



Urban Green Infrastructure Development as Perceived by Urban Household in Chittagong City of Bangladesh

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Authors' contributions

This work was done in collaboration among all the three authors. Author MKI designed the study, performed the analysis and wrote the first draft of the manuscript. Author KJC collected the data and relevant literature where author MSA supervised the overall study. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Along with different initiatives in public and private sectors Chittagong city dwellers are also contributing to increasing urban greenery. This study was aimed to find their perception and contribution to urban greenery development.

Place and Duration of Study: The study was carried out in the Chittagong city of Bangladesh in four different residential areas between May 2019 and June 2019.

Methodology: We have surveyed 100 respondent families who were selected through purposive random sampling. After sorting we have used MS excel 2010 to analyze the data.

Results: The study revealed that household people covered 13.04% of the total household area by greener infrastructure which is about 179.07sq.ft per household. In this study it is found that 49.99% of the respondents practice indoor plantation, 62.44% have roof-top gardening where only 17.61% have gardens in their premises. 128 species have been in their household area of which 36

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flowerings, 33 fruits 36 vegetables, 12 medicinal additionally 11 are ornamental plant species. It has also revealed in the study that 14% house-hold directly uses the roof where 86% use containers for their rooftop garden. They use compost manure, inorganic fertilizer, and food waste as manure. Where 6% prefer composting, 73% is food waste and 21% use inorganic fertilizer. According to 27% of people, the environmental benefits derived from the household greenery are the main reason for developing their garden where 26% claimed it for recreation, 24% for aesthetic and 13% for the religious benefit and only 10% do it for monetary benefit.

Conclusion: Household people can be an important catalyst for “Urban green infrastructure development.” Hope this study will be an expedient caseworker on the way of planning for sustainable Chittagong city development which will embed the Environment and Urbanism in a frame of ‘Sustainable Urban Development’.

Keywords: Urbanization; environment; sustainability; households; green infrastructure.

1. INTRODUCTION

The economy of Bangladesh has undergone a major transformation over the past two decades and also stands out in terms of development indicators [1]. In recent times urbanization is a growing phenomenon in Bangladesh [2]. Unlike other major cities of the country, Chittagong getting urbanized very rapidly [3]. Chittagong is the second-largest city in Bangladesh and having the principal seaport contributing 30% of the national GDP [4] become the country's economic hub and industrial activities [3]. Due to the increasing population and availability of jobs during the last four decades, the city has expanded in all directions, mostly in unplanned and chaotic ways [5]. The rapid development of housing and other urban infrastructure often produces a variety of discontinuous urban development's which ultimately reduce the number of green areas of the city. A study conducted [6] claimed that Chittagong city growth is dispersed type growth towards urban sprawl, the study also concluded that the buildup area is increasing as vegetation cover decreasing. Another study conducted in 2016 [5] said that during the last 36 years from their study period, 56% of the land cover has changed, mainly because of the expansion of built-up areas and other human activities also claimed the built-up area around Chittagong city. This research also concluded that the city has expanded by 618%, with an average annual rate of increase of 17.5%. As a result of rapid urbanization, the vegetated hills near urban development areas face serious threats of further encroachment and degradation, given that 2178 ha of hills have already been intruded over the study period.

However, in general, a sustainable city must be economically viable, socially peaceful, and

environmentally friendly. A sustainable city provides a healthy environment and meets multiple goals i.e., healthy living and working environments: access to water and sanitation, waste disposal, drains, paved roads, and other forms of infrastructure and services essential for health and a prosperous socio-economic base [7]. Urban sustainability is creating sustainability in terms of socio-economic and environmental aspects. Again environmental consideration must be entranced in economic policy as a core element of urban planning for sustainable urbanization [8]. But due to unplanned urbanization, the urban environment of Bangladesh is getting destroyed [9]. Again some experts believe that urbanization engulfs all the green spaces, forest land, parks, and agricultural lands of a city area leading the urban environment unfit for living [10]. This phenomenon is also common in Chittagong which ultimately resulting in different environmental problems like air pollution water pollution noise and soil pollution. As a result, it has been a burning question for decades that “Should Chittagong encourages urbanization more?” or what are the ways of reducing environmental pollution and enhancing the green area of the city. We have to come into a consensus that Bangladesh needs to build an urban space that is capable of innovating, is better connected and more livable. To make cities competitive, cities should be supported by their green areas to ensure sustainable development.

Nevertheless, in recent times, the concept of green infrastructure has grown into an attractive urban sustainability research and policy theme. The concept of Green Infrastructure has been defined as a set of man-made elements which provide multiple environmental friendly functions at both building and urban scales [11]. Green

infrastructure is essentially a term that covers open spaces, parks, private gardens, scrublands, drainage, waterways, street trees, and vertical greenery [12]. The term green infrastructure originates from Towards a Sustainable America, the 1999 report of President's Council on Sustainable Development [13]. Again, Natural England (the executive non-departmental public body responsible to the secretary of state for environment, food, and rural affair) defined it as a strategically planned and delivered network of high-quality green spaces and other environmental features [12]. Therefore, urban greening discusses to any vegetation initiative including the planting of trees, shrubs, grass, or agricultural plots whose design is intended to improve the environmental quality, economic opportunity, or aesthetic value associated with a city's landscape. It also includes rooftop gardening, indoor plantation as well as facades or vertical greenery. For developing a sustainable urban area, Green Infrastructure development is one of the key tools that have been getting more emphasis by many urban planners and experts [10]. It is believed that multifunctional advantages can be derived by developing urban green infrastructures. Though Economic evaluations have historically failed to take into account the true value of landscape resources due to a lack of clarity in assessing the total value (market and non-market) of Green infrastructures, environmental and social benefits have been well addressed in the different studies [14]. The importance of green infrastructure in its widest sense is to promote biodiversity, abate ecological adversity, and improve human and ecological wellbeing [15]. Again urban greening refers to strategies and techniques that protect and restore ecology which means combining urbanism and nature to create a healthy, civilizing, and enrich place to live [8]. Trees and other vegetation intercept particles and gaseous pollutants [16]. Moreover, they act as carbon sinks that help mitigate global warming. Many cities have established and conserved forests for protecting their drinking water resources [17]. Urban green protects soils and moderates harsh urban climates by cooling the air, reducing wind speeds, and by shading. In arid regions, forest shelterbelts around cities help combat desertification and dust storms [18]. In many developing countries, trees often have cultural and spiritual values [10] that could assist new urban dwellers in finding their place in cities and towns. Besides, Green areas provide recreational sites, especially for lower-income residents. The urban poor generally have few

affordable options for recreation, and thus place a high value on green areas [10]. Urban green can have a positive impact on physical and mental health; providing settings for physical exercise and cultural and spiritual values as well urban green spaces play an important part in offering town dwellers a more stress-free environment, irrespective of sex, age, or socio-economic background [19].

However, rooftop vegetation is widely considered as a key component of, 'green infrastructure' development [20] Similarly, some studies support that promoting and popularizing roof gardening and indoor plantation are alternative and effective ways of urban greening thereafter urban green infrastructure development [10]. Rooftop gardening is generally defined as an art and science of growing plants on the fallow spaces within, surrounding, or adjacent to the residence, most frequently referred to as a garden [21]. Other conservative areas of roof gardening include an atrium, balcony, and window boxes. Plants are grown for an of variety utilitarian and non-utilitarian purposes [22]. Rooftop vegetation offer opportunities for significant social, economic, and environmental benefits that are both private and public in nature; particularly in cities [23]. Green plants act as natural filters, increase the city's biomass, counteract the climatic changes, and regulate the indoor climates of buildings by insulation against extreme heat and cold. In Switzerland and parts of Germany, this kind of mental shift-resulting in imagining buildings as displacing and not destroying land surface-has become federal law: developers must either improve the biodiversity of existing land or transfer the green space that they displace to their rooftop or other building surfaces [21]. Even old buildings are required to transfer one-fourth of the land they have displaced to their roofs [24]. So, the Green roof is a holistic sustainability strategy that provides a wide range of social, economic, and environmental benefits to multiple stakeholders including developers and owners, municipalities, the building occupants, and the community. Improved aesthetics, biodiversity, and/or employment opportunities are offered by the green roof to the community, and the building occupants enjoy productivity gains, and/or improved psychological and physical well-being from green roofs [20]. Besides, green roofs, particularly at urban scale can have more qualitative than quantitative benefits – adding biodiversity back into the dense urban environment. The preservation of the biodiversity

potential of a green roof, particularly birds, bees, insects, and plants, supports urban agriculture [20]. Again, agricultural benefits generated from green roofs may potentially address the issue of urban food security [25]. In a word we can say, a rooftop garden can offer an improved environmental quality by bringing nature back into the city [15]. But with the increasing number of population and extensive development has changed the environment of the city of Bangladesh over the last decades. Our green surrounding gradually disappears as our village turns to the city. Fresh and healthy air has been displaced by pollution [23]. Urban dwellers have hardly seen any greenery around them and every inch of land is occupied by various types of infrastructure [26]. The solution lies in planting as many trees as possible, and the only place to do that seems to be on the rooftop or balcony and other vacant areas. In recent years urban greening, rooftop gardening has become more popular in our country especially in Dhaka, Chittagong, and Sylhet. Some research evidence that in Dhaka institutional building, private building, commercial building as well as the hospital are contributing to green infrastructure development by creating rooftop vegetation in their roof [20]. On most of the roofs, some form of pleasure garden exists (78%), sometimes there are fruit gardens (12%), and less often, vegetable garden as well (8%) where different types of plants are planted [27].

Some researchers assumed that the green agenda can be realized in developing countries by focusing on specific industrial sectors such as the private sector is driven construction industry [28]. Others believe the responsibility for maintaining urban green sites lies more in the public sector [29]. Intending to make the capital a greener city, Dhaka City Corporation (both Dhaka North City Corporation- DNCC and Dhaka South City Corporation- DSCC) has recently taken several environment-friendly initiatives. Of the many projects regarding massive plantation, one of the lucrative projects for its citizens is encouraging more people into rooftop gardening. The person, who will make a garden in his /her roof, will get a 10 percent holding tax rebate, and it is promised by Sayeed Khokon, Mayor, DSCC [30].

However, the public sector in most developing countries is overwhelmed by more and more urban planning and governance issues to address, where household people are contributing a significant role in urban green

infrastructure development [31]. Nevertheless, the role of urban households in promoting green infrastructure development in urban areas is less discussed. In our country, few studies have been carried out in Dhaka and Sylhet city to investigate the role of the household in urban greening in which many things need to be well addressed. It is also a fact that there have not done any specific studies to evaluate the contributions and perceptions of people in urban green infrastructure development in Chittagong city. However, for smart planning of green infrastructure development it is important for urban planners, urban designers, urban geographers, and policymakers the potentials of households in green infrastructure development in contemporary urban areas [31]. Therefore, Chittagong city has been targeted for conducting this study as Chittagong is the second rapidly urbanizing city in the country which still needs proper planning for achieving sustainability. This study has been set out to investigate how city dwellers contribute to green infrastructure development in urban areas. That being said, this study was conducted

- (i) To identify the plant types, diversity of species used in rooftop gardens, indoor plant keeping, and periphery vegetation of the residential buildings.
- (ii) To evaluate peoples' perception about plant keeping in and around the household areas and its significance
- (iii) To investigate the maintenance and silviculture practices followed in managing the gardens.

Hope, this study will be an expedient caseworker on the way of planning for sustainable Chittagong city development that will embed the environment and urbanism in a frame of "Sustainable Urban Development".

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The city is located on the banks of the Karnaphuli River and lies between the coordinate 22°22'N and 91°48'E. The area of Chittagong City Corporation is about 168.07 km² (64.89 sq. mi) and encompasses a population of more than 2.5 million. By gender, the population was found 54.36% and 45.64% male and female respectively. The Chittagong City Corporation (CCC) is liable for governing municipal areas in the Chittagong Metropolitan Area.

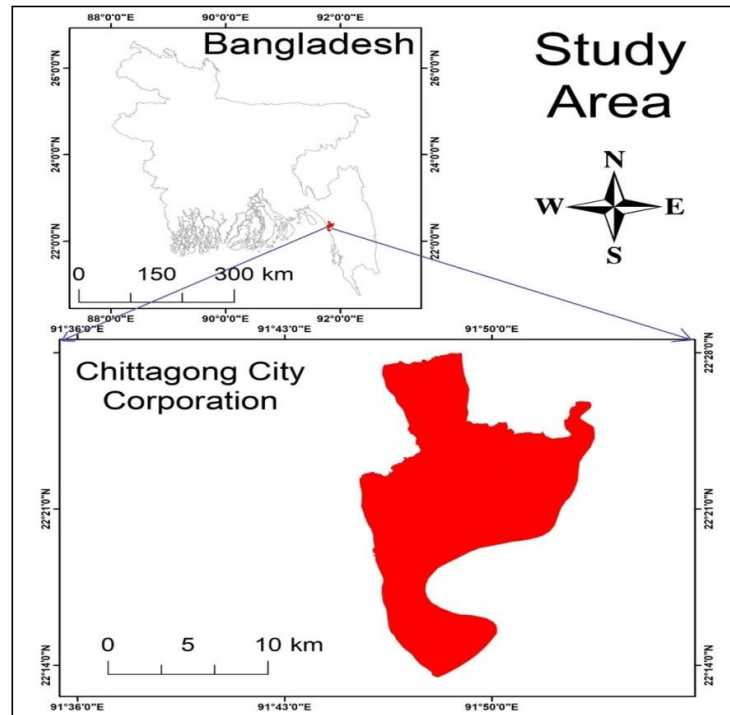


Fig. 1. Map of study area (Chittagong city corporation)

2.2 Site Selection and Data Collection

Four different residential areas addressed as Nasirabad Housing Society, Goribullah Sha housing society, Khulsi residential area, and Jamalkhan have been selected for the survey. A total of 100 families have been surveyed and taken 25 households from each of the zones. The families were selected by purposive random sampling because almost all households don't have any greenery in their house.

2.3 Data Compilation and Analysis

After sorting and cleansing data, the analysis was done by using Microsoft Office Excel 2010.

3. RESULTS AND DISCUSSION

3.1 Household Contribution in Urban Greenery Development

3.1.1 Household area vs. green area

The households were found to be much interested in developing vegetation coverage in their building. Among the surveyed households on an average, they live in 1374.11 sq. ft where

179.07 sq. ft of their house is covered as green spaces. This is shown in Fig. 2. It is about 13.04% of the total area.

It's a good sign of urban greenery development and environmental sustainability as we know greenery can ensure urban sustainability.

3.1.2 People's preference during placement of the plant

Rooftop vegetation, premises garden, and indoor plantations were found to be practiced by the households. Fig. 3 shows their percentage in the study area. They keep the plant in their balcony, veranda, and different corner of the house that are mainly for the beautification of their living place.

We found that 4.52% of the respondent prefers to plant greenery in their roof, premises along with indoor places, 15.37% family placed plants both in rooftop and indoor spaces. 39.11% of households are placed in their indoor zones like balcony, veranda, and different corners of the house for their gardening which is usually remaining vacant with grey infrastructure in other households who do not have any garden. Only 2.19% of the family have gardens both in their

premise and rooftop together was 7.46% have plants in their premises. Again 3.44% have both in indoor and premise where 27.91% have a garden in rooftop only.

In Fig. 3, it indicated that vegetation is very poor in the periphery because there have limited vacant places around there house. Again, most of the households live on rent that why they have less opportunity of making a garden in the rooftop. So they do their garden in their balcony, veranda, or other vacant places in the house so that the area covered by indoor plantation is the maximum.

3.1.3 Species composition

126 species have been found thereof which 36 flowering, 33 Fruits, 34 vegetables, 12 medicinal and 11 are ornamental plant species. Their percentage is shown in Fig. 4. Here flowering plants and vegetable species are seen to be mostly dominated. Fruits plant are also given much importance, where a significant amount of ornamental and medicinal plant species are seen to be planted by the households.

3.2 Urban Greenery Development and Maintenances

3.2.1 Media

3.2.1.1 Soil media

Soil collected from different sources is used as media of plantation. The common sources of soil are collected soil from their villages, soil collecting during the construction of a building; some are bought from nearby nurseries.

3.2.1.2 Water media

Water as media of plant growing is used only for those species which can grow in water. Some ornamental plant species like money plants are planted in the water.

3.2.2 Base of media used for plantation

Normal two type's methods are followed to grow the plants in the roof. Some households directly use the soil at the base of the roof. Some use a different type of container like plastic pot, earthen pot, sac, different rejected containers, etc. for using soil media. But for indoor plantation, they use a different container. Again for premises plantation most of the family plant different

species in the soil directly while only a few households use container-based soil media for their premises vegetation. It is shown in Fig. 5 that only 14% of households directly use the roof where 86% use containers for their garden.

3.2.2.1 Direct roof as media base

For this normally they make a soil bed of 10-18cm depth for vegetable or flowering plant depending on the size of the mature plant. Normally small flowering plants, vegetables, and spicy plants having small are grown in such bed. They opined that deep-rooted plants can't grow in those beds. Some people prepare cemented boxes on the roof and put soil in it to plant different fruits species like Guava, papaya, etc.

3.2.2.2 Different container as the base of soil

Various types of containers are seen to be used by different households. They use a plastic container, earthen pot, sac, and different types of rejected bottle tin, plastic, ceramic, etc. Again they use a container of different sizes depending on the size and shape of the plant.

1. Small size containers (height \leq 18cm and radius \leq 8): These types of containers are being used for flowering plant and ornamental plants as well as for some kind of shrub depending on size.
2. Medium size containers (height 18-30 cm and radius 8-15 cm): These are used for a different, flowering plant, shrub (like Brinjal, Chili, pineapple, etc.), and small size fruit plant (like dragon fruit).
3. Large containers (height \geq 30cm and radius \geq 12cm): Perennial plants are planted in such containers.

3.2.3 Types of container

Different household people use different types of containers depending on the availability, flexibility, and cost of the container. People's choices also greatly influence the type of container they prefer.

It is shown in Fig. 6 that, 34.93% of containers used by household are of plastic, 28.71% are earthen, 10.52% are sack where 25.84% are rejected containers. The majority of the containers are plastic pots. Though it is not an environment-friendly process they claim that plastic container is easier and flexible to handle, so they prefer it more. For making a garden a

huge amount (25.84% of total container used) of rejected bottle, container, bucket made of plastic, tin, ceramic is used. This is one of the very effective environmental practices. Such practices ensure the „reuse“ of rejected containers which assures the reduction of solid waste at the household level. But according to most of the respondents, the major problem of using a container is that after a certain time growth of the plant gets stopped. Plant roots don't get sufficient area to increase and hinders plant growth. In a restricted area, plants get limited nutrients and water from the soil, so they have to supply water and manure continuously in a regular interval.

The above findings excavate the major cognizance of household people about the household greenery development in different places in and around the house. The different procedure of making a garden in and around the house followed by city people has been revealed in the above discussion. This will be effective and inspirational to the other household people who want to be allied on the way of urban greenery development as well as 'Sustainable urban development'.

3.3 Maintenance

Watering, weeding, and using manure are mainly carried out for the maintenance of plants.

3.3.1 Watering

It is found in my study that on average every household uses to water their garden 1-2 times daily depending on their garden and requirement of the plant. Early morning and evening are the best time for watering according to the households.

3.3.2 Weeding

Weeding is done randomly rather than routinely. On average weeding is done thrice in a month.

3.3.3 Total time dedicated to gardening

It depends on the size and willingness of the household how much time they spend on the garden. It is found in my study that on average every household spends approximately 30-40 minutes per day for their garden.

3.3.4 Manure

Three types of manure are found to be used by households. They use compost manure,

inorganic fertilizer, and food waste as manure. They are shown in Fig. 7.

3.3.4.1 Compost as manure

Very few people use composting for use in their garden. They use a traditional way of composting. They mix the soil, cow dung, dead leaf, and food and after a few days, they use it as manure. Only 6% of households are found to use composting for manure.

3.3.4.2 Inorganic fertilizer

Inorganic fertilizer is used in little amount by the households. 21% of respondents agreed about using inorganic fertilizer. Some people said they only use "Triple Super Phosphate (TSP)".

3.3.4.3 Food waste

This is used by most of the family which includes mainly vegetable waste, fruit waste, eggshell, tea leaves, etc. Instead of throwing the food waste into dust bin, they use it as manure for their plant. For using eggshell they first make it crushed and those pulverized shells are thrust into the soil.

Fig. 7 indicates that manure used by the household is very environment friendly. Because composting (6%) and food waste (73%) contribute a major portion of their fertilizer content. It is found that instead of throwing out the food waste like vegetable waste, eggshell, tea leaves are used as manure which also reduces the amount of domestic waste as well as ensure environment-friendly fertilizer use. These practices of households found in this study are evidence of environment-friendly green initiatives of an urban household.

3.4 Benefits Getting from the Household Greenery

3.4.1 Overall benefits from the household greenery

Households are getting some direct benefits from their garden. Households opined that they get multifunctional benefits like; environmental, aesthetic, religious, monetary, and recreational benefits.

Fig. 8 shows that 84.9% of respondents opined they get the aesthetic benefit, 49.95% supported about the religious benefit, 97.26% expressed

that they get environmentally benefited, 93% of respondents claimed that they get recreational benefit where only 34.24% people confirmed about monetary benefit.

They believe that greenery is effective in reducing CO2 and surrounding temperature. The Hindu community use flowers like Joba (China rose) in their worship. People use to decorate their houses with different ornamental (like

Money plant, cactus, Patabahar, etc.) and flowering plants where some people said that they love to spend their past time by (Instead of buy) doing different maintenance of the garden and they enjoy it. It found that some households indirectly get the monetary benefit as their produced vegetable and fruits save some money that might be spent to buy from the market and they argued it as a successful aspect of their garden.

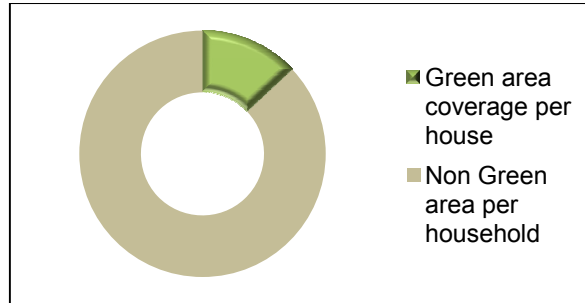


Fig. 2. Average area covered by green space in and around the household

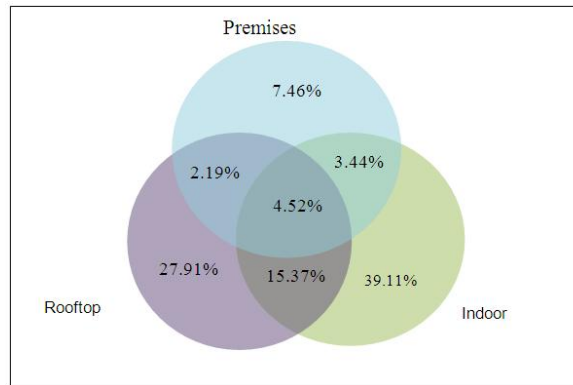


Fig. 3. Percentage distribution of plant keeping in different areas of households of the respondents

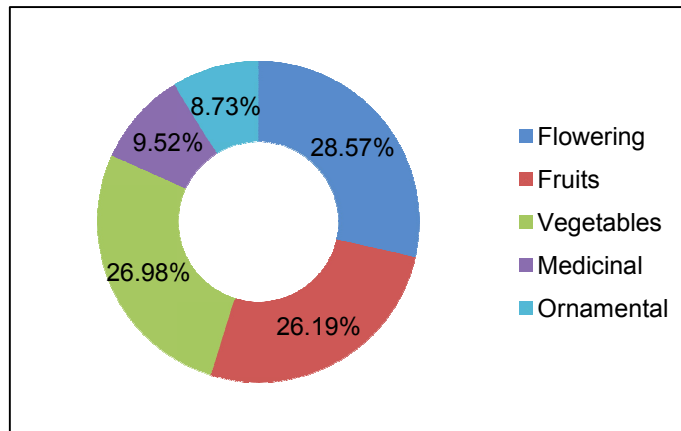


Fig. 4. Species found in the household garden in the chittagong city

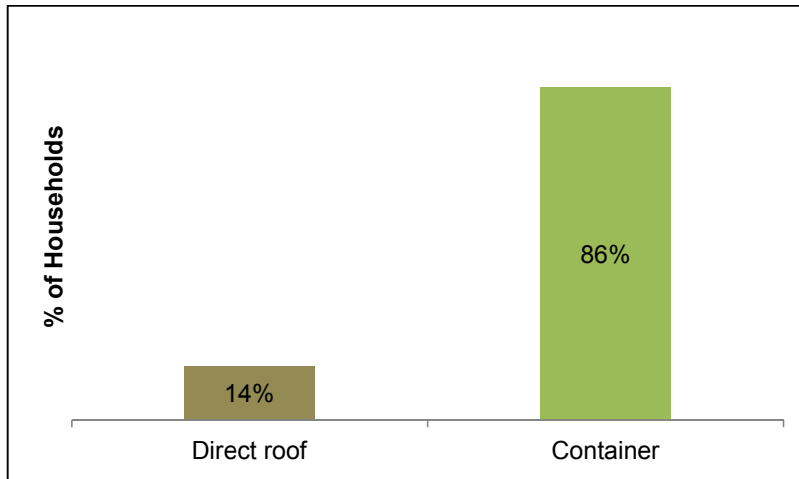


Fig. 5. Base of preparing media for gardening

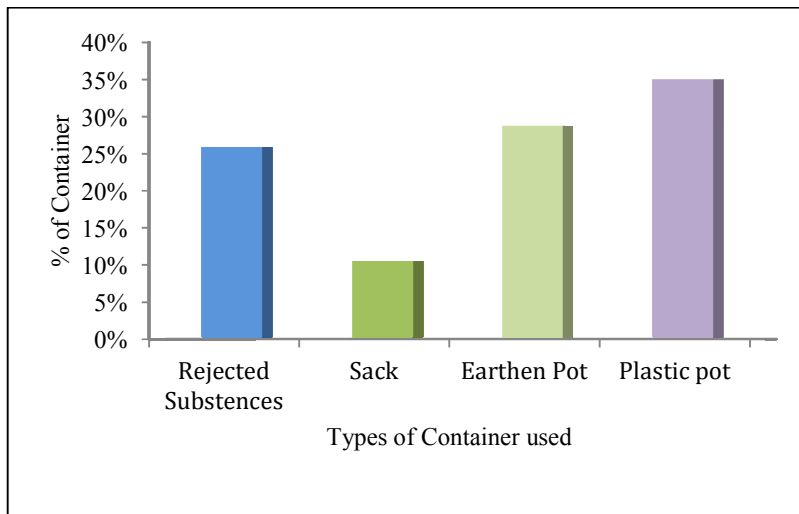


Fig. 6. Percentage of choosing different containers as base of soil media

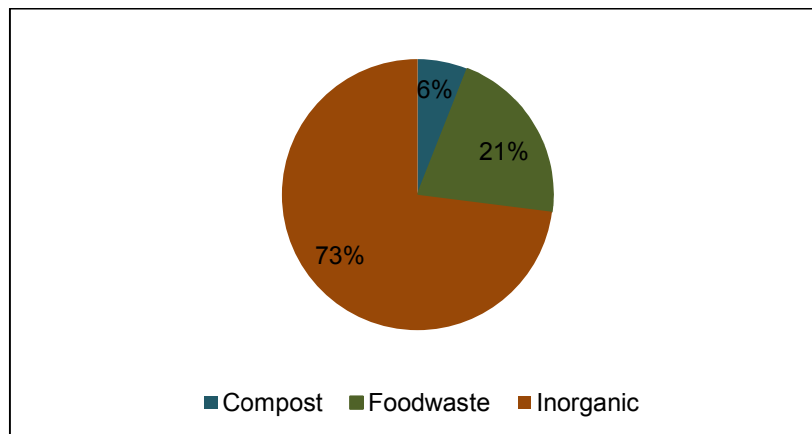


Fig. 7. Percentage of using different manure used by different households in their garden

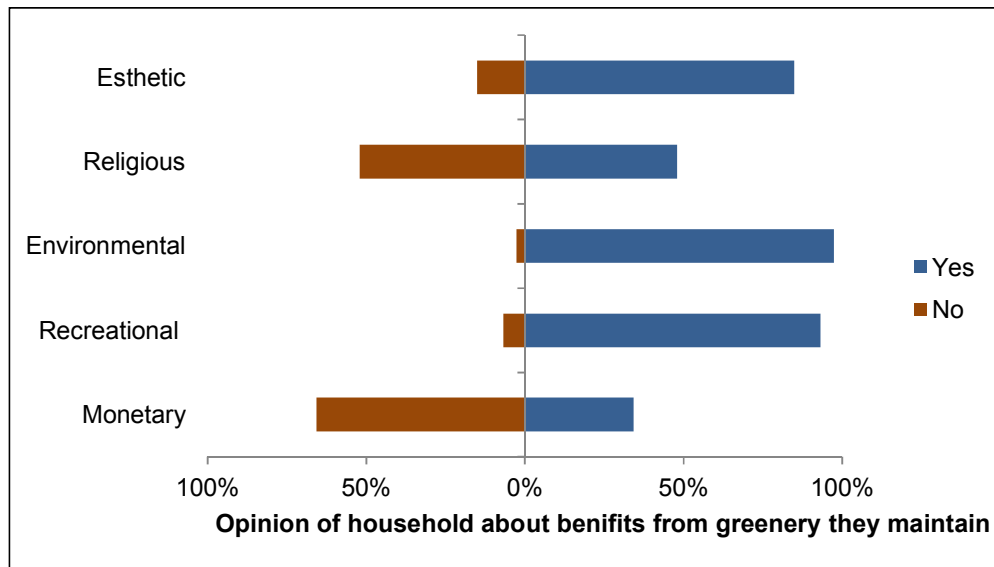


Fig. 8. Opinion of respondents about the benefits from household greenery

3.4.2 Nutritional, medicare, and other benefits from household greenery

They produce different types of fruits in their garden which supply vitamins and nutrients to them. Vegetables and other food items produced in their garden also meet there the requirement of nutrients to some extent. They claimed that they can afford some fresh and chemical-free fruits and vegetables to their family members which prevent them from consuming chemical. The respondent said vegetables and fruits are sometimes mixed with chemicals like formalin, carbide, etc. so they consume their produced vegetable and fruits rather than selling it to others. Again some respondents said that they enjoy distributing some of their produced food and vegetable to their relatives and neighbors. This way a strong social relationship builds up among the community. Furthermore, they also get many Medicare facilities as they plant different medicinal plant like *Ocimum tenuiflorum*, *Justicia adhatoda*, *Azadirachta indica*, *Centella asiatica*, *Asparagus racemosus* etc. in their garden.

4. CONCLUSION

It has been excavated in this study that household people of Chittagong City are interested in urban green infrastructure development. They are developing different green infrastructure in and around their house. At this level, their contribution to urban greenery

development is very appreciating as it is an emerging sector for achieving urban sustainability in Chittagong city. They are getting benefited from those infrastructures which are making them more sustainable in terms of socio-economic and environmental perspective which is acting as a catalyst for achieving urban sustainability. But it is revealed in this study that they do this job in their way, they don't have any specific guidelines for their household greenery development. No doubt, their cognizance, and methods can be the footsteps for developing more 'green infrastructure' at the household level but for establishing sustainable greenery they need some specific guidelines. The whole activity of improving urban household greenery should be more organized. More research should be carried out for finding a more precise method of rooftop gardening, indoor plantation, and periphery vegetation. However, for ensuring sustainable urban household greenery development, everyone has to work together by enhancing inter-sectoral collaboration. As it is still an emerging sector which can contribute greatly to build up a sustainable city by enhancing urban greenery. Household people in Chittagong do it on their cognizance. If more research is carried on a rooftop garden, indoor and periphery vegetation we will be able to find systematic and improved processes of urban greenery development at the household level.

However, some specific steps can improve our rooftop vegetation, indoor and premises greenery

thereafter can enrich our urban green coverage which is a crucial need for Sustainable City Development. Some steps like formulating policy about 'green coverage' to make rooftop garden and vertical greenery mandatory for all household owners and developers, making different social and community organizations of households, owners, and Developer Company for 'Urban Greenery Development'. Encouraging the city people by giving incentives for increasing household-level greenery, popularizing rooftop gardening, indoor and periphery garden by media coverage, emphasizing more specific research to find the improved processes of household-level urban greenery development can be the ways of increasing urban greenery. Mass media coverage can act as a catalyst in developing urban green infrastructure at the household level. Different important aspects and benefits of household greenery development can be promulgated in print media, satellite channels, and other social media. Different documentary on successful urban greenery development can be exhibited in different media. It will make city dwellers more enthusiastic about rooftop gardening, indoor plantation, and periphery garden. Seminar symposiums and workshops can be arranged to make people more interested in urban greenery development. Most importantly emphasis should be given on carrying out analytical, strategic, and specific research to investigate and develop easier, specific, and effective methods of developing a rooftop garden, indoor plantation, and periphery garden.

CONSENT

As Per International Standard or University Standard, Participant's Written Consent Has Been Collected And Preserved By The Author(s).

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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