scale were 4, 3, 2, 1, and 0 respectively. The assessment score of the participants varied from 0 to 100 and based on the perception score, the participants were categorized into the following groups: low, medium, and high role perceived respectively. On the contrary, the explanatory variables were measured utilizing descriptive statistics like frequency, percentage, range, mean, standard deviation etc.

The second objective of the study; adoption behavior of city dwellers concerning adaptation to urban agriculture was measured using descriptive statistics such as frequency, percentage, rank order etc. The third objective; perceived role of urban agriculture in supporting environmental sustainability was evaluated developing residents perception index (RPI). Moreover, the following formula was executed to calculate the RPI and to understand the relative proportion of the statements associated to perception concerning the role of UA on environmental sustainability (Billah et al., 2021).

$$RPI = N_1 \times 4 + N_2 \times 3 + N_3 \times 2 + N_4 \times 1 + N_5 \times 0 \ldots\ldots\ldots\ldots\ldots (1)$$

Where, N_1 = Number of respondents rated the role of UA as very strongly agree, N_2 = strongly agree, N_3 = moderately agree, N_4 = somewhat agree, N_5 = not at all agree.

The RPI score varied from 0-800, where 0 denotes no role perceived while 800 signifies highest role perceived of UA on environmental sustainability. For better understanding, the RPI score was converted into percentage using the subsequent formula (Billah et al., 2023).

$$\% \text{ RPI} = \frac{\text{Observed RPI score}}{\text{Possible highest RPI score}} \times 100 \ldots\ldots\ldots\ldots\ldots (2)$$

Meanwhile, the fourth objective of the study; factors affecting city dwellers' ability to adopt urban agriculture was assessed employing inferential statistics. Pearson product-moment correlation (*r*) was operated to investigate the association between the dependent and independent variables. Conversely, multiple linear regression analysis (both enter and stepwise methods) was performed to detect the potential factors affecting farmers' ability to perceive the role of UA on environmental sustainability. Stepwise regression analysis assisted in determining the

specific contribution of factor variables by excluding irrelevant variables from the model (Billah et al., 2015). The formula used for multiple regression analysis was as follows:

$$y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \ldots\ldots\ldots\ldots + \beta_{14} X_{14} + \in i \ldots\ldots \quad (3)$$

Where; y_i = Perceived role of UA, β_0 = constant, X_1 = age, X_2 = sex, X_3 = education, X_4 = access to market, X_5 = farm size, X_6 = training exposure, X_7 = credit received, X_8 = annual income, X_9 = access to extension services, X_{10} = media contact, X_{11} = group membership, X_{12} = knowledge, X_{13} = innovativeness, X_{14} = awareness, and $\in$I = Error term.

Accordingly, the fifth objective; constraints confrontation in adopting urban agriculture was evaluated utilizing descriptive statistics like frequency, percentage, rank order and so forth. The collected data were scrupulously cleaned, coded, and analyzed with the statistical package for social science (SPSS) version 29. To prepare the relevant charts and graphs, Microsoft excel and Origin Pro 2023b graphical software were also used.

3. Results and discussion

3.1 Socio-economic attributes of the respondents

Findings reveal that over half (52.5%) of the respondents belonged to middle aged group, dominated surprisingly by female participants (58%). This is perhaps that the aged and female counterparts are more aware of food security and urban environmental sustainability. The results show that the majority (44.5%) of them had higher secondary education which is a good sign of adopting an urban farming system. The outcomes also reveal that almost three-quarters (74.5%) of them had small farm sizes and a large portion (51%) of the respondents had high annual income. On the other hand, a significant portion (61%) of them did not receive any credit.

The results show that nearly half of the respondents (52.5%) had medium exposure to contact media while a substantial portion (60%) of them didn't receive any institutional training. In addition, it was found that the majority (43.5%) of respondents had no membership in groups and a substantial portion (58.5%) of them didn't get desired access to extension services. The results also indicate that over half (54.5%) of the respondents had medium knowledge while 51% of them were moderately aware of the role of urban agriculture on environmental sustainability (**Table 1**). Several studies (Dubbeling and Massonneau, 2014; Nigus et al., 2024) exposed nearly parallel sorts of socio-demographic attributes in adopting urban farming practices.

Table 1. Socio-demographic attributes of the city dwellers.

Variables	Definition	Mean	SD
Age	Age of respondents in years	46.41	9.52
Sex	1 = male, 2 = female	1.24	0.43
Education	Years of formal education of respondents	8.48	3.11
Market access	1 = access, 0 = otherwise	0.87	0.34
Farm size	Size of farms in hectares	0.45	0.41
Training exposure	Training received in number of days	2.08	3.27
Credit received	Credit received from any sources in US$	$297.55	$362.91
Annual income	Annual income from farming in a year in US$	$2,828.43	$1,122.29
Access to Agricultural extension service (AES)	1 = access, 0 = otherwise	0.48	0.50
Media contact	Scale score of media contact	23.38	6.21
Group membership	Scale score of group membership	0.47	0.50
Knowledge	Scale score of knowledge of respondents	18.91	5.90
Innovativeness	1 = laggard, 2 = late majority, 3 = early majority, 4 = early adopter, 5 = innovator	3.16	1.24
Awareness	1 = aware, 0 = otherwise	0.82	0.39

3.2 Adoption behavior of city dwellers concerning adaptation to urban agriculture

Results signify that city dwellers were distributed to various adopter categories in relation to adoption of urban agricultural practices and majority (34.5%) of them belonged to early adopter categories whereas only 9% of them found as laggards (**Fig. 2**). Rogers (1962) explored that in case of adoption of innovations, the respondents were classified on the following adopter categories; innovators (2.5%), early adopter (13.5%), early majority (34%), late majority (34%) and laggard (16%). It seems that with the duration of time and changing of situation, the number of innovators and early adopters has increased markedly in adopting innovations.

Table 2 explores that city dwellers are trying to adopt a wide variety of urban farming practices with a view to adapting to the changing environment. Findings denote that the most adopted urban farming practice was rooftop gardening (93.5%), followed by homestead gardens (80%), container gardens (66.5%), vertical farms (43.5%), green walls (37%) and so forth while large scale agri-business (3%) was remarkably identified as the least adopted urban agricultural practices by the respondents. This is because of easy and comfortable access to and maintenance of rooftops as well as homestead gardening by the city dwellers. The research report of Abdillah et al. (2023) explored that majority of city dwellers adopted urban farming practices reasonably for getting fresh food and protecting the environment from being altered while Veen (2015) identified that the commonly adopted urban farming practices were rooftop gardens, large scale agri-business and so forth.

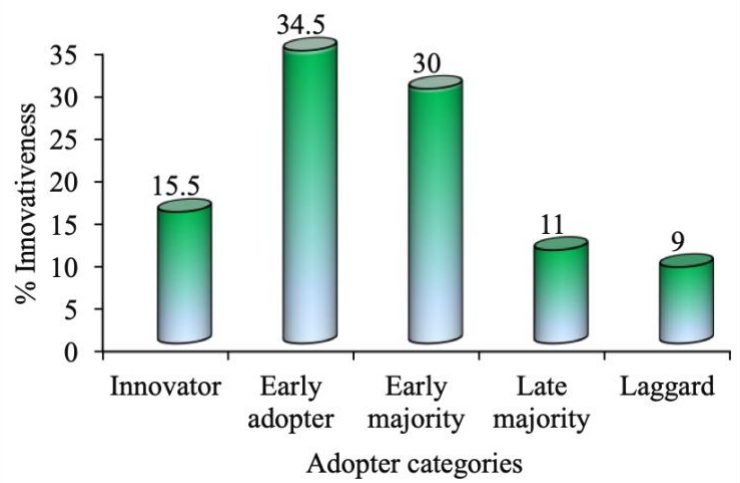

Figure 2. Adopter categories of respondents based on their innovativeness.

Table 2. Nature and extent of adoption of urban agriculture for environmental sustainability.

Urban agricultural practices	Extent of adoption (n=200)	
	(%)	Rank order
Small scale agri-business	36.5	6
Homestead gardens	80	2
Vertical farms	43.5	4
Container gardens	66.5	3
Rooftop gardens	93.5	1
Community gardens	14.5	8
Green walls	37	5
Large scale agri-business	3	10
Institutional gardens	19	7
Street landscaping	12	9

3.3 Perceived role of urban agriculture on environmental sustainability

Figure 3 explores that most (94.5%) of the city dwellers perceived a medium to high role of UA on environmental sustainability while only 5.5% perceived a low role exclusively with a mean of 73.85 and standard deviation of 21.57. The outcomes highlight that city dwellers' perception regarding the role of UA on environmental sustainability was positive and significant. Ladan et al. (2022) revealed that urban farming practices play a pivotal role in building environmental sustainability as well as ensuring food security.

The RPI values show that, reducing the cost of living (92.5%) was identified as the most potential role of urban agriculture perceived by the city dwellers followed by ensuring food security (90.5%), improving urban environment (89%), year-round supply of food (86.5%), control urban temperature (82.5%) and so forth (**Table 3**). The results are well aligned with several studies (Lovell, 2010; Pfeiffer et al., 2015). Zinia and McShane (2021) pointed out that urban farming system plays a significant role in reducing the negative effects of climate variability, developing ecological status and improving biodiversity.

3.4 Factors affecting city dwellers' ability to adopt urban agriculture

3.4.1 Relationship between dependent and independent variables

Figure 4 indicates the relationship between the dependent variable (perceived role of urban agriculture) and the independent variables (selected features of the participants). The color and size of the ellipse represents the nature and extent of relationship. Findings expose that amongst the fourteen selected attributes; respondents' education, training exposure, access to extension services, media contact, group membership, knowledge, innovativeness and awareness were positively associated to the focus variable and the result is supported by several studies (McDougall et al., 2019; Du and Tanaka, 2024). Conversely, there was no substantial relationship of age, sex, market access, farm size, credit received, and annual income with the perceived role of urban agriculture.

3.4.2 Determinants of adoption of urban agriculture for environmental sustainability

To identify the factors and their influence in forecasting the perceived role outcomes, multiple linear regression analysis was employed. The findings revealed that seven explanatory variables out of fourteen were significant with the F value of 62.27 and R^2 value of 0.825 (**Table 4**). Thus, the results indicate that about 82.5% variation in the perceived role of UA could be explained by the integrated effects of independent variables. The co-efficient of education (t=2.285 and p<0.05), market access (t=-2.246 and p<0.05), training exposure (t=3.246 and p<0.01), access to extension services (t=4.006 and p<0.05), media contact (t=2.658 and p<0.05), group membership (t=2.990 and p<0.05) and innovativeness (t=11.254 and p<0.05) were found significant. The results denote that these factors significantly influenced respondents' ability to perceive the role of UA on environmental sustainability.

For explaining the contribution of significant explanatory variables, a stepwise multiple linear regression was performed. The results show that amongst the significant variables, training exposure, access to extension services, media contact, education, group membership, access to market, and innovativeness finally entered the model and contributed together 81.9%of the total variation regarding the adoption of UA for farm sustainability.

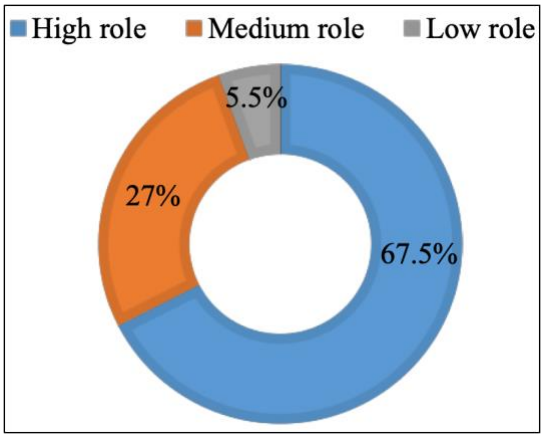

Figure 3. Distribution of respondents based on perceived role of urban agriculture.

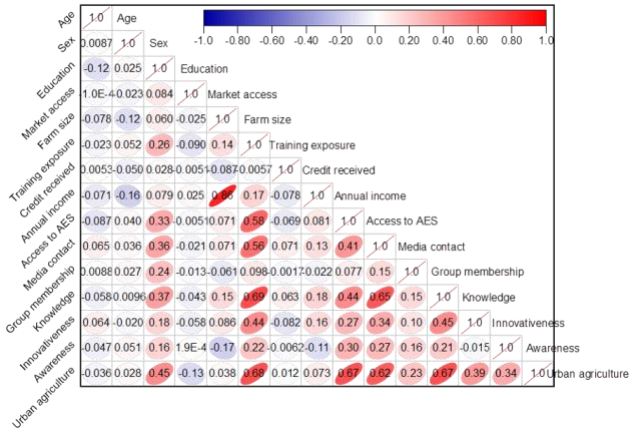

Figure 4. Correlation co-efficient of dependent and independent variables.

Table 3. Perceived role of urban agriculture on environmental sustainability.

Role of urban agriculture	RPI score	Percent (%)	Rank order
Reduce the cost of living	740	92.5	1
Ensure food security	724	90.5	2
Improve urban environment	712	89.0	3
Year-round supply of food	692	86.5	4
Control urban temperature	660	82.5	5
Create job facilities	644	80.5	6
Supply fresh quality food	640	80.0	7
Support climate change adaptation	620	77.5	8
Increase aesthetic value	616	77.0	9
Create green space	612	76.5	10
Reduce carbon emission	568	71.0	11
Reduce environmental pollution	536	67.0	12
Fulfill local demand	524	65.5	13
Ensure air purification	496	62.0	14
Recycle household waste	488	61.0	15
Form of physical exercise	476	59.5	16
Conserve biodiversity	472	59.0	17
Decreased greenhouse gas emission	432	54.0	18
Increase family income	416	52.0	19
Learn unique skills	396	49.5	20
Reduce monotony	372	46.5	21
Foster small agribusiness	364	45.5	22
Educate community	332	41.5	23
Increase community interaction	292	36.5	24
Reduce storm water run off	244	30.5	25

Results imply that innovativeness was detected as the most influential explanatory variable which entered the model and could solely explain 67.8% of the total variation of focus variable. It may be assumed from the findings that city dwellers having innovative behavior facilitate maximum adoption of urban farming practices. Veen (2015) explored that the highly accelerating determinants of adoption of urban farming were attitude, agricultural training and awareness of the stakeholders. The 2nd variable in the model was training exposure that could explain 7.6% of the total variation of dependent variable. Generally, agricultural training fosters diffusion of innovation systems, and the result is in line with several studies (Toth et al., 2016; Kanosvamhira, 2024).

It was found that media contact plays a pivotal role in explaining the focus variable which contributes 2.1% in adoption of urban agriculture. Surprisingly, the 4th variable that reveals important contribution was access to extension services (1.9%). This is because extension services assist in changing farmers' adoption behavior. Accordingly, group membership (1.5%), education (0.05%), and access to market (0.05%) were found as the prospective variables. Raja (2024) reported that city people having group membership and communication exposure are always enthusiastic in adopting urban farming practices.

3.5 Constraints confronted by city dwellers in adopting urban agriculture

Figure 5 shows that 89% of the city dwellers had confronted medium to high constraints in adopting urban agricultural practices, whereas a smaller portion (11%) of them encountered low constraints. This signifies that most of the city dwellers have triggered diverse extents of constraints in embracing urban agriculture for environmental sustainability.

Table 5 explores that city dwellers are confronting multiple constraints to adopt urban agricultural practices. It was found that urban people are severely facing the difficulty of high market value of land (89.5%), extreme temperature (87%), poor access to inputs (86.5%), urban pressure (83.5%), poor extension services (79.5%), lack of irrigation water (79.5%) and so forth in adopting UA and the result is supported by several studies (Chari and Ngcamu, 2022; Qiu et al., 2024). Hardman et al. (2022) and Pfeiffer et al. (2015) pointed out that unavailability of agricultural

land, high temperature, shortage of irrigation water, lack of agricultural inputs as well as public unwillingness are the critical barriers in conducting urban farming practices.

Table 4. Summary of multiple linear regression analysis.

Independent variables	Co-efficient (Beta)	t-value	Significance	Collinearity statistics	
				Tolerance	VIF
Constant		2.279	.024		
Age	-.012	-.382	.703	.942	1.061
Sex	-.011	-.345	.730	.957	1.045
Education	.082	2.285	.023	.736	1.358
Market access	-.071	-2.246	.026	.955	1.047
Farm size	-.029	-.472	.638	.255	3.925
Training exposure	.157	3.246	.001	.407	2.460
Credit received	.025	.784	.434	.962	1.040
Annual income	.015	.254	.800	.254	3.940
Access to extension services	.170	4.006	<.001	.525	1.905
Media contact	.116	2.658	.009	.498	2.010
Group membership	.096	2.990	.003	.911	1.098
Knowledge	.065	1.286	.200	.372	2.687
Innovativeness	.487	11.254	<.001	.505	1.979
Awareness	.060	1.770	.078	.832	1.202
n=200, R^2=0.825, F value=62.27					

Table 5. Severity of constraints confronted by city dwellers in adaptation to urban agriculture.

Constraints encountered in adopting UA	Percent (%)	Rank order
High production cost	74.5	8
Extreme temperature	87.0	2
Poor extension services	79.5	5
Soil toxicity	67.5	10
Municipal policy	66.5	12
High market value of land	89.5	1
Lack of information	50.5	16
Lack of irrigation water	79.0	6
Shortage of cultivable land	56.0	14
Lack of marketing facilities	43.0	18
Poor access to inputs	86.5	3
Rainfall variability	68.0	9
Change in legislation	39.0	19
Urban pressure	83.5	4
Rapid population growth	67.0	11
Lack of credit/money	31.0	20
Lack of training	64.0	13
Lack of motivation	52.0	15
Lack of post-harvest facilities	48.5	17
Low soil fertility	75.5	7

4. Conclusion and policy recommendation

City dwellers represent diverse socio-economic features and majority of them belong to early adopter categories in adopting urban farming practices. It has been identified that rooftop gardening, homestead gardening, container gardening are the most commonly adopted urban agricultural practices. Therefore, the concerned authorities and policy makers should initiate feasible initiatives like training on UA, subsidies for farm inputs and so on to improve city dwellers' situation and strengthen smart urban agricultural system.

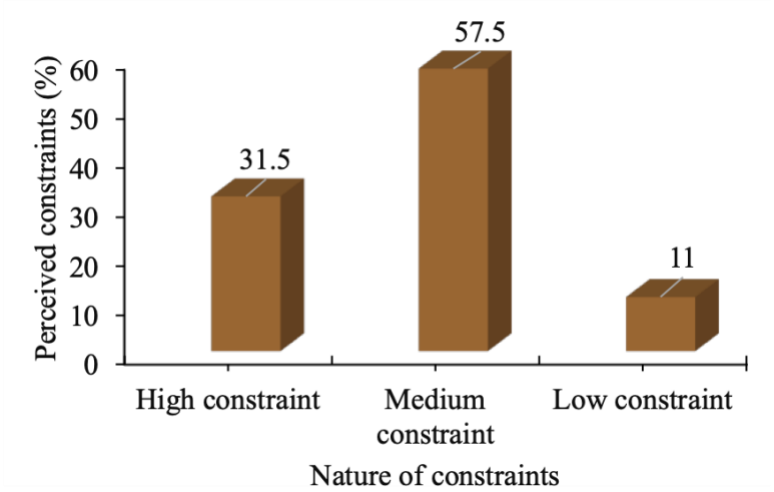

Figure 5. Constraints faced by respondents in adopting urban agriculture.

It was found that majority of city dwellers perceived medium to high role of UA on environmental sustainability while reducing the cost of living, supporting food security, improving urban environment, year-round supply of food and control urban temperature was detected as the most potential. Hence, well-planned, and appropriate strategies on adoption of UA such as awareness and motivational program, incorporate city dwellers into policy design can enhance urban environmental sustainability.

Innovativeness, training exposure, access to extension services, media contact, education, group membership, and access to market were identified as the potential factors in adoption of UA. However, a significant portion of respondents confronted medium to high constraints in adopting this innovation. Thus, easy access to services, capacity building approaches, and formation of farmers' organization for fostering adoption and mitigating constraints confrontation are highly recommended.

5. Acknowledgements

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6. Data availability statement

Data will be made available on request to the corresponding author.

7. Author contribution

M.M. Billah: conceptualization, data curation, formal analysis, investigation, methodology, and writing – original draft. Al Muzahid: data curation, formal analysis, and writing – review & editing. N. Millat: data curation, and writing – review & editing. M.M. Rahman: formal analysis, supervision, validation, and writing – review & editing. All authors approved the final version of the manuscript.

8. Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

9. Ethical statement

This study did not involve human participants or animals, and therefore did not require ethical approval.

10. Copyright statement

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