Acta Sci. Pol., Administratio Locorum 24(3) 2025, 317–333.
https://czasopisma.uwm.edu.pl/index.php/aspal plISSN 1644-0749 eISSN 2450-0771 DOI: 10.31648/aspal.10913

ORIGINAL PAPER
Received: 15.12.2024 Accepted: 09.04.2025

DETERMINANTS OF ROOFTOP GARDENING KNOWLEDGE AMONG GARDENERS: A CASE STUDY FROM DHAKA, BANGLADESH

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ABSTRACT

Motives: Urban farming is gaining much popularity in recent years in the form of rooftop gardening in densely populated cities. Gardening knowledge is an integral part for employing the practice with other socio-economic factors. Researchers are interested to explore the factors behind gardening knowledge.
Aim: The aim of the study is to explore the socio-economic characteristics of gardeners, to assess the present knowledge of rooftop gardeners, and to evaluate various aspects contributing to rooftop gardening knowledge in Bangladesh capital city Dhaka.
Results: The results of the research show that space for gardening and media contact of gardeners have positive relationship with their existing gardening knowledge. Access to different media can ameliorate the gardeners existing understanding by increasing knowledge. Gardeners who have the space for gardening can share the technical knowledge and space for building gardening community in the city.

Keywords: Bloom's taxonomy, knowledge test, media contact, descriptive statistics, regression analysis

INTRODUCTION

Beyond providing food, urban agriculture offers numerous additional benefits to both people and the environment, such as regulating urban temperatures, creating recreational activities, and fostering the development of cultural connections between urban residents and the surrounding landscapes (Langemeyer et al., 2021). It can serve as an urban oasis, an essential green area that provides city dwellers with a break from the concrete and a chance to engage with the dynamic lifecycles of a garden. In addition to helping residents build a greater sense of food security, rooftop agriculture makes urban areas more resource-efficient (Walters & Stoelzle Midden, 2018).

Increasingly, urban agriculture is being recognised as an essential component of holistic approaches to address issues arising from unchecked urbanisation

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in developing nations (Mougeot, 2006). Rooftop gardening, also called rooftop farming, is an effective strategy for urban agriculture where empty space is not available, and non-road areas are occupied by different building structures (Saha & Eckelman, 2017). Backyard, windowsill, and rooftop gardens are among the many agricultural endeavours that fall under the umbrella of urban agriculture (Brown & Jameton, 2000). Rooftop gardening has gained popularity among urban citizens because of its benefits, like access to fresh food, improved nutrition, and community building. Rooftop gardens can supply a family with enough plant-based nutrition, minimizing the need to buy fruits and vegetables at the market, where hyperinflation severely strains household budgets. Additionally, rooftop gardens hold significant ecological value in urban settings, providing gardeners with the resources needed to sustain their gardening activities (Thapa et al., 2021).

Wang (Wang & Zhang, 2023) notes that rooftop gardening has clear advantages and has grown significantly in many urban agriculture models and has seen significant growth. Cities including Bologna (Italy), Chicago (USA), Cleveland (USA), Hong Kong (China), Montreal (Canada), New York (USA), Portland (USA), Seattle (USA), Shanghai (China), Taipei (Taiwan), Tokyo (Japan), Toronto (Canada), Vancouver (Canada) and Warsaw (Poland) have experienced significant increases in the local food supply as a result of urban agricultural activities like allotment gardens and community gardens (Mokras-Grabowska, 2021; Walters & Stoelzle Midden, 2018).

Urban gardening plays a key role in safeguarding food and nutritional security for residents in many developing country cities (Orsini et al., 2013). Dhaka, the capital city of the South Asian country of Bangladesh, exemplifies this situation. In 2023, the Dhaka metro area was home to 23 million residents, an increase of 3.26% from 2022 (MacroTrends, 2023), driven by migration for better living. Concurrent urbanisation has seen the transformation of agricultural land into new roads, industries, hospitals, and institutions for this increased population. Such changes create serious obstacles to food security in developing countries such as Bangladesh. Among the various types of urban agriculture, Rooftop gardening (RTG) is the most suitable for Dhaka's crowded population because many buildings lack the space needed for other gardening techniques (Nayeem & Majumder, 2019).

According to Orsini et al. (2013) the development of urban horticulture and urban agriculture is one of the main tactics used in developing countries to combat urban poverty and enhance the quality of life. In terms of land and human resources, urban and peri-urban farming contrasts tremendously with rural agriculture. Rooftop gardening does not require high cost and long hours. Orsini et al. (2014) describe urban gardens as diverse systems found in cities, including public plots assigned to individuals or families, community gardens created in vacant or abandoned spaces, and private or shared gardens in yards, balconies, or rooftops.

The growing interest in RTG stems from city dwellers' aspirations for fresh crop cultivation and consumption. Specht et al. (2014) note that academics and practitioners are exploring ways to expand food production in buildings and on arable land in high-density urban regions, thereby severing the connection between production and land. The social, economic, food and ecological sustainability of cities are all strengthened through urban horticulture (Khan et al., 2020). The majority of Dhaka's rooftops are flat and well-suited for gardening (Kabir et al., 2023).

Sanyé-Mengual et al. (2015) found that in residential areas, where investing in high-tech infrastructure such as greenhouses and aquaponics is less affordable, rooftop gardens may become a means to support urban agriculture. Moreover, space availability is an essential factor that influences the practice of RTG. Hui (2011) stated that for successful urban gardening, appropriate growing techniques and adequate roof space must be determined. Additionally, Lovell (2010) indicated that edible landscapes and urban agriculture can be planned at many various scales and forms to offer a wide range of benefits to city dwellers. Varga-Szilay et al. (2024) described an extensive examination of gardening practices,

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motives of garden owners, and garden attributes in Hungary, addressing interconnected activities and facilitating effective knowledge transfer and education to encourage individuals toward biodiversity-friendly gardening methods. The communication mechanism for disseminating ecofriendly gardening information is lacking. There is a scarcity of explorative studies focusing on RTG through two specific lenses: knowledge of gardening and access to extension media. Thus, the general aim of this paper is to describe RTG from a socio-economic perspective. To achieve this aim, this study outlines three objectives: I) to analyse the socio-economic factors of gardeners, II) to explore the existing knowledge of rooftop gardeners, and III) to assess the various factors that contribute to RTG knowledge. The findings of this study are expected to shed light on the factors that influence knowledge acquisition for rooftop gardening on a larger scale.

LITERATURE REVIEW

Urban gardening knowledge and the use of different media

The contribution of gardening knowledge and media contact to rooftop gardening has not been extensively addressed in the academic literature. For rooftop farming education to be effective, it should exploit the knowledge and resources of local urban residents. Extension media serves as a communication tool, bridging innovations from research institutions to end users. Service relations between agricultural extension service organisations and farmers are characterised by interactions where a service provider (e.g., state or para-state technical support organisations or private consultants) assists beneficiary (individuals engaged in farming) to improve their practices (Laurent et al., 2006).

Agricultural extension has progressively shifted from a conventional focus on technology transfer and farm management information provided by the public sector to offering comprehensive advisory services, including marketing, environmental sustainability, pest diagnostics, and risk management (Norton & Alwang, 2020). Colussi et al. (2024) described three types of communication media: for interpersonal meetings (field days, conferences, retailers, extension agents, peer groups, conversations with neighbours), mass media (e.g., newspapers, magazines, radio, television, websites/blogs), and social media platforms (e.g., YouTube, WhatsApp, X/Twitter, Facebook, Instagram, LinkedIn). Extension contact serves as a vital assistance system and policy instrument. It is a fundamental component of the agricultural knowledge and information system, helping farmers make informed decisions (Daku et al., 2005).

Different types of extension media are regarded as sources of information that can adopt either top-down or bottom-up approaches. To be effective, the use of extension media should involve the whole family. Appolloni et al. (2021) showed the global distribution of various forms of rooftop agriculture, their varied farming intentions, and additional characteristics (e.g., farm sizes, building types, growing systems, products and reported yields, activities, adopting resource-efficient practices, or economic and social activities). They also described the multifunctionality of rooftop agriculture as most cases had a secondary farming goal, typically combining social education or image enhancement with quality-of-life improvements. Commercial rooftop farms that integrate greenhouse technologies and soilless systems remain rare despite their high capacity for food production. Rooftop gardens give urban planners additional options while also meeting diverse resident expectations.

Effective communication is essential for scaling up innovations such as urban gardening, and in this context, "medium" and "channels" are key terms. Extension media can contribute as important intermediates that enable communication between different agricultural stakeholders and city residents. If farmers can change their behaviour as a result of an extension worker's message, then the communication is effective (Pasaribu & Novanda, 2022). There is no specific description of the extent of access to extension media for urban gardening in the academic literature. City gardeners have less access to extension programs than rural residents (Kabir et al., 2023).

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Urban green infrastructure (UGI) is a strategy that supports climate change mitigation (Abdulateef & Al-Alwan, 2022). According to Dreesti and Keshav (2019), sustainable production was identified as the primary reason for adopting rooftop gardening, while utilizing space was the fifth reason given by rooftop gardeners in Kathmandu, Nepal. In Nepal, rooftop and balcony farms are being established by an increasing number of urban dwellers for gardening and agricultural needs. Bhattarai and Adhikari (2023) suggest that the vast majority of urban agriculture will take place on rooftops and balconies in more congested and developed urban settings. Developing a strategy to improve urban biodiversity should begin by valuing existing biodiversity reservoirs within the city. To accommodate and increase desirable fauna that can disperse across the city, it is important to expand green spaces such as greenhouses and building-integrated agriculture. RTG may increase resilience through a variety of ecological mechanisms, including reducing the environmental effect of food production and promoting social and self-sufficiency elements like diligent co-learning, communication, knowledge sharing, and produce exchange (Gasperi et al., 2016).

According to Zambrano-Prado et al. (2021), due to land scarcity in European cities, innovative approaches to promoting urban gardening have been developed in Barcelona, Berlin, Bologna, and Paris, among other cities. They also identified 20 barriers to rooftop urban agriculture projects based on stakeholder perceptions in four European cities. Prominent among them were administrative processes and building regulations (codes, design and structures). Pollution and water costs were found to be the main obstacles to rooftop urban agriculture in Barcelona and Paris. The cost of water seems to be a new hurdle and would be a suitable topic for further research, along with efforts to identify solutions, such as new technology, studies, and policymaking. There is a need for more regulations that address the difficulties communities have in obtaining supplies for home gardening. Extension professionals from research and academic institutes have the potential to overcome those challenges by using and combining multiple information channels.

Green information systems address the need for information regarding green spaces in both urban and non-urbanised areas (Nowak et al., 2020). The COVID-19 pandemic epidemic dramatically highlighted the digital divide in cities (Caragliu & Del Bo, 2023). While urban food production cannot feed an entire city, it can increase food security in some communities and offer other benefits to city dwellers, such as re-establishing a connection with food and educating them about its origins. When building integrated agriculture, social, educational, and economic objectives must be considered as they may hold the key to the success of future initiatives. Choosing the right crop is crucial to the success of integrated agricultural initiatives (D'Ostuni et al., 2022). There are differences in disseminating agricultural information via interpersonal channels, the mass media, cosmopolite channels. Innovations are spreading across all demographics and occupations to strengthen existing urban food systems and make better use of open urban spaces (Bohn & Viljoen, 2010). Three-quarters of the gardeners' knowledge was based on their early experiences; they were familiar with a wide range of potential crops and their requirements, including seasonal constraints (Turner et al., 2024).

The choice of communication channel varies among inhabitants. Gardeners' responses differ in active and passive ways, depending on the sources of communication media used. The urban integration of rooftop agriculture has been linked to several significant risks, including a lack of operational demonstration projects, nonintegrative regulations, inadequate public communication of research concepts, and inadequate knowledge (Specht & Sanyé--Mengual, 2017). Gardening knowledge often involves non-formal education when it comes through different extension media sources.

Cerón-Palma et al. (2012) described several barriers to rooftop eco greenhouses (RTEG), including economic, technological, social and environmental factors. Social barriers arise from the limited number

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of agricultural experts proficient in urban systems and the potential employment reductions in rural regions. Extension media, particularly mass media, provide enhanced opportunities for engaging citizen interest. Comparing the perceived risks associated with the production system with current rooftop agriculture practices and existing scientific knowledge reveals that certain negative perceptions of stakeholders were inconsistent with real-world practices and could, therefore, be attributed to a lack of understanding of actual implementation (Specht & Sanyé-Mengual, 2017).

Another review study noted that urban horticulture may not be appropriate in all locations due to pollution risks. Additionally, different cultivation techniques are used in different parts of the world, with varying conditions and needs (Eigenbrod & Gruda, 2015). They also suggested that modern, highly effective methods are more likely to appear in high-income countries, whereas simpler systems that require less upkeep and inputs will predominate in developing countries. Understanding the factors that influence plant diversity and composition in gardens is critical (Philpott et al., 2020).

RESEARCH METHODOLOGY

Gardening in Dhaka: A case study

This study was conducted in Dhaka, Dhaka city is divided into Dhaka North City Corporation and Dhaka South City Corporation. The Dhaka North City Corporation consists of 54 wards (Dhaka North City Corporation, The People's Republic of Bangladesh, & Japan International Cooperation Agency, 2019). In Bangladesh, a ward is an optional

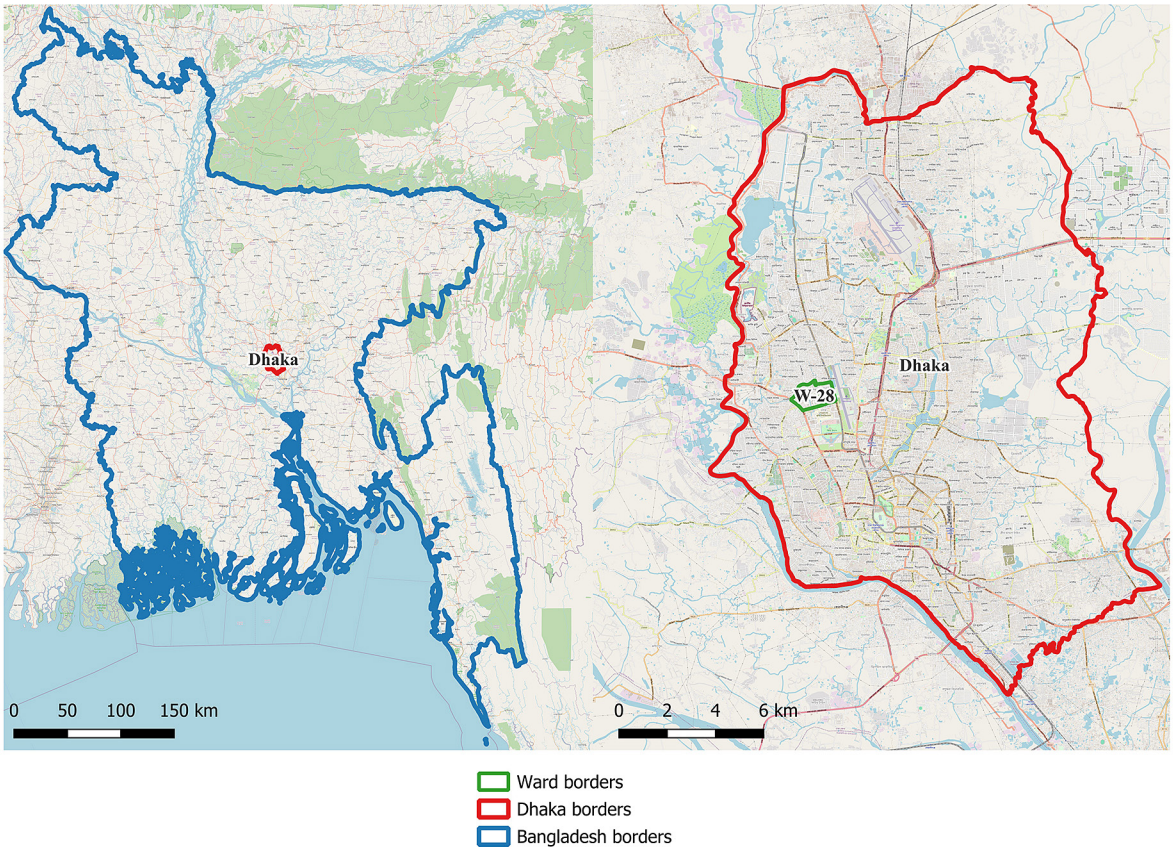

Fig. 1. Map showing ward 28 from Dhaka North City Corporation
Source: Spatial data collected from www.arcgis.com.

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subdivision of a city or town, particularly an electoral district, utilised for administrative and representative functions. It is an elective unit of a city or municipal corporation established to facilitate more direct representation, from which a single council member is elected (Wards of Bangladesh, 2024). Ward 28 was purposively selected for the study (Fig. 1). The areas under ward number 28 include Shyamolibag, Agargaon, and West Agargaon. Since most of Dhaka's rooftops are flat and easily accessible, gardening is a suitable choice for them (Kabir et al., 2023). Almost 77% of Dhaka's rooftops, which were dispersed similarly throughout the city, were either ideal or extremely appropriate for growing crops (Sultana et al., 2024).

Information about gardeners from the studied ward was collected from the Department of Agricultural Extension of Dhaka. The study population included the owners of rooftop gardens. The main reason for selecting rooftop gardeners was to gather detailed information from the respondents. The sample size was determined to be 108, based on a population of 150, a 95% confidence level, and a confidence interval of 5, with adjustments for finite populations (Cochran, 1977). These 108 gardeners were considered representative of the studied area. The data were collected between 10 January 2023 and 10 February 2023.

Study variables

Primary data were collected through structured interviews that utilised a questionnaire with both open-ended and close-ended questions. The questionnaire comprised three parts. Part one collected socio-economic information with metric questions. Part two evaluated the interviewees' knowledge of gardening. Part three assessed the use of different communication media sources. The interview schedule was pre-tested with 10 selected city residents from the study area and updated based on the compiled suggestions and comments from the pre-test. Prior to gathering data, a meeting was held with the local agricultural extension officer.

The dependent variable in this study was the gardening knowledge of rooftop/balcony garden owners. Gardening knowledge refers to the competence to remember or identify relevant information regarding farming practices. Gardening stimulates collaboration and cultivates a sense of community across generations, providing opportunities to gain knowledge about plants and their cultivation, promoting a healthy lifestyle through fruits and vegetables, and utilizing overlooked spaces (Eidimtiene et al., 2016). As Seel (2012) notes, knowledge primarily focuses on the capacity to learn and remember particular information. To assess participants' gardening knowledge, the study developed 20 questions based on Bloom's taxonomy of learning objectives (Kabir et al., 2022). The respondents' knowledge of rooftop/balcony gardening was assessed by the interviewer using a knowledge score based on their answers to these questions (Table 1).

Bloom's Taxonomy describes a systematic framework and multi-tiered approach for categorizing thought processes based on six cognitive levels (Magdato & Satparam, 2023). These levels include lower cognitive domains (knowledge and understanding) and higher cognitive domains (application, analysis, synthesis, and evaluation), representing low-order thinking (LOT) and high-order thinking (HOT) (Bilonozhko et al., 2023). Bilonozhko et al. (2023) also noted that the use of Bloom's taxonomy increasingly focuses on the continuous improvement of critical thinking abilities, where well-written interview questions are crucial since they correspond with various levels of behavioural engagement. They also found that oral assessments using prepared speaking formats have proven to be effective in maximizing each learner's potential. Furthermore, the three stages of the higher cognitive domain – analysis, synthesis, and evaluation – focus heavily on the capacity for critical thinking. Each question was assigned a weight of 2 points for a full answer, 1 for a partial answer, and 0 if the interviewee was unable to answer the question. The possible score range for this variable is 0 to 40.

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Table 1. The list of questions to test gardening knowledge

Sl. No.	Questions	Levels
1	Name two important flowers suitable for rooftop/balcony gardening.	Knowledge
2	Name two important vegetables suitable for rooftop/balcony gardening.	Knowledge
3	Name two important ornamental plants suitable for rooftop/balcony gardening.	Knowledge
4	Name two important medicinal plants suitable for rooftop/balcony gardening.	Knowledge
5	Name two important fruit trees suitable for rooftop/balcony gardening.	Knowledge
6	Name two shade-loving plants.	Knowledge
7	Name two sun-loving plants.	Knowledge
8	Name two important propagating materials.	Knowledge
9	What vegetables can be grown year-round in rooftop/balcony gardening?	Application
10	Name two major insects that attack vegetables.	Knowledge
11	Name two major insects that attack flowers.	Knowledge
12	Name two major diseases that affect vegetables.	Knowledge
13	Name two major diseases that affect flowers.	Knowledge
14	Provide fertiliser rates for two important flowers.	Knowledge
15	How do you understand the need for irrigation in your gardening?	Comprehension
16	When is de-potting necessary?	Application
17	How is plant nutrition maintained in rooftop/balcony gardens?	Synthesis
18	Differentiate between budding and grafting.	Analysis
19	Differentiate between training and pruning.	Analysis
20	What do you understand by Integrated Pest Management?	Evaluation

Source: Own elaboration.

Gardeners' access to and extent of use of communication media was an independent variable for this study. This characteristic relates to an individual's degree of interaction with different rooftop/balcony gardening-related communication channels. A media engagement score was calculated based on the type of extension media interaction with thirteen chosen media in order to assess the degree of media usage:

I) agricultural extension agents
II) nursery owners
III) friends, family, or neighbours
IV) agricultural researchers or academics
V) agriculture or tree fairs
VI) newspapers
VII) leaflets, booklets, or magazines
VIII) television
IX) radio
X) Facebook
XI) YouTube
XII) agricultural mobile apps
XIII) the Internet.

For a rooftop/balcony gardener, the resultant score might be anywhere from 0 to 52, where a score of 0 denotes no engagement with the extension media and 52 denotes the highest level of engagement.

Socio-economic variables may significantly influence individuals' views and decision-making processes (Tarashkar et al., 2024). The gardener's yearly income, available gardening space, and time dedicated to gardening will reflect the advantages of urban farming. Furthermore, these socio-economic characteristics will delineate work prospects and income generation elements. Access to garden spaces, garden design, and plant diversity are substantially influenced by level of socioeconomic circumstances (Kingsley et al., 2024). These aspects additionally recognise the availability of free urban green space. Different socio-economic groups have varying

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knowledge and communication media preferences for urban gardening. Socio-economic aspects influence whether people adopt, support, and sustain professional urban farming in metropolitan areas (Sroka et al., 2021). The selection of the independent variables was based on the objectives of our research, with some variables selected from previous studies (Chowdhury et al., 2020; Grard et al., 2018; Uddin et al., 2021; Mondal et al., 2020) (Table 2).

In this study, we used the ordinary least square (OLS) approach to identify the factors that influence rooftop/balcony gardeners' knowledge. OLS was chosen over alternative models due to its suitability and practicality (Kabir et al., 2022). The OLS model was specified as follows:

$$Y_i = \beta_0 \sum_{i=1}^{8} \beta_i X_i + \in \quad (1)$$

Where Y_i is the knowledge score, β_0 is the intercept, β_i is the parameters to be estimated, X_i is the independent variables, and $\in$ is the error term.

As mentioned earlier, knowledge was evaluated through 20 questions. Full answers were awarded 2 points, partial answers were given 1 point, and incorrect or unanswered questions were awarded 0. The scores were then summed across all 20 questions, giving possible scores ranging from 0 to 40. The respondents' knowledge was categorised into good (>32), fair (26–32) and poor (≤25) (El-sallamy et al., 2018).

Table 2. Description of variables

Variable	Description	Definition	Code
X_1	Age (years)	The respondent's age in years at the time of the interview	A score of 1 was assigned for each year of age.
X_2	Education (years)	The number of years of formal schooling completed by the respondent	A score of 1 was assigned for passing each level in an educational institution.
X_3	Family size (number)	Total number of members in the respondent's family, including the respondent	A score of 1 was given for each family member, including the respondent.
X_4	Annual income from the rooftop/balcony garden (BDT)	Annual income generated from gardening activities over the course of a year measured in Bangladeshi Taka (BDT)	A score of 1 was assigned for every 1000 BDT earned from gardening.
X_5	Space for gardening (percent)	The percentage of rooftop/balcony space occupied by gardens relative to the total space available	Total space and gardening space were measured in square feet and converted into percentages.
X_6	Crop diversification (number)	The number of different plant species cultivated within the gardening area	Scores were assigned based on the total number of plant types, categorised as vegetables, fruits, flowers, and others (e.g., medicinal, ornamental).
X_7	Gardening experience (years)	Total number of years they had been engaged in rooftop/balcony gardening	Each year of experience was assigned a score of 1.
X_8	Time spent gardening (hours per week)	Total number of hours dedicated to gardening activities per week	Each hour of gardening was assigned a score of 1.
X_9	Extension media access (score)	The extent to which respondents accessed gardening information through various media sources	Scores were determined by summing responses across 13 selected media sources, with a Likert score ranging from 0 (never) to 4 (regularly).
Y	Gardening knowledge (score)	The respondent's knowledge about gardening was assessed through a series of 20 questions using Bloom's taxonomy	Each full answer earned 2 points, partial answers earned 1 point, and incorrect or unanswered questions received 0; scores were then summed across all questions.

Source: Own elaboration.

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RESULTS

Socio-economic profiles of the rooftop/balcony gardeners

The study examined various socio-economic characteristics of rooftop/balcony gardeners, including age, education, family size, annual income, gardening space, plant diversification, gardening experience, allocated time for gardening, and access to media. Descriptive statistics (range, mean and standard deviation) were used to summarise these variables. Table 3 provides an overview of the respondents' socio-economic profiles. The respondents' ages ranged from 24 to 65 years. Educational background ranged from primary to postgraduation. Family members ranged from 2 to 10, revealing the presence of both nuclear and extended families. The average annual income was around 86,000 BDT (equivalent to 682 euros). The average space for gardening as a percentage of the total area is 63.5. Crop diversification ranged from 10 to 108 plant types. Gardening experience ranged from 2 to 20 years. Weekly time spent on gardening activities ranged from 2 to 20 hours. Scores for access to different communication media ranged from 3 to 40.

Table 3. Interviewee's descriptive information (N=108)

Variable	Range	Mean	SD
Age (score)	24–65	36.95	9.396
Education (score)	5–17	13.16	3.73
Family size (number)	2–10	4.85	1.85
Annual income from rooftop/ balcony garden (score)*	3–450	86.03	105
Space for gardening (per cent)	23.33–96.77	63.5	17.11
Crop diversification (score)	10–108	30.85	19.22
Gardening experience (score)	2–20	9.08	5.398
Time spend in gardening (score)	2–20	7.56	4.02
Communication media (score)	3–40	21.68	8.96

*1000 Bangladeshi Takas (BDT) = 7.93 Euro as accessed on 05 December 2024 from www.valutafx.com
Source: Own elaboration.

The mean age of the gardeners was 37 years, with minimum age of 24 years and a maximum of 65. The results are similar to those of Scott et al. (2020), who found that most gardeners were young adults aged 20–49 years. The educational qualifications of the participants averaged more than secondary education, reflecting the higher literacy rates among urban residents, as supported by the Bangladesh Bureau of Statistics (2015). Similarly, McClintock et al. (2016) revealed that 70% of gardeners had undergraduate or graduate degrees.

The table also reflects the family size and annual income from homestead gardening. The average family structure was nuclear, typical of urban settings. Gardeners utilised, on average, more than half of their available open space, suggesting extensive use of rooftop space, with almost all buildings having a network of pipes that bring water to the rooftops.

A notable diversity in crop selection was observed. Urban residents have a strong preference for growing fruits, vegetables, and flowers alongside other crops like medicinal herbs. This resulted in a wide range of plant varieties, from 10–108, with an average of 31 types per garden. The average gardening experience was 10 years, highlighting the established nature of urban gardening practices. Gardeners dedicated an average of 8 hours per week to their gardens, or approximately one hour per day. This contrasts with Baldi et al. (2024), who reported that more than 60% of gardeners spent 10 to 20 hours per week gardening.

Access to communication media for gardening showed scores ranging from 3 to 40, with an average of 22. However, cities face challenges related to the digital divide, exacerbated by global economic inflation. However, the digital divide is not only about material access but also usage disparities (Shin et al., 2021).

The gardeners' knowledge scores ranged from 18–36, with an average score of 30, against the possible range of 0–40. The majority of respondents, approximately 40%, demonstrated medium knowledge of gardening (Table 4). In contrast, 30 respondents

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Table 4. Distribution of respondents based on gardening knowledge

Dependent variables	Category	Range (score)	Respondents		Mean (score)	SD
			Number	Per cent		
Knowledge on gardening	Low	18–36	30	27.8	29.12	5.26
	Medium		42	38.9		
	High		36	33.3		
	Total		108	100		

Source: Own elaboration.

were categorised as having low knowledge, while only 34% exhibited high knowledge.

Technical knowledge of production systems significantly influences the potential for circularity in building-integrated agricultural practices like rooftop gardening and balcony gardening (D'Ostuni et al., 2022), and in this regard, rooftop gardening differs from community gardening. As community gardeners get and share knowledge about the production and quality of vegetables, they continue to develop (Gasperi et al., 2016). Rooftop gardening lacks this information exchange.

The analysis of the findings reveals that the mean score for gardening knowledge is 29.12 with a standard deviation of 5.26, while the mean score for communication media is 21.68 with a standard deviation of 8.96 (Fig. 2). The variability in respondents' gardening proficiency was less pronounced compared to their access to various modes of communication. Access to different sources of agricultural information showed greater diversification.

Variables determining gardening knowledge

A regression model was used to analyse the relationship between gardening knowledge and nine independent variables. There was a significant positive relationship between knowledge and two variables: space for gardening and the use of communication media (Table 5). Conversely, other variables (age, family size, annual income from gardening, crop diversity, gardening experience, and time spent gardening) had no significant relationship with knowledge.

Table 5. Regression coefficient of gardening knowledge

Independent variables	Co-efficient	S.E.	p-value
Age	-.107	.067	.114
Education	-.345	.161	.035*
Family size	.481	.384	.213
Annual income from the rooftop/balcony garden	.001	.008	.938
Space for gardening	.061	.031	.050*
Crop diversification	.088	.046	.057
Gardening experience	-.034	.101	.739
Time spent gardening	-.268	.169	.116
Media use	.175	.062	.006**
R^2	0.254		
F	3.698		

*Statistically significant at the 5% level and ** statistically significant at the 1% level
Source: Own elaboration.

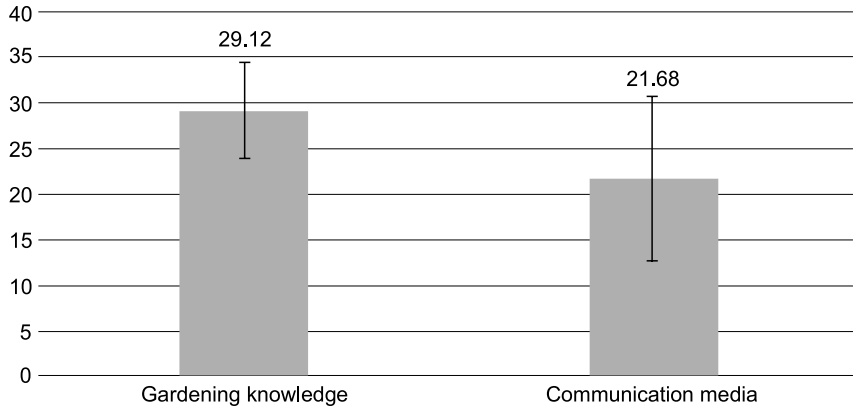

Fig. 2. Mean value with SD of gardening knowledge and communication media
Source: Own elaboration.

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There was a statistically significant negative relationship between gardening knowledge and education. This indicates that higher education does not correlate with technical or gardening expertise. Safayet et al. (2017) found that a lack of gardening knowledge is the second highest barrier to rooftop gardening. The model showed that only gardening space and access to communication media were the only statistically significant predictors of gardening knowledge. More information obtained from different media increases gardening knowledge. Similarly, those with more area for gardening have more gardening knowledge. The model's R^2 of 0.254 indicates that independent factors account for 25.4% of the variation in knowledge, leaving 74.6% unexplained variance. Both space for gardening ($p = 0.050$) and media access ($p = 0.006$) were positively correlated with gardening knowledge, indicating that people with more gardening space and media exposure are more likely to have more knowledge.

DISCUSSION

The research participants demonstrated varying levels of gardening knowledge, which is consistent with previous research on urban gardeners' characteristics. This study contributes to the literature by quantifying the relationship between gardeners' socio-economic characteristics and their gardening knowledge. Using OLS regression analysis, we identified space for gardening and media access as factors that influence gardening knowledge.

Our results also revealed that gardening knowledge is not uniform across all age groups of urban residents (Eidimtiene et al., 2016). Gardening is not merely a pastime or an activity to maintain physical fitness or engage the intellect; it is a collaboration between nature and humanity, refined through experience and cultivation. Gardening embodies age and wisdom (Wright & Wadsworth, 2014).

This study analysed the socio-economic characteristics of city gardeners, their existing gardening knowledge, and the factors that influence this knowledge. In the future, green roofs could support the development of sustainable urban agriculture systems that provide local people with wholesome, fresh vegetables (Walters & Stoelzle Midden, 2018). Various urban agricultural models draw people with varying demands (Kirby et al., 2021).

The study reveals that gardeners dedicated between 2 and 20 hours per week to gardening activities, reflecting the heterogeneity of their social characteristics. In adulthood and later stages, participants' engagement with the garden transitions into a multifaceted activity encompassing relaxation, social interactions, natural connections, and gardening activities (Lauwerijssen et al., 2024).

The percentage of space available to gardeners showed a significant positive correlation with their knowledge of gardening-related information. The availability of adequate areas gives gardeners the freedom to cultivate plants. Gardening space, including porches and balconies, is an important socio-economic feature that may differ according to socio-economic class and geographic location (Anderson et al., 2023).

Increased gardening knowledge is likely to motivate gardeners to grow diversified crops, including ornamental and medicinal plant species. Gardens can also augment the natural habitats of endangered species via deliberate cultivation or introduction (Seitz et al., 2022). Various urban agricultural models draw people with varying demands (Kirby et al., 2021).

The second objective of this study was to assess the existing gardening knowledge among urban gardeners. The findings revealed that the majority of respondents (72.2%) had medium to high levels of gardening knowledge, which aligns with their access to extension media. Gardeners with higher levels of education favoured mass media extension approaches, including radio and television (Mwololo et al., 2019).

The study demonstrated that gardening knowledge increases with greater access to media (Kabir et al., 2022). Urban residents use different media to seek information about gardening, with social media platforms becoming increasingly popular. According to Kabir et al. (2023), Facebook groups

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played a significant role in helping rooftop gardeners obtain the information and guidance they required, often filling the gap left by extension and advisory organisations.

A consistent global trend over the past few decades shows that farmers are ageing, with younger generations typically abandoning their family farms in search of other employment opportunities in urban areas (Orsini, 2020). Therefore, to sustain technical knowledge, a holistic approach involving research institutions, academics, public and private sectors, and diverse information sources is essential. Integrating technology into urban planning—such as in smart cities, where technology enhances efficiency and information sharing—can further improve gardening practices and the quality of life for urban residents (Khan et al., 2020). In order to achieve resilience in urban green growth, the resource-by-resource approach is less amenable to resilience management than the place-based approach (Vargas-Hernández & Zdunek-Wielgołaska, 2021).

The study identified space for gardening and communication media use as significant contributors to rooftop gardening knowledge. The fundamental difficulty for urban planners is determining which urban agriculture needs to be created or protected as a buffer against urban spatial expansion, as well as where, how, and why (Aubry et al., 2012). Urban gardening requires consistent support from institutions and organisations to ensure its sustainability across social, economic, and environmental dimensions. Combining innovative concepts like the circular economy concept with gardening knowledge is a strategy that can make cities sustainable. When gardeners adopt new technologies via different communication media, other city residents may be motivated to engage in gardening to make cities sustainable. The participants reported diverse effects and motivations. For example, in communally farmed places, sociability motivations predominate, while in employee-driven projects rather than volunteer efforts, economic motivations prevail (Kirby et al., 2021).

The study also underscores the importance of evaluating media access and gardening knowledge as tools for urban planners and policymakers. Gardening space also contributes to gardening knowledge. However, not all citizens have the opportunity to engage in gardening activities. This is particularly important in the context of urban agriculture policy and plan development, where associations between user needs, community impacts, and urban agriculture types could lead to increased funding or land allocation for particular forms of urban agriculture (Kirby et al., 2021).

As agricultural extension workers use different media channels to disseminate farming innovations, they can transfer more agricultural knowledge. Traditional elements that affect agricultural practices include demographics, socioeconomic level, resource endowments, and availability of institutional services (Pinthukas, 2015). Another study revealed that farm and household characteristics like educational attainment and access to extension services for zero-tillage farming, such as rooftop gardening, are significant factors in adoption decisions (Yigezu et al., 2018).

Knowledge and access to media are complementary factors. D'Ostuni et al. (2022) concluded that reconnecting people with food, educating them about healthy diets, and making production visible and tangible within the city boundaries should be considered the main goals of building integrated agriculture projects.

CONCLUSION

The research explored the factors influencing gardening knowledge and access to different media. The findings indicate that gardeners on rooftops or balconies were more engaged with extension media the longer they worked on their gardens. To encourage more people to use extension media for gardening information, government and non-government organisations should emphasise the health benefits of rooftop and balcony gardening.

A notable connection was observed between gardeners' knowledge and their access to extension media for gardening information. Thus, government

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agricultural institutes and other agricultural associations should focus their information-sharing initiatives on beginner gardeners or people who are interested in gardening but who have never planted a garden. Targeting this group could make it easier to persuade and motivate them to make gardening a regular habit. Crop diversity in rooftop and balcony gardens could be linked with gardeners' knowledge. As a result, NGOs and government agencies should advocate for cultivating a wider variety of plants and crops in urban gardening spaces.

This research provides valuable insights into the practice of urban farming in densely populated areas. When rooftop space is not available, innovative models, such as hanging gardens or staircase gardens, could be piloted to encourage other urban residents to participate. Knowledge of biological as well as kitchen waste management can be disseminated via different communication channel.

The study also demonstrated how socio-economic factors influence gardening knowledge and access to different media. As income and experience increase, gardeners are more likely to engage with diverse communication media. The ability to function, survive, adapt, and grow while incorporating traits like flexibility, redundancy, inclusiveness, robustness, reflectiveness, resourcefulness, and the ability to respond to disruptions and disturbances is a result of urban sprawl resilience (Vargas-Hernández & Zdunek-Wielgołaska, 2021).

The study is not without its limitations. Only ten variables were used. Policymakers were not directly involved. The study focused on a single ward using purposive sampling. Future research should engage active stakeholders for gardening.

More communication media inspires more institutions. A certain level of planning and institutionalisation of important parties is necessary to successfully implement Zero Acreage Farming (Zfarming) (Thomaier et al., 2015). How locals handle their own property – influenced by financial limitations and cultural beliefs about garden maintenance – significantly impacts bottom-up issues (Tratalos et al., 2007). To encourage more people to use media for gardening information, government and non-government organisations should emphasise the health benefits of rooftop and balcony gardening. The green information system is an in-depth database that can provide managers of urban green spaces with an abundance of support (Nowak et al., 2020).

The connection between a rooftop or balcony gardener's knowledge and their media use for gardening information is notable. To design future urban resilience, it is necessary to remind residents of the relationship between their life-supporting systems and themselves (Barthel & Isendahl, 2013). Thus, government agricultural institutes and other agricultural associations should focus their information-sharing initiatives on beginner gardeners or people who are interested in gardening but have never planted a garden. The development of shared resources like websites, blogs, web-based mapping, and similar technologies could foster other, more horizontal, and decentralised organisational structures (Barthel et al., 2015), making it easier to persuade and motivate individuals to make gardening a regular habit. Consequently, NGOs and government entities should promote more holistic approaches across various media regarding gardening on rooftops and balconies. Since gardening is a technical skill, relying solely on digital media will not yield effective results in practical implementation.

Author contributions: The authors have approved the final version of the article. The authors have contributed to this work as follows: Md. Sekender Ali and Mohummed Shofi Ullah Mazumder designed the study. Fida Al Hasan collected the data. Sk. Md. Nur E Alam and Marcin Feltynowski developed the concept and critically revised the article for important intellectual content. Sk. Md. Nur E Alam analysed and interpreted the data and drafted the article.

Acknowledgment

This article was prepared with the generous support of the Polish Section of the European Regional Science Association (ERSA). The authors gratefully acknowledge ERSA's contribution to this research.

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