



Case study

Rooftop Gardening as A Need for Sustainable Urban Farming: A case of Kathmandu, Nepal

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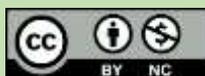
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Abstract

Rooftop gardening is one of the present needs for urban settlement for solving food security problems and promoting sustainable agriculture. To highlight the present status of rooftop gardening in Kathmandu a key informant survey was conducted where 52 respondents were selected where the majority of the rooftop garden maintainers were females (52.8%). All of the respondents have a positive response regarding rooftop gardening and was significant with a year of farming in roofs ($\chi^2=45$, $df=9$, $P\text{-value}=0.000$) and the area covered by rooftop farms range from 5-13%. There was a significant monetary value of the soft benefit from rooftop garden as food production (\$3456.86), air quality (\$11-19), stormwater retention (\$20609), and carbon sequestration (\$6-7) benefits. However, the traditional method was employed to maintain rooftop gardens with planting materials such as plastic bags, pots, and styrofoam carats. Since constraints were recorded in the study area regarding rooftop farming establishment and also is continuing, thus, there should be proper training for the individuals interested in rooftop gardening which enables them to manage and continue their farms more efficiently.

Keywords: Urban Heat Island; Traditional farming; Carbon Sequestration; Stormwater retention; Roof damage

Introduction

Today, more than half of the world's population lives in town or cities. Highly populated urban centers are growing, where undeveloped or green spaces are hard to be found. It can create food scarcity and nature in less environment in town. This is the major issue that humanity is facing in today's time. On the top of shopping malls and buildings there lies a treasure trove of unused and unwanted spaces:

rooftop. And they are the perfect spot for a bit of gardening and making the city green. Simply, Rooftop farming means the practice of growing food on the rooftop of buildings. In urban areas, it is taken as an opening to improve nutrition and food security (UNDP, 1996). Studies of the United Nations show that more and more people are running to colonize citified areas than countrified areas (UN, 2010). It

is estimated that the world urbanization will increase to 69% in 2050, where urban denizens will 86% in the more developed regions and 66% in the less developed regions of the world's population. This disturbs the ecological equilibrium and the relationship between nature and the human being (Deelstra and Girardet, 1999). By installing a green roof, we can achieve environmental, social and economic durability for the buildings in urban cities as it contributes to the mitigation of environmental problems, enhancement of community functions and development of urban food systems (Bay Localize, 2007; Canadian CED Network, 2007; Kisner, 2008; Kortright, 2001; Lim and Kishnani, 2010).

Green roofs can help to eradicate the adverse effects of UHI (Urban Heat Island) in the city and bring the nature back to the urban area and also improve aesthetics and urban psychology, as well as reduce pollutant concentrations and noise (Hui, 2006). The practice of gardening in the rooftop may seem a small step but it is a road toward sustainability and combating the devastation of climate change hazards (Kumar *et al.*, 2019). The microclimate of surroundings can be modified by rooftop farming as it helps to overcome the ecological problems and promotion of the metropolitan food system. Rooftop garden modulates the temperature on the roof as well as the room below the roof garden (Gupta, 2017). The garden in the roof aids in reducing carbon in the atmosphere. It cut off 30% of all CO₂ emissions for heating or cooling the building (Kumar *et al.*, 2019). Also, it can assist urban areas by reducing stormwater management costs. The rainwater is captured through absorption by the vegetation in the garden and minimizes overflowing impact on roads (Ries, 2014). Green roof helps to reduce air pollution by removing particulate matter and pollutant gases like nitrous oxide, sulfur dioxide, and carbon monoxide, in turn, cut off greenhouse gas emissions (Currie, 2008; Heisler, 1985). The main objective of this paper is to

address the people's response towards rooftop farming in Kathmandu and also the different practices adopted for running rooftop gardens and constraints faced by them in establishing and running rooftop garden.

Methodology

Study Area

Jadibuti koteswori lies in the Kathmandu district (province no. 3) which is bounded by the Manohara River in the east and south, the Bagmati river in the west, Madhyapur Thimi municipality of Bhaktapur District in the east and Lalitpur metropolitan city in the south. We had selected Jadibuti, ward no.32 for our study (Table 1.). Jadibuti, koteswori is a highly populated and urbanized area so people are often having an issue with the high price of agricultural products and their poor quality. In spite of no agricultural area available, people are encouraged to enhance rooftop farming traditionally. Though no training nor any kind of seminar was organized to train local people out there from the municipality level, most of the practices of the house rooftop farming distress from their city life. It is quite satisfying to see the roof of city areas full of greenery of some seasonal and off seasonal vegetables, decorative flowers, and fruits.

Research Design and Data Collection

The survey was conducted from 14th February to 10th of March, 2020 in Kathmandu metropolitan municipality ward no.32 jadibuti area from where 52 respondents were selected randomly, and key informant survey (KIS) was conducted. Data were collected using a semi-structured questionnaire that focuses on both the rooftop practitioners and non-practitioners. Pilot testing was done in 10 houses to set the accuracy of the questionnaire, then the survey has proceeded accordingly where the pre-tested houses were not included.

Table 1: Features of the study area

Features	Description	References
Ecological zone	Mid hill	(Climate data, 2012)
Area	4.34 km ² (1.68 sq mi)	(Climate data, 2012)
Altitude	4,600 ft	(Climate data, 2012)
Annual average temperature	18.1 °C 64.5 °F	(Climate data, 2012)
Precipitation (rainfall)	1505 mm	(Climate data, 2012)
Average family size	4	(CBS, 2015)
Literacy rate	86 %	(CBS, 2015)

Data Analysis

Data entry was done by using Ms-Excel (2016) and for descriptive and inferential statistics IBM SPSS V. 20 was used. However, the calculation of soft benefit was done by using the formula suggested by (Tomalty et al., 2010) and cited by (Kumar et al., 2019; Tomalty et al., 2010). The details of the calculation of soft benefits are as follows:

Food production value (b)= $P \times g \times a$

Where p=productivity (\$2 per square meter per month and for lettuces, herbs, and flowers (high case scenario) \$20 per square meter per month)

g= duration of growing; as crops were grown all the year so it is taken as 12 months

a= area of the roof covered by a garden in M^2

Strom water retention (b)= $(R+E) \times C \times a$

R= retention basin, \$20.13 for pond and highest value 1059.44/ m^3

E= Value of erosion mitigation i.e. \$13.66/ m^3

C= retention capacity, \$42.7/ m^2

a= area of rooftop garden in m^2

Air Quality (b)= $(g / \text{months}) [H_{sg} \times a_{sg} + H_{tg} \times a_{tg} + H_d \times a_d]$

Where,

H_{sg} , H_{tg} , H_d represents the health benefit for short grass pollution absorption (0.0521 US\$/ m^2), for tall herbaceous plant pollution absorption (0.0673 US\$/ m^2), and for deciduous plant pollution absorption (0.0839 US\$/ m^2) per year respectively.

a_{sg} = area covered by short grasses

a_{tg} = area covered by tall herbaceous cops

a_d = area covered by deciduous plants

Carbon Sequestration Value (b)= $S_d \times a_d + S_g \times a_g + S_f \times a_f$

Where, S_d , S_g , and S_f represents the value of carbon sequestration by deciduous plants (\$39.11/ha.), by grasses (\$28.46/ha), and by productive agriculture (\$28.59/ha),

a_d = area covered by deciduous crops

a_g = area covered by grasses

a_f = area covered by productive agriculture

Result and Discussions

Primary Information

During the survey, 28(52.8%) were female and 24(45.3%) were males aged between 17-61 (36.06 ± 1.689). As female members were actively involved in rooftop gardening, female frequency exceeds male. Among those respondents, Bhramin was more i.e. 43.4% followed by Chettri 30.2%, Newar 20.8%, and Janajatis 3.8%. The findings show that

more male members (69.8%) had land ownership comparison to female members (28.3%). Mostly the respondents were involved in the business (35.8%) followed by serviceman (30.2%), farmer (17%), and few (15%) were engaged in other occupations. The average size of family members in the study area was 4.41 ± 0.13 . the average size of the building of the surveyed respondents was 4.20 storied and the area of the roof was $331.56 \pm 18.62 m^2$.

Peoples Response Towards Rooftop Farming and The Size of The Rooftop Garden

Among the surveyed respondents 45 of them have a positive response towards rooftop gardening are also practicing it but remaining 7 respondents thought have a positive response towards rooftop gardening but are not practicing it due to the various constraints faced by them in an establishment like lack of proper knowledge and smaller size of a roof which is required for other various purposes. The range of continuing rooftop farming was 1-9 years and significant with having rooftop farm ($\chi^2 = 45$, $df = 9$, $P\text{-value} = 0.000$ and Cramers' $V = 1.00$ at $P\text{-value} = 0.000$).

Among the rooftop practitioners, about 7.03% of the roof was covered by gardens which vary from 5-13% of the coverage of roofs by gardens in the study area. The satisfaction gained from rooftop practitioners was appreciatively high because of the supply of fresh, healthy, and pesticide-free organic products from their garden. Also, the cost of vegetable requirement is being reduced by the supply of vegetables though not confined to nil. The observation on people's response was similar to the finding of Thapa et al. (2020) in Dhulikhel and Kumar et al. (2019) in Pokhara. They also observed the reduction in cost due to rooftop gardening and are also encouraging their neighbors and amigos for establishing rooftop gardening.

Soft Benefit Calculation

The monetary benefits acquired from rooftop gardening are calculated on a monetary basis as suggested by (Tomalty et al., 2010).

The utilization of green roofs should be promoted in an urban setting as it promotes the ecosystem services and has a huge impact on solving food security problems. The production of daily table requirements is possible in the rooftop garden. Through the measure of area and season of vegetables, food production benefit is calculated in monetary values within the study area. The food production value ranges from \$592- \$5923 i.e \$592 is for low case scenario of mixed fruits and vegetables and \$5923 for high case scenarios like ornamental plants, lettuce. Since the arrangement of crops includes fruits, vegetables, flowers, and lettuces too, so the value lies somewhere between \$3456.86. the findings on the food production value in Kathmandu is higher than that of Pokhara (Kumar et al., 2019). this is due to the production of more diverse and

high-value crops in Kathmandu. The Storm water retention value in the study area was found to be ranging from \$467-\$20609. As the study area is a dense and highly populated urban area where low-cost stormwater management seems to be impossible. Thus, the values lie to the upper range somewhere to \$20609. Also, air quality and carbon sequestration contribute to the good ecosystem services in rooftop gardening whose monetary values were found to be \$11-19 and \$6-7 respectively. Still, the values of air quality and carbon sequestration should be expressed in terms of the whole area but for an easy evaluation of the share of each house, we have presented an average value as done by (Kumar et al., 2019) for each house of the study area. The findings were slightly higher than that of (Kumar et al., 2019) due to the greater size of roofs and many more combinations of crops including high-value crops in the study area. However, the findings were slightly lower than that of (Safayet et al., 2017) as compared with the case of Bangladesh. The details of the calculation both in Nepali currency (Rs.) and dollar (\$) is shown in Table 2.

Planting Material Used in The Study Area

For the cultivation management of rooftop farming, different kinds of planting materials are used. Mostly, unwanted or recycled products are used which help in the re-use of wastage and locally available materials. According to the survey, most of the respondents generally used plastic bags (N=45) and earthen pots (N=45) followed by bottles and cans (N=38), waste bags (N=35), Styrofoam crates (N=31), plastic pots (N=23). The use of planting materials for rooftop farming is represented in Fig. 1. The use of recyclable materials and waste bags has been used as planting material in Bologna Italy which includes plastic bags, styrofoam crates, pots, and floating tanks (Sanyé-Mengual et al., 2015). However, in the modernized green roof, planting materials are limited by modern hydroponics setup and other advancements for rooftop gardening (URBES, 2014) but due to the high cost of establishment and maintenance, they are lacking in the study area.

Table 2: Calculation of Soft Benefits

Benefits	USD value (\$)	Nrs value (Rs.)
Food production	5923- 59230	716146.38- 7161463.8
Strom water retention	467- 20609	56464.69- 2491821.82
Air quality	11-19	1330- 2297.28
Carbon sequestration	6-7	725.46- 846.37

1 USD= Rs. 120.91 (Calculated On 11 MAY 2020)

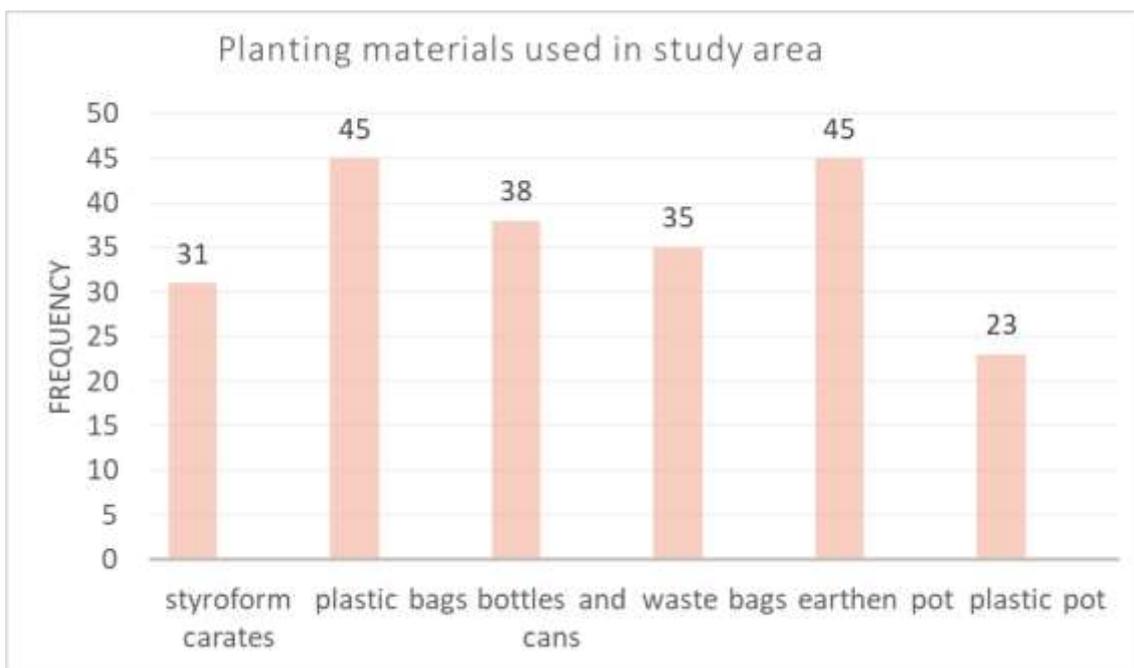


Fig. 1: Planting Materials Used in the Study Area

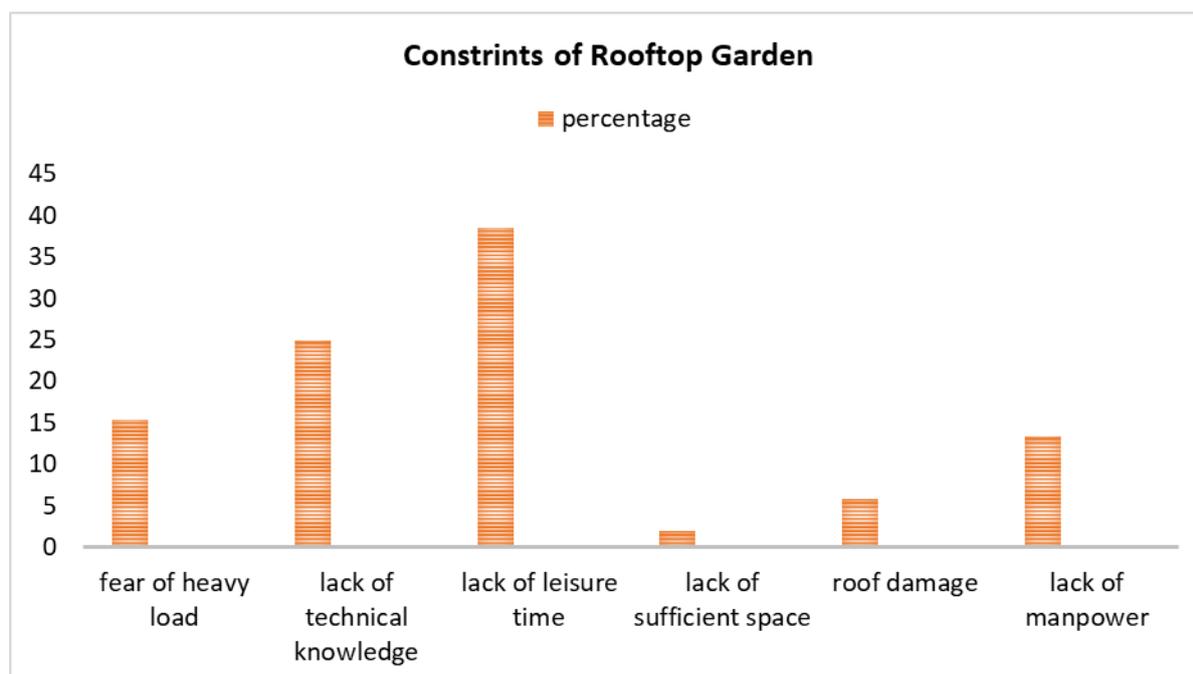


Fig. 2: Constraints of Rooftop Gardening

Constraints of Rooftop Gardening

During the survey, 45 respondents have accessibility for the rooftop gardening and people are engaged in it. So, to know the reason for respondents why they do not have rooftop farming and some of the other related problems of rooftop farming for rooftop farmers. The majority of the farmers facing problems for the feasible farming because of lack of leisure time (38.5%), likewise due to lack of technical knowledge (35%), fear of heavy load on their roof (15.4%), lack of manpower (13.4%), roof damage (5.8%), and lack of sufficient space (1.9%). The constraints regarding this gardening are represented in Fig. 2. the constraints for rooftop farming has been reported by Kumar et al. (2019) in Pokhara, Thapa et al. (2020) in Dhulikhel and Safayet et al. (2017) in Bangladesh which was similar to the constraints associated in our study area but much of their involved respondents were non-rooftop practitioners.

Conclusion

Rooftop gardening is not only the source of fresh fruits and vegetables but also provides in-depth ecosystem services and promotes the sustainability of urban areas. They have significant importance and share on monetary benefits acquired from soft benefits such as food production, stormwater retention, air quality, and carbon sequestration benefits. The respondents of the study area also revealed that the lack of technical knowledge and fear of roof damage by soils and water is one of the limiting factors for continuing and extending the rooftop garden. However, the experience of rooftop gardening was a significant factor to have and continue the gardening. Regarding all of the pros and cons, an effective strategy for promoting green roofs in the dense urban area should be promoted because they have a huge impact on the ecosystem and urban sustainability.

Government planning and priorities should focus on urban agriculture by promoting rooftop gardening and farming.

Authors' Contribution

Sandesh Thapa & Rakshya Bhandari designed the research plan; Sandesh Thapa, Anjal Nainabasti & Sashila Acharya performed experimental works & collected the required data. Sandesh Thapa & Neha Rai analysed the data; all authors jointly prepared the manuscript & critical revised and finalized the manuscript. Final form of manuscript was approved by all authors.

Conflict of Interest

The authors declare that there is no conflict of interest with present publication.

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