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**Corresponding Author**

Ramyajit Mondal  
e-mail: ramyajitmondal93@gmail.com

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## Author's Address

<sup>1</sup>Institute of Agriculture, Visva-Bharati, Sriniketan, West Bengal (731 236), India

<sup>2</sup>Dept. of Agronomy, Faculty of Agriculture, Bidhan Chandra Krishi Vishwavidyalaya, Mohanpur, Nadia, West Bengal (741 252), India

# Rooftop Farming – An Overview

Udit Debangshi<sup>1</sup> and Ramyajit Mondal<sup>2\*</sup>

## Abstract

The land has become an expensive unit in India due to its diversion following urbanization, industrialization etc. Further, migration and settlement of rural people in urban areas has been increasing at an alarming rate. It is estimated that, in India, 40.76% of the population is expected to reside in urban areas by 2030. Thus, it is going to increase pressure on natural resources and production volume in the rural areas due to increasing demand for food in urban areas. The cultivated land in urban areas is already limited. Hence, the rooftop area available on the urban households/government and non-government offices can be exploited to produce various crops. This Greener rooftop is a like a psychological relief centre, which makes households stress-free. This environmentally and economically sustainable method to promote food security, food quality and reduce the carbon foot-prints, has emerged as a viable option in the recent years.

## 1. Introduction

India has nearly 46 million-plus cities, with Mumbai, Delhi and Kolkata having populations over 10 million. There are 54 urban agglomerations in India with a population of one million or more according to 2011 census against 35 in 2001 (www.censusindia.gov.in). So, urbanisation has become a common phenomenon in India. Further, it is going to increase at an incremental rate. Thus, we are losing our agricultural land every hour and the population is growing by leaps and bounds and also no. of buildings simultaneously. It means we will have less horizontal land to grow food and as a consequence, the problem of food supply in terms of quantity, quality and affordability, will be high amongst the citizens as more mouths to be fed than produces. This alarming situation poses a greater challenge for our future generations. To cope up with this situation, we have to increase the productivity per unit area. So, rooftop farming is found to be a viable option.

## 2. Benefits of Rooftop Farming

### 2.1. Shortage of cultivated land

In view of less scope for horizontal expansion, vertical farming (e.g., rooftop farming) is the most practical solution for any developing

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city that is facing land scarcity ([www.housing.com](http://www.housing.com)). In India, the reports by UN state of the world population 2007, by 2030, 40.76% of country's population is expected to settle in urban areas ([www.worldwidejournals.com](http://www.worldwidejournals.com)). So, exploitation of vertical farming is the only way in urban areas.



**Figure 1: Vertical farming in urban areas**

### 2.2. Food quality

The primary reason for which urban rooftop farming is required in India is the child and adult malnutrition. According to 'The State of Food Security and Nutrition in the World, 2020' report, 14% of India's population (189.2 million) are undernourished and 34.7% of the children aged under five are stunted, in India. The products grown on rooftops with minimal usage of synthetic chemicals will be highly competitive in terms of price, freshness and quality. Farming within the buildings supply fresh food which avoid transport problems too ([www.agrifarming.in](http://www.agrifarming.in)).

### 2.3. Economic benefit

In rooftop a wide variety of fruits and vegetables can be grown, which are more fresh and healthier than canned and packed foods, by selling the goods which may leads to conversion of your own roof tops into profit-making garden.

### 2.4. Conservation of environment

A sustainable city is the city which meets the needs of the present generation without sacrificing the resource base for the future generations. Within the context of city-scale ecosystems, isolated patches of urban green space, including urban agriculture and green roofs, can be hotspots for biodiversity (Williams et al., 2014). Declining wildlife populations in farmland and rural areas due to pesticide use increased the importance of cities

as wildlife refuge, while organic cultivation in rooftop farming can increase plant, insect, and bird habitat in densely built environments and contribute to urban corridor networks (Gilbert, 1989). Rooftop farming make cities more eco-friendly. It can play a significant role in urban environmental management and enhance the deteriorating quality of This increases energy usage and contributes to the poor air quality that often plagues big cities. A green roof helps to improve the overall air quality. According to a study, green roofs help reduce up to, 37% of sulphur dioxide, 21% of nitrous acid, 0.2kg of dust particles / square metre each year. Rooftop farming can reduce the temperature of roofs and the surrounding air that contribute to overall cooling a local climate and can help reduce urban heat island effect (Hui, 2011). Thus, rooftop farming can also reduce the environmental impact of food transportation.

### 2.5. Climatic hazards

In India, more than 60% of total food production is monsoon dependent. But, the severity of climatic hazards such as drought, storm and winds, is low under rooftop farming than conventional farming.

### 2.6. Carbon foot-print

The 20th century, has seen a rapid rise in global temperatures, which could be due to rise in carbon dioxide and other greenhouse gases released from the burning of fossil fuels, deforestation, agriculture and other industrial processes. This phenomenon is called as 'enhanced greenhouse effect' ([www.nrcs.usda.gov](http://www.nrcs.usda.gov)). Employing vegetation in highly populated areas can act as a carbon capture and storage system. Rooftop farming on an urban fringe could potentially reduce greenhouse gas emissions thus mitigates climate change. As rooftop farming depends less on the chemicals and also avoids transportation problems, it reduces the carbon foot-print.

### 2.7. Year around production

The rooftop farming can be a solution to achieve year-round production with limited water, nutrition and climatic intervention, to meet the needs of growing urban population.

### 2.8. Psychological relief

Research has shown a positive relationship between the amount of green space in the living environment and physical and mental health and longevity; leading to stress reduction and attention restoration, healthy behaviour and social integration. The rooftop farming is a creative way to alleviate stress, anxiety and depression. Studies have also found that exposure to nature and vegetation



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provides an array of psychological benefits including improvement in mindfulness, decreased anxiety and increased productivity of our daily life.



Figure 2: Psychological relief in rooftop

### 3. Factors Influencing Rooftop Farming

The following factors will influence the rooftop farming-

#### 3.1. Site selection

Site used for rooftop farming requires a vacant and open roof space, better sunlight, irrigation water facility, pleasant wind etc. But, if the roof is too small, it restricts the gardening, community gathering, physical exercise or indoor games etc. On the other hand, if the roof is large, then opportunity cost of gardening is high. When rooftop is accessible to all and particularly when this is a community garden, rooftop of different buildings can be interconnected by constructor. Some buildings are not designed to withstand the additional weight of rooftop garden. So, an architect can be involved for its effective utilization. Sometimes we can't use the whole space of the roof to plant trees due to the unequal sunlight, wind distribution, so it is better to plant trees where there is more sun-light and less wind speed.



Figure 3: Aerial view of rooftop land use

#### 3.2. Intense sunlight

Rooftop garden are exposed to more intense sunlight than ground level due to its height which may be sometimes dangerous for growing saplings, so use some light shading materials or netting or a shady wall to protect the crop from sunlight. After the, the plants can tolerate the intense light, once they cross the seedling stage and the solar radiation helps is photosynthesis and produce more dry matter.

#### 3.3. Managing the strong wind

The rooftop farming is susceptible to high windy condition. A light breeze ( $3-4 \text{ km hour}^{-1}$ ) is pleasant as it increases the photosynthesis by continuously replacing the carbon around the leaf and reducing the stomatal resistance. However, a strong wind (greater the  $15-20 \text{ km hour}^{-1}$ .) can seriously damage the plant. Thus, wind breaks like walls, canvases, net or light cloths can be used for this purpose. The saplings can be placed around the roof wall which protects from wind.



Figure 4: Light cloth wind break

#### 3.4. Soil management

Well drained loamy soil with high organic matter, which can improve the soil physical, chemical as well as biological properties and sustain the production has to be used. Mix the soil with FYM and sand with 1:1:1 ratio (clay: sand: FYM=1:1:1). The waste produced from roof top garden can be recycled and reused as organic fertilizer for the soil. Sometimes, due to intense sunlight, the moisture from soil gets evaporated. Hence, mulch material like degradable plastic mulch or straw mulch of rice, maize, wheat etc., Can be used.

#### 3.5. Water management

Water management is very important in rooftop farming. Access of municipal water is necessary. The rain water harvesting structures can be constructed. The residents

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on the floor immediately below the roof are often worried about seepage, which can be reduced by surface drainage and daily check-up. Getting the rooftop professionally waterproofed is a must. Pipe watering or some time hand sprinkler or drip irrigation can be adopted to minimise water loss. Drainage of planters is very important and placing the planters on brick stands can be practised.



**Figure 5: A beautiful aerial view rooftop**

### 3.6. Pest management

The rooftop gardens suffer less pest incidence due to better sunlight and care. The pests can be taken care of by some common deterrents like chilli and garlic decoctions, neem oil infused with common detergent and marigold petals. Use natural trap (okra, alfalfa, castor bean) and repellent crop (basil, garlic, onion) or biopesticide like TAGLIFE (*Trichoderma viride*), VAM (*Glomus mosseae*), AZOPHOS (*Azotobacter*) TAGMONUS (*Pseudomonas fluorescense*), MARGOSA (*Azadirachtin*).

### 3.7. Rooftop way

Rooftop way is the way by which you can easily reach the rooftop garden. There should be official access to the roof by stairway or elevator to make the garden available to everyone and an electrical source is very much practical. Some hanging plants in rooftop's way make an immense attraction towards the garden.



**Figure 6: Rooftop way**

### 3.8. Harvesting

In rooftop farming, the hand tools like small sickle, small axe, cutter, blade etc. are enough. After harvesting, the food materials should be washed properly with clean water and store it or use it as consumption. For long term storage purpose, "PUSA Farm Sun Fridge" is an innovative, off-grid, battery less, cold storage facility for perishables that uses a combination of evaporative cooling and solar refrigeration to store harvested farm products on rooftop or nearer to the buildings without electrical connection can suit well.

## 4. Selection of Plants for Rooftop Farming

The choice of crops to be grown depends on the feasibility and market study; demand, and ability to withstand environmental and climatic adversities. Eg. fruit trees, leafy greens, flowers and vegetables. These grow well in pots, grow-bags and even plastic drums.



**Figure 7: Growing leafy green plants**

### 4.1. Seasonal vegetables

Vegetables such as beans, brinjals, tomatoes, carrots, broccoli, garlic, green peas, okra (*bhindi*), sponge gourd, ridge gourd, snake gourd, bitter gourd and bottle gourd, can be successfully grown. It is always good to grow them on the southern or western side of the roof, so that, plants will have enough sun light and can thrive well.

### 4.2. Small fruit trees

These are to be planted in plastic drums (minimum 100-litre capacity) or the largest available grow-bags. The trees that can be grown in this way include sapota, guava, apple, citrus fruit such as orange, lime, soursop (*Hanuman phal*), Indian gooseberry (dwarf *amla*), bananas.



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**Figure 8: Small tree saplings in bags**

### 4.2. Leafy green plants

Sweet potatoes, lettuce, spinach, potatoes, coriander, turmeric and ginger can be grown in separate plastic-bags or pots that are deep enough to cater for tubers.

### 4.3. Hanging plants

The vertical space on roof wall has to be utilized efficiently. The vegetable shrubs and vines such as beans, gourds and tall tomato varieties can be planted near the walls and railings. Reason to grow flowers in your vegetable garden is to attract native bees and other beneficial insects. Flowers such as bougainvillea, jasmine, hibiscus, sunflower, tulips, lavender, rose, oleander etc can be grown in planters.



**Figure 9: Hanging plants in rooftop**



**Figure 10: Growing flowers in rooftop**

## 5. Cost Estimation in a Rooftop Farming Model

Initial cost of rooftop farming is high. But it will be compensated by the benefit. In general, the cost of cultivation will be around Rs. 10,000 to 15,000 per roof area of 500 sq ft. The benefit will be up to Rs. 1.0 lakh ([www.urbanmali.com](http://www.urbanmali.com)).

## 6. Limitation of Rooftop Farming

- o High initial cost.
- o Sometime insurance companies may charge a higher premium than they would to cover the same building without a roof garden.
- o Roof gardens require more maintenance e.g., Replacing the growing media and frequent watering etc.
- o The structure and weight of a roof garden can cause problems for the overall building. The roof weight may increase by as much as 30–950 kg per square meter for roof gardens depending on depth of soil, when saturated by heavy rain. Most building roofs require proper reinforcement. High roof gardens may have problems with high winds damaging plants and young seedling.
- o In order to repair a leaking roof garden, it will require removing multiple layers to get down to the bottom waterproof layer.

## 7. Conclusion

The rooftop farming has an immense scope with high range of diversity to meet the food security in urban areas. If government and other responsible organizations step forward to encourage the practice of rooftop farming, a sustainable green and smart city can be built by ensuring food supply. It also helps to meet the demand of fresh and hygienic foods and creates healthy atmosphere by improving air quality which lessening the impact of climate change. This farming is a better option for promoting organic production of vegetables.

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