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Research Article

BALCONY AND TERRACE GARDENS IN URBAN GREENING AND LOCAL FOOD PRODUCTION: SCENARIOS FROM MUMBAI METROPOLITAN REGION (MMR), INDIA

***Prem Jose Vazhacharickal**
Department of Biotechnology, Mar Augusthinose College, Ramapuram, Kerala, India
**Author for Correspondence*

ABSTRACT
The Millennium Development Goals (MGDs) recognized the role of urban and peri-urban agriculture (UPA) in reducing urban poverty and ensuring environmental sustainability. Mumbai Metropolitan Region is a fastest growing region in India with a population of 21 million. The rapid urbanization and high proportion of people below the poverty line along with higher migration to MMR makes the region vulnerable to food crisis. This paper focuses on the current situation of balcony gardens and terrace gardens in MMR with special attention towards their contribution in ecosystem service. An overview about the various concepts of city farming was also presented in the paper. The question about various technical non feasibility of these production systems was also mentioned. Based on primary and secondary data, this paper attempts to confirm that UPA is one of the best options to address increasing urban food demand and can serve to complement rural supply chains and reduce ecological food prints in India. City farming should be planned and incorporated into the city architecture for the better sustainability and resiliencies especially in MMR.

Keywords: *Balcony garden; Urban heat island; Urban and peri-urban agriculture; Terrace garden*

INTRODUCTION
Rapid population growth and migration towards urban areas increased the city dwellers' demand for food, shelter, water and basic necessities (Cohen, 2006). Since 2010, for the first time in human history, more than 50% of the global population lives in urban areas and it is well known that uncontrolled urbanization can lead to poverty, malnutrition, social insecurity and unemployment (Kundu, 2007; Van Veenhuizen and Danso, 2007; Tacoli, 2012). In many developing countries, growing poverty, lack of formal employment opportunities, hunger, demand of food produce, proximity to markets and the availability of cheap resources including organic wastes and wastewater in cities have spurred the development of urban and peri-urban agriculture (UPA). "Urban and peri-urban agriculture can be broadly defined as the production, processing and distribution of foodstuff from crop and animal production, fish, ornamental and flowers within and around urban areas" (Mougot, 2000). The contribution of UPA towards livelihood strategies, waste recycling, employment, income generation and food security (Figure 1) of the urban poor especially in developing countries has often been stressed (Ezedinma and Chukuezi, 1999; Ruel *et al.*, 1999; Yasmeen, 2001; Cofie *et al.*, 2003; Obuobie *et al.*, 2006; Hill *et al.*, 2007; Graefe *et al.*, 2008; Sinha, 2009). In South Asia, more than 11 million urban inhabitants are involved in UPA activities and worldwide over 200 million urban inhabitants contribute 15 to 20% of the global food production (Armar-Klemesu, 2000).
India is the biggest democratic nation with a population of 1.23 billion where one third of the poor still lives below the poverty line of 1 US$ per day (Datt and Ravallion, 2002; Deaton and Dreze, 2002; Census India, 2011). The current growth rate and genie coefficient and multidimensional poverty index of India is 4.0, 36.8 and 0.28 respectively (Krueger, 2008; Panagariya, 2008). In 1950, it was estimated that more than 70% of the total population lives in rural areas and agriculture contributes 56% of the Gross domestic product (GDP). India's rate of urbanization is estimated to be about 3.5% per annum. The projection is that by 2020, about 50% of the total population of India will live in urban areas. Population explosion and migration of people towards urban area demands more pressure on food, shelter, water and basic necessities (Cohen, 2006).

The problem of urban heat island (UHI) due to the lack of greenery as well as high density of buildings is the main problem of many urban cities (Hui, 2011). The heat island intensity can make a difference up to 10 °C temperature difference regarding the rural area and can sustainably increase energy use as well as production of anthropogenic heat (Oiu *et al.,* 2013). Urban vegetation moderate air temperature through shading, absorption and cooling effect due to evapotranspiration (Katayama *et al.,* 1993; McPherson *et al.,* 1994; Avissar, 1996; Dimoudi and Nikolopoulou, 2003; Wong *et al.,* 2003; Shashua-Bar *et al.,* 2009). Urban agriculture in the form of roof garden, balcony garden, community garden contribute to the increase in evapotranspiration reduce air temperature in urban areas and mitigate urban heat island (Saiz *et al.,* 2006; Shashua-Bar *et al.,* 2009; Figure 2).

The innovative form of this green urban architecture often defined as "ZFarming" (Zero-acreage farming) synergies between agriculture and buildings makes a small scale resource saving system (Specht *et al.,* 2013). Urban agriculture can act as a solution for climate change adaption (Specht *et al.,* 2013), reducing urban energy footprint (Oberndorfer *et al.,* 2007; De Zeeuw, 2011) and reduce pressure on agricultural land (Specht *et al.,* 2013). Knowledge of UPA production systems based on balconies and terraces of urban centres in India are still scarce. The main objectives of the study were (1) to characterize the different balcony and terrace gardens in MMR (2) to study their role in local food production and urban greening.

MATERIALS AND METHODS

Study Area

Mumbai ($18^{o}53'$ - $19^{o}04'$ N and $77^{o}48'$- $77^{o}53'$ E), formerly known as Bombay has a population of 21 million in 2009, thus becoming the second largest urban agglomeration in India (Census India, 2011; United Nations, 2012). Mumbai Metropolitan Region (MMR) covers 4,355 km^2 with a population density of 4,065 per km^2 (Figure 3). The temperature varies between 28 and 37 ^{o}C during hot months and from 16 to 25 ^{o}C during cold months (Gowda *et al.,* 2008; Shankar, 2008).

Study Approach

The methodology used in this paper was based on primary and secondary data from various sources. I collected different research articles and books from multiple academic databases. Thus, this paper built partially on my own research work as well as on a literature survey.

RESULTS AND DISCUSSION

In the following, the potentials, types and advantages of urban farming in MMR were presented. The results are mainly based on three dimensions of sustainability especially social, environment and economical.

History

The history of terrace garden in Mumbai start with the Doshi's invention of urban farming in Bandra. The concept was experimented and developed by Dr. Ramesh T. Doshi who started 111 m^2 terrace garden in Banda. The idea was to provide the vegetables sufficient throughout the year and making the household self-sufficient. With his new innovation, city farming can be possible on open space which receives ample sunlight, with organic wastes, bagasse (sugarcane debris), minimal soil and water requirements. Used drums with holes or plastic sacks can be used for this, and organic wastes can be daily deposited into it (Anonymous, 2014).

This idea support the family with nutrition, reduce the purchase of vegetables from the market and use of local grown for home consumption. Dr. Doshi's innovative practices were adopted by lot people and NGO's in Mumbai. Due to limited land and space in cities, where plants are grown in containers or cylinders with limited soil to support the root zone of the plant. He used High Density Poly Ethylene (HDPE) bags usually cement or fertilizer bags with a diameter and length of 9 inch each for vegetables. In the case of fruit trees bigger bags were used (18 to 24 inch) where the two sides are open. The base of the sacks was filled with sugarcane residues, which holds the soils and allows water to drain. The base layer

is filled by compost layer and layer of soil above it based on the calculation of 20 to 40 liters of soil per m^2 of area.

Terrace Gardens and Balcony Gardens

Green roof tops with living vegetation provide green spaces, mitigation urban heat island, energy conservation, improving the air quality and increases biodiversity (Getter and Rowe, 2006; Snodgrass and Snodgrass, 2006; Luckett, 2009).

Balcony and terrace gardens give pleasure to city dwellers and provide an opportunity for enhancing creativity as well psychological benefits (Figure 4). In addition, they change the visual appearance of the building, screening from neighbors, and conceal unwanted pipeline and unappealing scenery (Green, 2004).

Terrace and balcony gardens are highly popular in urban middle and upper class families in MMR and were found as a sort of leisure activity for some people. Suspicion about the quality of vegetables available in urban markets and recycling of household waste is the main motivation for these farming (Vazhacharickal and Buerkert, 2011).

Major city gardens in Mumbai includes Dr. Doshi's garden (Bandra), Rosary high school (Dockyard road), Mumbai Port Trust (Victoria Dock), Mahim natural park (Mahim), Marathi Vidnyan Parishad (Sion), Nana Nany park (Chowpatty).

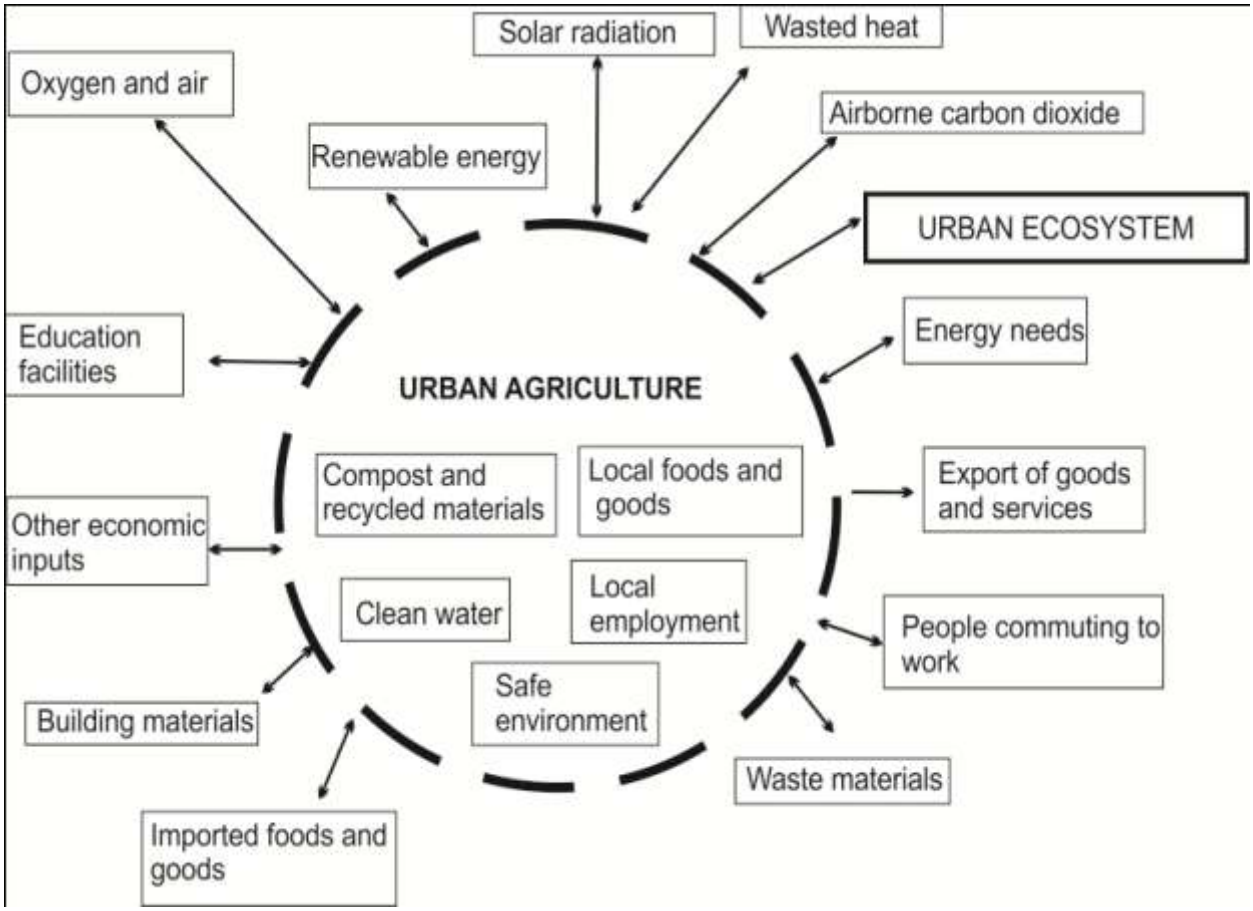

Figure 1: Interaction of urban agriculture with various components (modified after; Barton, 2000; Onyango, 2010)

Table 1: Major Terrace garden across the Mumbai Metropolitan Region and their details

Name	Year of establishment	Area (m^2)	Crops	Description
Dr. Doshi's garden	N.A*	111	Fruits, vegetables, flowers	Terrace garden
Rosary high school	2004	37	Fruits, vegetables, flowers	Garden for children
Mumbai Port Trust	2002	278	Fruits, vegetables, flowers	Central kitchen garden
Mahim natural park	2009	37	Fruits, vegetables	Community farm
Nana Nany park	2010	N.A*	Fruits, vegetables	Community farm
Marathi Vidnyan Parishad	N.A*	60	Fruits, vegetables, flowers	Demonstration garden

** Not available*

Actors Involved

The major actors involved in city farming and community farming initiatives in MMR involves Marathi Vidnyan Parishad, Urban leaves, Mumbai port trust and Vidya Vaaridhi Trust (Figure 5). These actors give advice in setting up urban farms, terrace gardens, kitchen gardens, training of community and school children and practical demonstrations. Some actors have connections with Kitchen Gardeners International (USA) to have sophisticated planning especially with KGI Gardener Planner (Figure 8).

Preparation of Amrut Jal and Amrut Mitti

The preparation of Amrut Jal (fermented solution), 1 liter of cow dung, 1 liter of cow urine, 50 g black jiggery were mixed in 10 liters of water and kept for 3 days. The mixture is stirred 2 to 3 times in day, both clock and anti-clock wise. The final solution can be diluted to 1:10 times with water. For Amrut Mitti (fermented slurry), topsoil from shades were taken and mixed with green biomass which was dried previously. Before mixing, the dried green biomasses were soaked in Amrut Jal for 24 h. Now soaked biomass and top soil were spread one above the other and Amrut Jal was sprinkled to moist the topsoil. Likewise 15 to 20 layers were made. Every 7 days, the heaps were tilled and sprinkled with Amrut Jal, the Amrut Mitti will be ready in 30 days (Figure 6).

Building Materials

The building materials for balcony and terrace gardens includes Metal and plastic drums, Plastic sacks, grow bags, Plastic and earthen pots, basins, bricks etc (Figure 7). The building materials have adequate pores for the aeration and free flow of water during irrigation. In the case of bricks, they can be placed one above another to desired height and later filled soil and biomass. A tarpaulin sheet can be spread before to avoid the problem of algae at the base of the drum or bed, but not necessary.

Plants

The plants popular among city farming in MMR includes fruits, ornamental plants and vegetables. Criteria for the selection of plants depend on the creativity of the farmers, aesthetic appeal, plant characteristics, longer span, disease and pest resistance (Getter and Rowe, 2006). The plants should also posse's easy propagation, rapid establishment, high ground cover density and tolerant to extreme climatic conditions.

Table 2: Major vegetables produced in various Balcony garden and Terrace garden across the Mumbai Metropolitan Region

Common name (English)	Local name (Hindi)	Botanical name
Okra	Bhindi	*Abelmoschus esculentus* L
Snake gourd	Chichonda	*Trichosanthes anguina* L
Eggplant	Baingan	*Solanum melongena* L
Spinach	Palak	*Spinacia oleracea* L
Red amaranth	Lal Maat	*Amaranthus cruentus* L
Fenugreek	Methi	*Trigonella foenum-graecum* L
Bitter gourd	Karela	*Momordica charantia* Descourt
Green amaranth	Chawli	*Amaranthus tritis* L
Taro	Alu	*Colocasia esculenta* L
Cluster bean	Gawaar	*Cyamopsis tetragonoloba* L
Chilli	Mirchi	*Capsicum annuum* L
Cauliflower	Phulgobhi	*Brassica oleracea L*
Tomato	Tamatar	*Solanum lycopersicum* L
Cucumber	Kheera	*Cucumis sativus* L

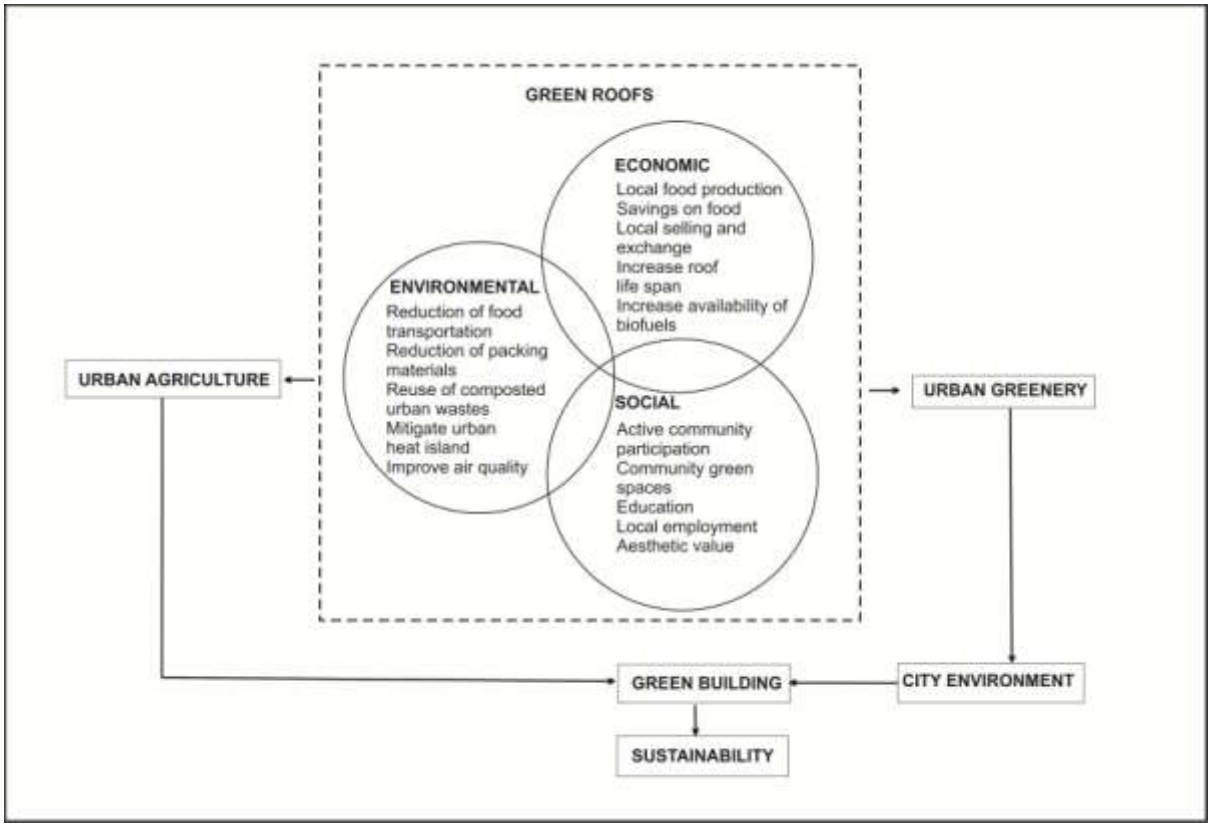

Figure 2: Schematic diagram showing benefits of green roofs leading to sustainability (After Hui, 2011)

Figure 3: Satellite map of Mumbai Metropolitan Region (MMR) showing major urban hubs (base map courtesy: NASA)

Figure 4: Major city farming in Mumbai Metropolitan Region (MMR): (top left), Terrace Garden; (top right), building material for terrace garden; (middle left), community terrace garden; (middle right), educational classes and demonstration for school children; (bottom left), balcony garden; (bottom right), outside view of a balcony garden

Advantages

The major contributions of urban farming were 1) Eco-effective architecture and urban landscapes 2) reducing food miles and transportation emissions 3) use and recycling of water resources 4) energy consumption and production 5) recycling of organic waste 6) new landscape opportunities 7) improving community food security 8) provision of educational facilities 9) linking consumers to food production 10) inspiring designers and planners 11) as an economic advantage for urban areas 12) potential products and yields (Specht *et al*., 2013; Vazhacharickal and Gangopadhyay, 2014).

Figure 5: Major city farming in Mumbai Metropolitan Region (MMR): (top left), terrace garden from Mumbai Port Trust; (top right), building materials used in Mumbai Port trust terrace garden; (middle left), community terrace garden in Mahim nature park; (middle right), from Nana Nany park; (bottom left), from Bavans college; (bottom right), from Marathi Vidnyan Parishad (photo courtesy; Preethi Patil, Urban Leaves)

Figure 6: Composting for city farming in Mumbai Metropolitan Region (MMR): (top left), dried plant materials; (top right), kitchen wastes; (middle left), dried plant leaves; (middle right), growing of green manure; (bottom left), cut green manure; (bottom right), planting seedling on mature compost (photo courtesy; Preethi Patil, Urban Leaves)

Figure 7: Various materials used for city farming in Mumbai Metropolitan Region (MMR): (top left), baked mud bricks; (top right), wooden panels; (middle left), concrete bricks; (middle right), earthen pots; (bottom left), plastic basins; (bottom right), plastic drums (photo courtesy; Preethi Patil, Urban Leaves)

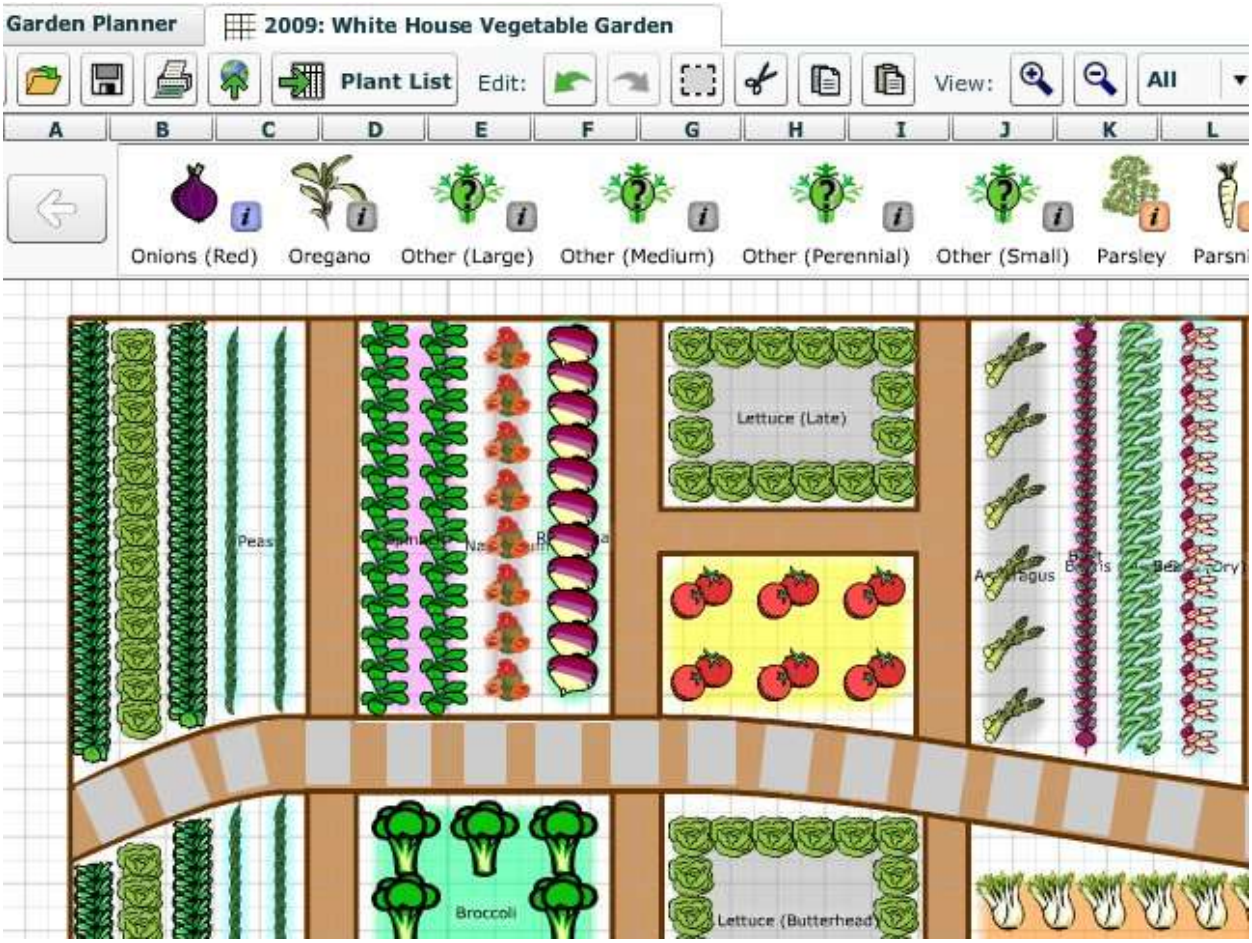

Figure 8: KGI garden planer for systematic terrace gardening (Adapted from Kitchen Gardeners International, 2014)

Disadvantages

The major disadvantages were technical constraints, lack of experience and bias in food system research, usage of untreated wastewater, lack of acceptance, exclusionary practices and trust, food quality and health risks, challenges of constructing and reinforcing, completions with other uses and financing (Specht *et al.*, 2013).

Policy Making

The city farming should be incorporated as an integral component in sustainable city development. These can strengthen the urban resilience and reduce the vulnerability for poor people. The contribution of city farming towards reducing environmental foot prints especially energy, CO_2, water and nutrients and enhancing resilience against climate change (De Zeeuw *et al.*, 2011). The development of 'recreational agriculture' where sustainable agricultural production coupled with recreational services to urban citizens including school children. Sustainable development cannot be achieved without ecologically sustainable urbanization. Planners and policy makers can explore non-conventional approach of implementing sustainable urban planning with UPA (Gupta and Gangopadhyay, 2014). High technology intensive based UPA can be also implemented especially in the case of MMR.

SWOT Analysis

In order to evaluate the potential of city farming a SWOT analysis has been performed. The strengths include production of safe food, reduction of transportation cost, environment and social benefits and

better usages of spaces. The major weakness includes lack of space for faring, lack of appreciation, lack of research and technological development. The opportunities were growing demand for safe and organic food, benefits of community and leisure time activities. The major threats were high cost for re-enforcement, leakage problem, air pollution, rain and harmful insects.

Ecosystem Services

The city farming provides various ecosystem services to the urban inhabitants. It also provides a microclimate for birds, butterflies, spiders and bees. In addition, they can provide a valuable leisure time activity for urban inhabitants and working in a community. The additional services include educational training for school children, recycling organic wastes, urban greening, mitigating climate change and provision of natural ecosystem for insects and animals in urban areas. They can also balance the family expenditure for vegetables and encourage local production.

Reasons

The main reasons involved behind the concept of city farming were 1) the production of better tasting, nutritious food without chemical pesticides and fertilizers 2) Recycle city's waste and turn them into resources 3) reduce the food miles on food 4) improvement of creativity, joy and social learning.

Conclusion

This study reveals the overall scenario of balcony and terrace gardens in MMR which are based on sustainability in urban food production. According to the current literature, city faming in MMR has a great potential in environment, social, economic aspects. City farming should be integrated into the city planning; however, their full integration may be restricted by limitations and difficulties. The production of food and non-food goods improves the architecture, reducing food miles, and improving resource usage and energy efficiency as well as mitigating climatic changes. These production systems could contribute additional contribution for urban food production which can even used for demonstration as well as learning for school children.

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