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Views expressed in the articles are of the authors and not necessarily of the Institute.

-Editor

About the Issue

Cities are home to at least 55% of the world's population, who consume 80% of the food produced globally. To support such a big population while also addressing food security challenges, urban areas must promote urban farming for ensuring sustainable food systems and financial stability.

Urban Farming empowers people who are unemployed, underemployed, malnourished, have unhealthy diets, suffer from hunger or food insecurity. It provides business growth, job creation, urban redevelopment, increases property value, creates more green space and reduces pollution, improves health and wellness. Urban Farming follows several good practices and techniques like space management, hydroponics, aquaponics, organic waste management, income generation activities etc.

In order to brainstorm the issues on Urban Farming, MANAGE Centre for Gender in Agriculture, Nutritional Security and Urban Agriculture has organized an International Seminar on "Urban & Peri-urban Agriculture – Good Practices and Innovations" from 14th to 15th March, 2023 successfully. In this special issue of Journal of Agricultural Extension Management, we are glad to share 10 select research articles presented in the seminar which focus on diverse aspects of Urban and Peri-Urban Agriculture for spreading new knowledge in this emerging area. I am sure that this special issue will be useful for practitioners, scientists, extensionists, research scholars and policy-makers who promote and support Urban Agriculture initiatives.

(Dr. P.Chandra Shekara)
Director General, MANAGE

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CONTENTS

Nature and Spatial Typology of Urban Agriculture in Southern Corporations of Kerala in India

Archana T Shaji[1] and G. S Sreedaya[2]

ABSTRACT

Urban agriculture is an increasingly popular topic around the world, considering its importance in mitigating problems of rapid urbanisation. For strategic urban planning, it is necessary to understand the nature and spatial typology of urban agriculture. Therefore, the present study was conducted in Southern Corporations of Kerala, namely Thiruvananthapuram, Kollam and Kochi corporations, to understand urban agriculture practices, nature and spatial typology of urban agriculture in the mentioned locations. The total sample size for the study was ninety urban farmers, thirty each from selected locations. The data was collected from respondents using well-structured interview schedule and field observations. Information collected included land ownership details, type of urban agriculture practiced, area utilized and types of crops grown. Data analysis was done using percentage and frequency analysis. The result indicated the most prominent type of urban agriculture in Southern Corporations of Kerala were rooftop gardening (44.44 %). All the land area used for urban farming was under private ownership and the farmers grew a combination of crops in their field. The main combination of crop grown was solanaceous+ legumes + crucifers+ leafy, which was observed in 20.00 per cent of respondents. It is expected that the present study will aid in making a sustainable urban food production system, which is environmentally and socially sound.

Keywords: Corporations, Urban Agriculture, Spatial Typology, Kerala, India

Introduction

The number of people living in cities worldwide climbed from 0.8 billion in 1950 to 4.4 billion in 2020, and is expected to reach 6.7 billion by 2050. It is expected that more than 60 per cent of the global population and approximately 50 per cent of the nation's population will be urban by 2030 (UN, 2018). The increased population can further lead to problems like environmental degradation, pollution, climate change, health issues, unemployment and food insecurity (Sujathamma, 2019). It is also observed that along with the rise in urban population the number of

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slums and urban poor around cities are increasing. Therefore, urban and peri-urban agriculture can be offered as a viable livelihood strategy for alleviating poverty, ensuring household food security (Khumalo and Sibanda, 2019), and tackling these problems. Therefore, cities worldwide are developing new urban food policies and supporting Urban Agriculture (Li et al., 2020).

Urban agriculture is defined as agricultural activities involving the planting, processing and distribution of agricultural products from crops and livestock by conserving natural resources and applying waste management techniques in urban areas for the benefit of the surrounding communities by Othman et al. (2017). The major function of Urban Agriculture is to increase food supply and income generation in cities (FAO, 2007). It also enhances food availability and quality across nations and economies, and community members participating in urban agriculture practices show great dietary consumption (Zezza and Tasciotti 2010). Particularly in low-income communities with limited access to affordable, nutritious foods, urban agriculture can boost access to fruits and vegetables. The present study identifies different urban agricultural practices like crops cultivated by farmers, land areas used for understanding nature and spatial typologies.

Review of Literature

The construction of a strategy for enhancing Urban Agriculture production requires an awareness of the appropriate Urban Agriculture typologies and forms. This aids even more in assuring the availability of the product and optimising the production space available to ensure the area's food security (Rogemma, 2015). Residential gardens, community gardens, urban farms, institutional garden and illegal gardens were the main typologies identified in Urban Agriculture areas in Rome by Pulighe and Lupia (2016). According to Napawan (2016) main spatial typologies of Urban Agriculture include kitchen gardens, allotment farming, edible landscapes, small-scale farms, large-scale farms and retail, distribution, and support sites. Concerns about pollution, health, and climate change can all be lessened by disseminating Urban Agriculture typologies (Krisker, 2016).

According to the Urban Agricultural Act in Korea, the five spatial types of Urban Agriculture in Korea are Urban Agriculture in residential buildings, Urban Agriculture in neighbourhoods, Urban Agriculture in city centres, Urban Agriculture in a farm or park and Urban Agriculture for school education and (Oh Kim, 2017). Thornton et al. (2020) reported that there exists a wide diversity among urban agriculture typologies in the Brazilian town of Sao Paulo. The types of Urban Agriculture can vary from professional and privately owned holdings to community gardens.The main urban spaces that can be used for Urban Agriculture includes transition spaces, unconsolidated urban spaces, peri-urban agriculture spaces, farm built clusters, residual spaces, rural settlements and low-density urban spaces (Marat-mendes et al., 2021). Kumari and Shirisha (2022) reported that 43.3 per cent urban farmers cultivated three to four food types including fruits and vegetables. The majority of respondents, 88.0 per cent engaged in urban gardening on terraces, while 37.0 per cent worked in front yards. To make sustainable food production that is environmentally and socially sound urban food economy, it is high time to design, plan, and construct intricate relationships between the urban, suburban, and rural areas of production (Bohn and Chu 2021).

Methodology

The most urbanised districts in Southern Kerala include Thiruvananthapuram, Kollam and Ernakulam (GOK, 2012). Therefore, the study was conducted in purposively selected three Corporations in Southern Kerala which are Thiruvananthapuram, Kollam and Kochi Municipal Corporation. Thirty progressive urban farmers involved in rooftop and homestead cultivation were purposively selected in consultation with the officials and ward members from each corporation. From each corporation five wards were chosen and from these wards six respondents each were selected making up a total of thirty respondents from a corporation. The total number of respondents for the study was ninety. The data was collected using a well-structured interview schedule. Spatial typology is used to program and design local food production elements in urban areas. An inventory of the different types of urban agriculture, nature of ownership, land area and types of crops was made based on observations. . Data analysis was done using percentage and frequency analysis.

Result

Profile Characteristics of Urban Farmers

Age

The mean age of respondents was 51. Among respondents 58.89 per cent of farmers belong to the middle age category and 22.22 per cent to young age and 18.89 per cent to the old age category.

Gender

Among 90 respondents, there were 47 female farmers and 43 male farmers. The frequency of female farmers was higher (52.22 %).

Educational Status

The result indicated that, most of the urban farmers belonged to the graduate and above category, followed by higher secondary school and high school. No respondent belonged to illiterate, can read and write only and primary school category. This may be because of the better socio-economic characteristics of urban population and high literacy rate in Kerala. Most of the farmers (51 %) belonged to the graduate and above category.

Occupational status

Occupational status refers to the main activity done by the respondent by which contributes to his income. The majority of respondents belonged to urban farming + employee category (47.78%), followed by urban farming (30%) and urban farming+ business (22.22%).

Annual income

The respondents are categorized into low, medium and high annual income based on mean and standard deviation. The result indicated that 66.67 per cent of the respondents were medium in the income category, 17.78 per cent in high income and 15.56 per cent in low income category.

Table 1: Distribution of Respondents based on Annual Income

Sl.No.	Categories	Frequency	Percentage
1	Low income (≤ 3 Lakhs)	14	15.56
2	Medium income (3-9 Lakhs)	60	66.67
3	High income (≥ 9 Lakhs)	16	17.78
	Total	90	100
Min=1 lakh, Max=20 Lakhs, Mean=6, SD=3			

Urban Farming experience

The classification of farmers into low, medium and high urban farming experience was done based on mean and standard deviation. Most of the farmers (61.11 %) belonged to the medium category of farming experience while 22.27per cent of respondent had low experience, lowest frequency was observed in high experience category (16.67 %).

Table 2: Distribution of Respondents based on Urban Farming Experience

Sl. No.	Categories	Frequency	Percentage
1	Low experience (< 4 years)	20	22.22
2	Medium experience (4-14 years)	55	61.11
3	High experience (> 14 years)	15	16.67
	Total	90	100

Min= 2 years, Max= 28 years, Mean=8.65, SD=5.45

Nature and Spatial typology of Urban Agriculture

Nature and spatial typology is the inventory of the different types of urban farming along with the area used and crops cultivated. The main type of urban agriculture practice was rooftop farming in grow bags and containers, about 44.44% of respondent were cultivating crops in their rooftops. The next common practices were home gardens, kitchen gardens, polyhouse cultivation and urban farms, the percentage of farmers involved in these were 21.11 per cent, 15.56 per cent, 5.56 per cent and 3.3 per cent respectively. The various combinations of home gardens, poultry, fisheries, rooftop cultivation, rain shelter and kitchen gardens were collectively observed among 11.08 percent of respondents.

The crop cultivation was mainly seen in a mixed combination rather than cultivating a single crop, farmers grew different types of vegetables and fruits in the limited area available for them. The combinations were mainly of solanaceous, legumes, crucifers, leafy vegetable, fruit crops and tubers. The solanaceous+ legume, crucifers + leafy vegetable combination was cultivated by 20 per cent of farmers, followed by the solanaceous+ leafy+ legumes combination by 16.67 per cent. The next common combinations were leafy+ legume +solanaceous +fruits 14.44 per cent and leafy+ legume+ solanaceous+ fruits + cucurbit combination by 14.44 per cent of farmers.

Table 3: Nature and spatial typology of urban agriculture

Sl. No	Types of urban agriculture	Frequency	Percentage	Area (sq.ft)
1	Rooftop- grow bags	36	40	33150
2	Rooftop-container	3	3.33	2600
3	Rooftop-grow bag + container	1	1.11	800
4	Home garden	19	21.11	150
5	Kitchen garden	14	15.56	10,016
6	Polyhouse	5	5.56	4300
7	Urban farm	3	3.33	13,0680
8	Home garden +poultry	3	3.33	8274
9	Home garden+ rooftop	1	1.11	7302
10	Rooftop + home garden +poultry	1	1.11	2877
11	Home garden +rooftop + poultry +fisheries	1	1.11	2542
12	Kitchen garden + rooftop	1	1.11	1603
13	Rooftop + rain shelter	1	1.11	1350

14	Kitchen garden + rain shelter	1	1.11	871
	Total	90	100	

Table 4: Crop combinations in Urban Agriculture

Sl. No.	Types of crops grown	Frequency	Percentage
1	Solanaceous+legumes +crucifers+leafy	18	20.00
2	Solanaceous+leafy+legumes	15	16.67
3	Leafy+legumes+solanaceous+fruits	13	14.44
4	Leafy+legumes+solanaceous+fruits +cucurbits	13	14.44
5	Solanaceous+legumes+crucifers	8	8.89
6	Solanaceous+tubers+fruits+cucurbits	7	7.78
7	Solanaceous+tubers+fruit	6	6.67
8	Leafy+legumes+cucurbits	4	4.44
9	Solanaceous+fruit crops+crucifers	2	2.22
10	Solanaceous+legumes+crucifers +cucurbits	2	2.22
11	Solanaceous+legumes	1	1.11
12	Solanaceous+fruit crops	1	1.11
	Total	90	100.00

Domestic Waste Management

Domestic waste management refers to how urban farmer disposes his/her household wastes. The waste generated mainly included plastic and food waste. The main method of disposal was waste collection by municipal workers and waste van collection. It was also seen that most of the respondent have compost or biogas units in their household, which is used to decompose food waste and later the slurry or residue after decomposing was used as manure for growing plants. The details like types of waste generated, the waste disposal methods, the usage of organic waste and disposal methods are given in the following tables.

Table 5: Types of Waste Generated

Sl.No.	Types of waste	Frequency	Percentage
1	Plastic waste	67	74.44 %
2	Plastic and paper waste	10	11.11 %

3	Plastic and food waste	10	11.11 %
4	Plastic waste and cans	3	3.33 %
	Total	90	100.00 %

Table 6: Waste Disposal Methods

Sl. No.	Disposal Methods	Frequency	Percentage
1	Workers collected	37	41.11 %
2	Waste van	39	43.33 %
3	Roadside dumping+workers	5	5.56 %
4	Dumping site	6	6.67 %
5	Workers collected+ dumping site	3	3.33 %
	Total	90	100.00 %

Table 7: Distribution of Respondents based on Household Organic waste generated and used for Urban Agriculture

Sl. No.	Category	Frequency	Percentage
1	Respondents using household waste for UA	74	82.22 %
2	Respondents not using household waste for UA	16	17.78 %
	Total	90	100 %

Table 8: Organic waste disposal methods

Sl. No.	Disposal methods	Frequency	Percentage
1	Biogas	45	60.81
2	Compost	19	25.68
3	Bucket compost	6	8.11
4	Biogas and compost	4	5.41
	Total	74	100%

Problems faced by Urban Farmers

The constraints faced by urban farmers were collected using open ended questionnaire. The results indicated that the major constraint faced by farmers was the incidence of pest and diseases (90.00 %) followed by not getting quality inputs for urban agriculture (80.00 %). The least frequency (46.66 %) was observed in case of risk of building damage due to urban agriculture.

Table 9: Problems faced by Urban Farmers

Sl.No.	Constraints	Frequency	Percentage
1	There are no remunerative prices for commodities	72	80.00
2	Incidence of pest and disease	81	90.00
3	The produce is considered inferior by consumers because of the shape and size of the produce and cannot sell the produce	68	75.60
4	Not getting quality inputs	75	83.33
5	High level of competition	75	83.30
6	Lack of time to spent on agricultural activities	52	57.77
7	Not having adequate space for cultivation	58	64.44
8	Risk of building damage	42	46.66

Conclusion

The present study indicated that most of the farmers involved in urban agriculture are cultivating their crops on rooftops in grow bags. They were cultivated crops as the combination of vegetables. The main problems faced by urban farmers include higher incidence of pests and diseases and not getting quality inputs for farming. In the present scenario of grow bag ban and decreasing land area in farming. It is necessary to come up with policies and strategies that can reduce these issues and scale up urban agriculture.

The main strategy for scaling up Urban Agriculture should conversion of fallow land and vacant land to cultivable areas. There are many vacant spaces in urban areas that are underutilised, this has to be identified and should be allotted to individuals who are interested in farming. This can be done by making an inventory of urban agriculture state-wide. It can further help to understand various typologies and common cultivation practices among farmers and the problems faced by them.

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Exploring Urban Agriculture's Impact on Ecosystem Services and Beneficiary Characteristics

G. S. Sreedaya[1], R. Ajith Kumar[2], Archana T Shaji[3] and Riza Mathew[4]

ABSTRACT

Urban agricultural systems can contribute to the health of the natural ecology and offer more ecosystem services than they demand. Restructuring agriculture, particularly urban agriculture, as a component of a greener infrastructure system might lead to the creation of a network of agricultural systems that enhance the health of the local ecosystem by supplying ecosystem services and avoiding harmful externalities. cities could gain largely from the ecosystem services of urban agriculture in terms of environmental and socio-economic benefits, such as water regulation, enhanced food security, or improved air quality. Urban agriculture has indeed been proposed as a means for delivering ecosystem services like benefits for mental health and cultural enrichment. Ecosystem services are often grouped into four categories: provisioning services example food and fiber, regulating services example climate regulation, and erosion control, supporting services of soil formation, oxygen production), and cultural services example recreational and health benefits. (Millennium Ecosystem Assessment, 2005). This study was conducted in Thiruvananthapuram corporation, the Capital of Kerala, to delineate the ecosystem services provided by urban agriculture as perceived by the citizens of Thiruvananthapuram corporation. Evaluation of the ecosystem services and suggesting suitable strategies for urban planners are the other objectives. 390 randomly selected respondents from 32 wards of Thiruvananthapuram corporation became part of the study. Data was collected through a pretested questionnaire and measured in the Likert Scale. The analytical tools are principal component analysis, mean, percentage, and correlation.

Keywords: Urban Agriculture, Ecosystem Services, Kerala, India.

Introduction

As India's population gets more urbanized by 2030, it is anticipated that 50 percent of Indians and nearly 60 percent of the world's population will live in cities (UN-World Urban Prospectus, 2018). The number of million-plus cities

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in the country, meanwhile, has steadily increased from 23 in 1991,and 35 in 2001, to 53 in 2011 (Census of India, 2011). The transport sector of Indian cities contributes to over 7% of total GHG emissions in India. High vehicular emissions in many cities have raised air pollution to unbearable levels (Ghose et al., 2004).

The creation of sustainable and resilient cities is one of the challenges of policymakers around the globe. Promoting urban green infrastructures represented by all vegetation cover in and around cities, including urban forests, grassland, sparks, green roofs, gardens, urban farms, and street trees etc. is widely believed to provide critical ecosystem services and play a vital role in mitigating the negative impacts brought about by urbanization (Bodnaruk et al., 2017).

Urban greening policies are important for revitalizing communities, reducing the financial burdens of healthcare and increasing quality of life. Most policies focus on community benefits, and reducing the negative effects of urban development, such as surface runoff and the urban heat island effect. Green Spaces is a cost-effective ecosystem-based approach for climate adaptation in Indian cities.

Ecosystem services provided by urban agriculture/urban gardens are often grouped into four categories: provisioning services (e.g., food and fiber), regulating services (e.g., climate regulation, erosion control), supporting services (e.g., soil formation, oxygen production), and cultural services (e.g., recreational and health benefits) (Millennium Ecosystem Assessment, 2005). Kerala, the second-most urbanized state in India, has 47.7 percent of its residents, living in cities (GOK, 2018). Thiruvananthapuram Corporation is the largest municipal corporation in Kerala by area and population. Urban agriculture is practiced in city areas widely. But the ecosystem services benefits of urban agriculture remain less discussed. Therefore, the present study is aimed to understand ecosystem services provided by urban green spaces in the Thiruvananthapuram Corporation.

Objectives

The study's main objective was to understand various ecosystem services provided by urban gardens in Thiruvananthapuram Corporation, the capital of Kerala. The profile characteristics of beneficiaries of ecosystem services of urban agriculture were also identified.

Methodology

The present study was conducted in the Thiruvananthapuram Corporation. Six public gardens in Thiruvananthapuram Corporation, where people used to come regularly for recreation and relaxation were purposefully identified. Thirty gardeners, actively involved in maintaining these six gardens were selected, who were the primary contacts. The data were collected using a pre-tested interview schedule from these primary contacts. By nonparticipant observation and snowball technique, 270 other respondents, who were either regular visitors of these six public gardens or actively engaged in urban agriculture through home gardens/rooftop gardens/community vegetable gardens (residents associations) were also identified as respondents. Thus, the total sample size was 300. The data were collected using a pre-tested interview schedule

As an initial step, 40 ecosystem services were identified using a free listing technique (Bernard,1999; Vieling et al 2014) and were classified into 4 main categories, which were provisioning, habitat, regulating and cultural services. These 40 services were sent to thirty experts of Kerala Agricultural University and nearby institutions for judge's rating. Their responses were collected on a five-point continuum with options "most relevant", "more relevant", "relevant", "less relevant", and "least relevant" with scores of 5,4,3,2 and 1 respectively. Based on the relevancy rating, 20 ecosystem services, which had the highest relevancy scores, were finally selected.

The 300 selected respondents of the study, were asked to rate benefits derived from the mentioned 20 statements in the five-point continuum. The level of agreement was strongly agree, agree, undecided, disagree and strongly disagree. The scores given were 5,4,3,2 and 1 respectively. The means scores and percentage analysis was further done to analyse the level of agreement.

The data collected were statistically analysed using frequency, percentage analysis, correlation and regression.

Result

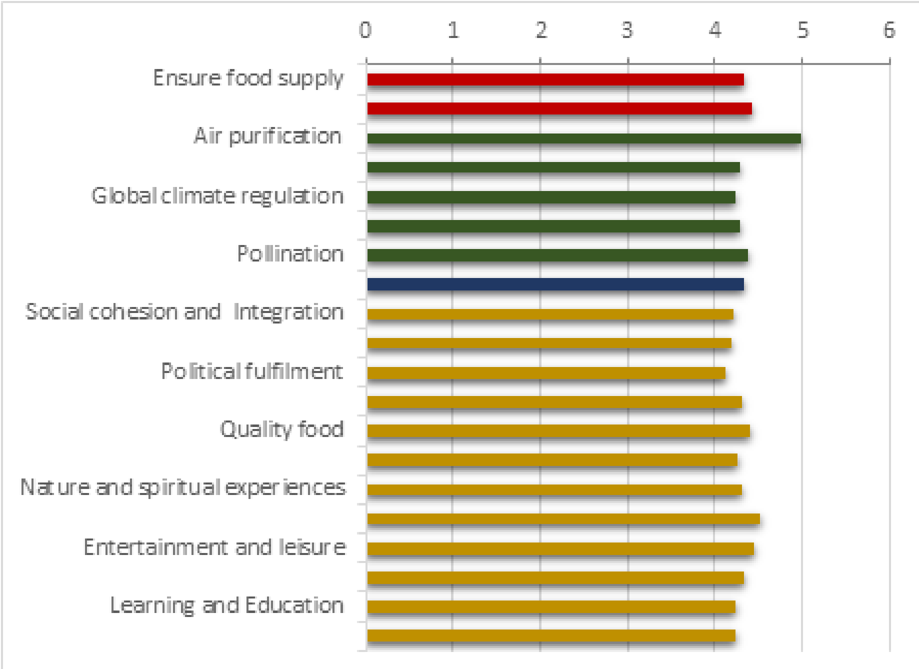
1. Ecosystem Services

The 14 ecosystem services were categorised into four, i.e. provisional services, regulating services, habitat services and cultural services. The level of agreement on the ecosystem benefits of respondents was measured using a five-point continuum and the Mean Score (MS) of each ecosystem was calculated and shown in Table-1.

The two provisioning services identified were ensuring food supply 4.32 and ensuring therapeutic services through medicinal and aromatic plants 4.43. The regulating services include air purification 4.99, local climate regulation 4.29, global climate regulation (4.24), maintenance of soil fertility (4.29) and pollination (4.38). The overall mean score for regulating services was 4.43. Regarding habitat service which solely included the maintenance of biodiversity, the mean score was 4.33. The twelve cultural services were learning & education (4.24), social cohesion & integration (4.22), entertainment & leisure (4.44), maintenance of cultural heritage (4.24), aesthetic information (4.25), relaxation and stress reduction (4.52), quality of food(4.4), place-making (4.2), biophilia (4.31), exercise & physical recreation (4.32), nature & spiritual experiences (4.31) and political fulfilment (4.13). The total mean score of cultural services was 4.29.

Table 1: Ecosystem services of Urban Agriculture

Sl. No	Categories	Mean Score	Overall Mean Score
I.	**Provisional Services**		
1.	Ensure food supply	4.32	4.37
2.	Ensure therapeutic services through Medicinal and aromatic plants	4.43	
II	**Regulating service**		
3.	Air purification	4.99	4.43
4.	Micro climate regulation	4.29	
5.	Global climate regulation	4.24	
6.	Maintenance of soil fertility	4.29	
7.	Pollination	4.38	
III.	**Habitat services**		
8.	Biodiversity	4.33	4.33
IV.	**Cultural services**		
9.	Social cohesion and integration	4.22	4.29
10	Place-making	4.2	
11	Political fulfilment	4.13	
12	Biophilia	4.31	
13	Quality food	4.4	
14	Aesthetic information	4.25	



The analysis result indicated the most felt benefit from the ecosystem service of urban agriculture was regulating services, which has a mean score of 4.43. The mean score for air purification was the highest and it was the most agreed ecosystem benefit. Therefore, it can be concluded that the most important ecosystem service from urban gardens according to the respondents was air purification followed by relaxation and stress reduction benefits.

Discussion

1. Ecosystem Services

Ecosystem services from urban gardens can be crucial in resolving several urban policy issues in cities, including encouraging the stewardship of urban ecosystems, generating opportunities for recreation and healthy living, and fostering social cohesion (Camps-Clavet et al, 2016). Among the ecosystem services, highest mean score was observed in the case of regulating services, which included the air pollution and climate regulation benefits of urban green spaces. Green spaces aid in building an efficient and highly localized stable food system that can support the development of sustainable urban environments by reducing food miles and carbon emissions. It can also increase carbon sequestration, and lower greenhouse gas emissions (McDougall et al., 2019).

The main ecosystem service of urban agriculture is the habitat service, which solely includes biodiversity maintenance. The present scenario of forest land conversion for human inhabitation has resulted in the loss of habitat of many birds and animals. Urban gardening can be an effective way for increasing biodiversity in urban areas by enhancing the local flora and fauna. Ponds, moss, ground cover, and various vascular vegetative structures are examples of features in domestic gardens that may promote plant biodiversity (Smith et al., 2005). Urban agriculture systems can improve urban biodiversity and provide crucial ecosystem services like pollination, pest management, and climate resilience including diversified vegetative structure, increased native plant variety, and a decrease in urban impermeable surface (Lin et al, 2015). There is a direct correlation between the number of years of maintenance and the diversity of habitats and urban household vegetation. Diversity was also influenced by the quantity of land, the layout of the space, and economic concerns. For many years, the residences were kept with more vegetation and rich diversity. In most cases, lack of space is the main constraint in urban areas to maintain biodiversity. It can be reduced by a household level approach to biodiversity maintenance (Salini, 2023).

The primary reasons for participating in Urban Agriculture are food production for domestic consumption, income supplementation, and rising market food prices (Nugent, 2000). The provisional services of urban gardening are mainly the supply of fruits and vegetables and the therapeutically benefits of medicinal plants grown and it had the second highest mean score. Many people engage in urban farming because of their gardening interests, it gives them access to a garden, access to fresh food, and social contact (Corrigan, 2011). Urban agriculture in some cases was necessary for the subsistence of citizens it provided financial gain. In some contexts, it improves the food security of farming households (Poulsen et al., 2015).

The social and cultural services of urban gardens mainly emphasise citizen involvement through capacity building, participatory management, and multilevel governance (RUAF, 2003). Urban gardens can act as a space for knowledge sharing between generations and individuals. It can aid in capacity building required to provide citizens with knowledge and skills in a variety of urban agriculture-related areas. Numerous people regard urban gardening as a nice way to spend their free time which helps them to preserve the urban environment (Dieleman, 2017). It is crucial for food sovereignty because it is a region that contributes significant quantities of local products to the metropolis.

2. Profile characteristics of respondents

The profile characteristics like age, annual income, gender, time spent in urban farming, educational status and job status, and health consciousness were measured using procedures developed by the researcher appropriate for the study. Environmental orientation was measured using the scale followed by Arathy (2022). It was observed that most of the respondents (44 %) were in the young age category (less than 32 years) followed by the middle-age category viz. 30 percent (32-46 years). Among the respondents, 62 percent were women. Most of the respondents (49 %) were graduates, 46 percent with a higher secondary level of education or diploma. Regarding job status, 34 percent were government employees, 21 percent were private employees, 16 percent were retired officials, 16 percent were self -employed individuals and 13 percent of respondents were homemakers. Regarding annual income, 25 percent belonged to Rs. 3-4 lakhs/ year, 24 percent to 1-2 lakhs/ year and 2-3 lakhs/ year categories. It was observed that 43 percent of respondents spent about 2-3 hours daily in urban agriculture activities or spent their time in urban gardens followed by 29 percent of respondents who spent 1-2 hours/per day in urban farming activities, and 17 percent belonged to 3-4 hours/day category. There were only 11 percent of respondents spent more than 4 hours daily in urban agriculture. It was observed that 67 percent of respondents belonged to the medium health consciousness category followed by 21 percent in the high health consciousness and 12 percent in the low health consciousness category. Most of the respondents (74% belonged to the medium environmental orientation category followed by 22 percent in the high environmental orientation category.

3. Relationship between ecosystem services and profile characteristics

The cause effect relationship between ecosystem services and profile characteristics was found using regression analysis. The ecosystem service score was positively and significantly associated with time spent in urban agriculture activities, health consciousness and environmental orientation. A negatively significant association was seen in the case with that of age and ecosystem service means score.

Table 2: Regression Analysis

Sl. No	Independent variables	Estimate	P value
1	Age	-0.007	0.000*
2	Gender	0.026	0.599
3	Annual income	-0.025	0.195
4	Job-status	-0.018	0.140
5	Time spent in urban agriculture activities	0.132	0.000*
6	Education	0.055	0.146
7	Health consciousness	0.070	0.000*
8	Environmental orientation	0.104	0.000*
	P values less than 0.05 are significant		

People who are highly health conscious in urban areas usually opt for growing their food, which is free of chemical use. They also agreed that urban agriculture ensures food supply and that the food produced without chemicals is tastier and healthier. This might be the reason they opined that urban agriculture provides ecosystem services in urban areas.

Respondents who had high environmental orientation were aware of the problems in their surroundings. They may have greater awareness about the issues related to rapid urbanization and the importance of urban agriculture in this scenario. Therefore they may have felt that urban agriculture greatly contributed to the ecosystem services, which reduces the problems of air pollution and climate change.

It was also observed that the individuals who spent more time in urban gardens/ urban agriculture activities had a higher mean score for ecosystem services. They might have felt the various benefits of urban agriculture /urban gardens in maintaining biodiversity in urban areas for pollination of crops, providing aesthetics and pleasure, reducing depression and anxiety and increasing their food supply as they spent more time in the farm areas.

Conclusion

Urbanisation is happening all around the world. The current scenario of rapid urbanisation and decrease in land area as forest covers and cultivable farm land resulted in biodiversity loss. Urban greening is a cost-effective climate mitigation strategy that the policymakers can implement around the globe.

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Nutrient Management in Hydroponic Systems for Urban and Peri-Urban Agriculture

A.B.Jadhav

ABSTRACT

Soil based agriculture systems in urban and peri-urban areas or around metro cities is facing various challenges such as rapid urbanization, industrialization, natural disaster, declining soil fertility, mineral mining and sewage water based polluted leafy vegetables etc. which are creating lot many problems. In the new era, soilless cultivation is gaining popularity all over the world and India because of efficient use of the water, fertilizers and other resources for quality vegetable production in urban and peri-urban areas. In this article historical background of soilless culture and various types of soilless culture systems their advantages and limitations are discussed. Among factors affecting soilless production systems, the nutrient solution is considered to be one of the most important determining factors of crop yield and quality. Plant nutrients, classification, their functions and essentiality for plants along with plant usable forms and critical nutrient concentration are thoroughly discussed in the article. The concept of pH of the nutrient solution and its effect on nutrient availability; relation between electrical conductivity and osmotic potential along with its effects on nutrient uptake are discussed in the article. Oxygenation in the nutrient solution is also important for root growth and overall plant growth; factors affecting nutrient solutions behaviour are also reported, emphasizing temperature; formulation and preparation of nutrient solutions considering different fertilizer sources are described as well.

Keywords: Urban Agriculture, Nutrient Management, Hydroponics, Peri-Urban Agriculture, Soilless Culture.

Introduction

The word hydroponic is derived from two Greek words, *hydro*, meaning water, and *ponos*, meaning labor (i.e., working water). The word first appeared in a scientific magazine article published in February 1937 and was authored by W. F. Gericke. Resh (1995) defines hydroponics as "the science of growing plants without the use of soil, but by use of an inert medium, such as gravel, cocopeat, oasis cube, sand, peat, vermiculite, pumice, or sawdust, to which is added a nutrient solution containing all the essential elements needed by the plant for its normal growth and development." Wignarajah (1995) defines

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hydroponics as "the technique of growing plants without soil, in a liquid culture by supplying water soluble essential nutrients". Harris (1977) suggested that a modern definition of hydroponics would be "the science of growing plants in a medium, other than soil, using mixtures of the essential plant nutrient elements dissolved in water." Jensen (1997) stated that hydroponics "is a technology for growing plants in nutrient solutions (water containing soluble fertilizers) with or without the use of an artificial medium (sand, gravel, cocopeat, oasis cubes vermiculite, rockwool, perlite, peat moss, coir, or sawdust) to provide mechanical support."Jensen defined the growing of plants without media as "liquid hydroponics" and with media as "aggregate hydroponics." Similarly related hydroponic terms are "aqua (water) culture," "hydroculture," "nutriculture," "soilless culture," "soilless agriculture," "tank farming," or "chemical culture." The growing of plants in an inorganic substance (such as cocpeat, oasis cube, sand, gravel, perlite, or rockwool) or in an organic material (such as sphagnum peat moss, pine bark, or coconut fiber) that are periodically watered with a nutrient solution should be referred to as soilless culture but not necessarily hydroponic. Hydroponics used to be considered a system where there was no growing media at all, such as the Nutrient Film Technique in vegetables.

Importance of Soilless Culture

Food security with good quality is one of the pivotal themes of the new millennium that the most urgent challenge for the agriculture sector. Further, increasing industrialization, urbanization, climate change (particularly uncertain rainfall) rapid soil erosion, degrading soil fertility, soil pollution, soil salinization, excess use of irrigation water, intensive agriculture, nutrient mining, reducing natural resources, less use of organic manures and reducing organic matter etc. are the major concerns for reducing yield and productivity of crops. Moreover, the strict dependency of agricultural practice on water availability in the age of drastic climate change (desertification) make the situation complex (Table 1). Modification in growth medium is an alternative for sustainable production and to conserve fast depleting land and available water resources. In the present scenario, soil less cultivation might be commenced successfully and considered as alternative option for growing healthy food plants, crops or vegetables (Butler and Oebker, 2006). Agriculture without soil includes hydro agriculture (Hydroponics), aqua agriculture (Aquaponics) and aerobic agriculture (Aeroponics) as well as substrate culture is considered one of the more innovative agricultural strategies to produce more from less, to feed increasing population. Among these different soilless cultivation systems, hydroponics techniques are gaining popularity because of its efficient management of resources and quality food production. Various commercial and specialty crops can be grown using hydroponics including leafy vegetables, tomatoes, cucumbers, peppers, strawberries, and many more. This article covers different aspects of soilless cultivation, their types, with more stress on nutrients required their essentiality, their functions and overall nutrient solution management.

Why Go for Soilless Cultivation/Hydroponics?

- Limited water availability and water pollution
- Severe soil degradation/ reduction in fertile soils
- Urbanization and industrialization thereby reducing area for cultivation
- High demand particularly for vegetables in urban and peri-urban area
- Environment friendly and for quality vegetable production
- Oligo-elements and bio-fortification
- Higher nutrient and water use efficiency
- Nutrient mining

Table 1: Water Use Efficiency (WUE) in Soilless Cultivation Systems of Important Crops.

Type of efficiency	Species	Crop water requirement (L kg^{-1})		
		Soilless cultivation system/ Hydroponics		Soil cultivation system*
WUE	Lettuce	1.6	Barbosa et al., 2015	76
	Hot pepper	58	Ahmed et al., 2014	110
	Sweet pepper	17	El-Sayed et al., 2015	121
	Zucchini Squash	39	Rouphael et al., 2005	97
	Muskmelon	42	Hamdy et al., 2002	170
	Spinach	8.3	Van Ginkel et al., 2017	106
	Strawberries	136	Van Ginkel et al., 2017	544
	Brassica	5.0	Van Ginkel et al., 2017	129
	Tomatoes	35	Massa et al., 2010	78

Types of Soilless Cultivation

There are different types of soilless cultivation systems as stated below and Shown in figure 1.

1. Aeroponic/fogoponics
2. Deep Water Culture (DWC)/ Deep Flow Technique (DFT)/ Floating Raft Technology (FRT
3. Drip system (recovery and non-recovery)
4. Ebb and Flow
5. NFT (Nutrient File Technique) or (Nutrient Flow Technique
6. Grow bag/Dutch Bag/other media

Aeroponics

- Most sophisticated and high-tech method
- Plants with roots are suspended in container/trails
- Nutrient are sprayed on roots with timer
- Very high nutrient and water use efficiency.
- Droplet size in aeroponic ideal 30 to 100 micron
- Needs regular monitoring/suitable for leafy & fruity veggies

Advantages of Aeroponics

- The modern aeroponics system uses a low-pressure, high-pressure, or ultrasonic fogger approach to growing fruit and vegetables.
- Higher nutrient use efficiency and higher water use efficiency (85 to 95 %)
- It permits a massive amount of plant growth/ fast growth/
- Higher yields are possible with aeroponics.
- Aeroponics requires very little space to create high levels of production.
- It takes fewer resources to produce a yield through aeroponics
- It produces healthier root systems / less disease/pest and best research tool

Limitations of Aeroponics

- High initial setup cost / expensive growing method
- Technocrat with specialty in nutrient, plant physiology climate parameters & their interactions is necessary
- Close monitoring or attention required and suitable for certain leafy vegetables.
- Power backup requires (Aeroponics system uses high pressure pumps, sprinklers and timers

Deep Water Culture (DWC)/ Deep Flow Technique (DFT)/ Floating Raft Technology (FRT)

- Suitable for leafy veggies in that roots are suspended in nutrient and oxygen rich bed
- Rectangular tank with one feet filled nutrient rich solution
- Plants are fixed on stay foam, thermacol sheet etc
- Suitable for short-term, non-fruiting like leafy greens/herbs

Advantages and Limitations of DWC

Advantages	Limitations
* Components are bed, nutrient solution, water, air pump * Suitable for almost all leafy veggies like lettuce, spinach/ Simple to set up * Fairly simple to understand * Requires fair monitoring * Maintenance cost is less * Plants grow faster and higher yield	* Fluctuations in nutrient concentration * Needs close monitoring for pH and EC of nutrient solution * Needs monitoring of water temperature (O_2 solubility) * Air pump needs to work properly. * Mosquito and algal growth in water

Drip System (recovery and non-recovery)

- Most simple similar to conventional system
- Instead of soil, inert growing media is used
- Media: Coco peat, oasis cube, rockwool, hydrotones etc
- Growth fast and high yield used mostly for leaf and fruity vegetables

Advantages and Limitations of Drip system

Advantages	Limitations
* Similar to soil and simple to build, provides more control over nutrient & water supply growth fast, high yield and cost effective * Growing media helps to hold sufficient water * Requires fair monitoring, Low maintenance * Flexible and Low maintenance * Growth fast/ higher yield/ suitable for most crops as per growth habit	* Fair technical expertise/ pH and EC need to be monitored. Under water re-cycling: maintenance cost slight. * Under non-recovery : Waste of nutrients/water * Some growing media may have algal growth/salt hold: needs to monitor

Ebb and Flow

- Also termed as flood and drain/ popular hydroponic system due to easily built
- Delivers water, nutrients and oxygen to plant roots in floods and drain cycle
- Can be used to most leafy and fruity vegetables, simple/Reliable/easy to install/less cost
- Cucumbers, beans, tomatoes, and other medium-to-large sized plants

Advantages and limitations of Ebb and Flow

Advantages	Limitations
* Simple, easy built, not costly components required * Scalable and adaptable to different growing needs. * Resource efficient (water and nutrients)	* Dependent on electricity and a pump * Expanded systems are more complicated to build * Unstable pH and nutrient levels of the recycled solution * Getting the cycle timing right can be challenging

NFT (Nutrient Flow Technique)

- Most suitable for commercial leafy veggies production
- A shallow stream of water (film) containing nutrients will be re-circulated through pipes
- NFT channel slope and flow rate of nutrient solution are very important
- Suitable for leafy and fruity vegetables this can be the vertical or horizontal system which easily increases the growing area

Advantages and Limitations of NFT

Advantages	Limitations
* Production and productivity is higher * Easy to build, maintain and inspect for any root disease * High water and nutrient use efficiency * Oasis cube, coco-chips, rockwool etc * Oxygenation is optimum recirculation * Suitable for all areas may be vertical or horizontal farming	* Monitoring of pH and EC required. * Initial cost is very high particularly for NFT channels * Roots can block the flow of nutrient solution * Not suitable for crops having tap root systems like carrots/ raddish * Power failure can cause problems

Growing Media

There are different kinds of growing media (figure 2) are used for mechanical support in soilless cultivation. Further different types of media are suitable for specific kinds of soilless cultivation system adopted.

Criteria for Selecting Media

- pH/EC/ More CEC should be optimum and serve as the reservoir of plant nutrients.
- Sufficiently firm enough to encourage or support the plants.
- Provides aeration for the exchange of gases/O2.
- Should not shrink or expand easily, should have good drainage and porosity.
- Should be easily available and economical and should be sterilized easily.
- Free from pathogens, pests, weed and seeds etc. and should not react with nutrient elements
- Must be reusable and restrict algal growth

Advantages of Soil less Cultivation

Advantages	Limitations
* Higher water and nutrient use efficiency * Less growing period and continuous Production * Require less space * Higher productivity and higher yields * Good quality of produce due to controlled condition * Less depend on seasonality * No severe disease and pest attack * Do not require tillage practices, weeding, soil fertilization crop rotation	* Higher initial cost/ Monitoring of pH and EC Necessary and effective to control nutrient solutions * Higher technical knowledge More periodic and routine work Efficient electrical systems * Needs to monitor microbial diseases through water

Reference: Alfredo Aires (http://dx.doi.org/10.5772/intechopen.73011)

Nutrient Management in Hydroponic Systems

Arnon and Stout (1939) described three requirements that an element had to meet to be considered essential for plants. There are a total of 17 essential nutrients along with their critical nutrient concentration and plant usable forms are stated in Table 2.

1. Plant unable to complete its life cycle without that nutrient
2. Element is essential for the plant when it is having a specific role or the function of the nutrient is specific which cannot be replaced by other.
3. The element is having direct role in metabolism.

Primary nutrients	Secondary nutrients	Micronutrients
Carbon, hydrogen, oxygen, nitrogen, phosphorus, and potassium	Calcium, Magnesium and Sulphur	Iron, manganese, zinc, copper, boron, molybdenum, chlorine, nickel

Table 2: Concentrations of Nutrients in Higher Plants (on dry weight tissue basis)

Sr.No.	Nutrient	Plant usable form	Concentration in plants (%)	Ppm
1	Carbon	CO_2	45	450000
2	Hydrogen	H_2O	6	60000
3	Oxygen	H_2O, O_2	45	450000
4	Nitrogen	NH_4, NO_3	1.5	15000
5	Phosphorus	H_2PO_4, HPO_4	0.2	2000
6	Potassium	K^+	1	10000
7	Calcium	Ca^{2+}	0.5	5000
8	Magnesium	Mg^{2+}	0.2	2000
9	Sulphur	SO_4^{2-}	0.1	1000
10	Iron	Fe^{2+}, Fe^{3+}	0.01	100
11	Manganese	Mn^{2+}	0.005	50
12	Zinc	Zn^{2+}	0.002	20
13	Copper	Cu^{2+}	0.0006	6
14	Molybdenum	MoO_4	0.1	0.00001
15	Boron	H_3BO_3	20	0.002
16	Chlorine	Cl^-	0.01	100
17	Nickel	Ni^{2+}		

Function and deficiency symptoms of essential nutrients.

Nitrogen:

- Component of chlorophyll, enzyme, amino acids and protein
- Encourages vegetative growth & deep green colour
- Enhances plumpness in cereal crops and succulence in crops
- Role in utilization of carbohydrates

Phosphorus

- Energy storage & transfer (1 ATP/ADP= 1200 cal/mole)
- Cell division, cell development, root lengthening, seed and fruit development, early maturity and early ripening
- Component of nucleic acid, co-enzyme, nucleotides, phospholipids, phosphoproteins & sugar phosphates
- Phytic acid/ phytin- storage form of P in seeds

Potassium

- More than 80 plant enzymes require K for activation
- Synthesis of ATP, translocation of carbohydrates
- Synthesis of amino acids, proteins, chlorophyll
- Enhance resistance against moisture stress by regulating opening & closing of stomata and disease resistance
- Affects the rate of transpiration & water uptakes, produces strong stiff straw which inhibit lodging in crops

Calcium

- Immobile in plant, Constituent of cell wall, require for cell elongation & division
- Activation of enzymes, role in structure & permeability of cell membrane
- Enhance uptake of NO3-N

Magnesium

- Component of chlorophyll (15-20% Mg present in Chlorophyll)
- Structural component of ribosome- protein synthesis
- Imparts dark green colour/ Photosynthesis/ glycolysis
- Role in oil seed crops, Helps in transport of P
- Synthesis of carbohydrates, fats & vitamins

Sulphur

- Component of protein (S- containing amino acids cystine, cysteine & methionine),
- Requires for chlorophyll synthesis, Important role in oil synthesis
- Requires for the synthesis of co-enzymes A
- Involved in synthesis of fatty acids & component of ferridoxin

Iron

- Absorbed by plants as $Fe2+$ & $Fe3+$, activation of enzymes
- Component of porhyrin, cytochromes, hames, hematin, ferridoxin, ferrichrome and haemoglobin (imp. In photosynthesis & respiration)
- 75% of Fe is associated with chloroplast, required for synthesis of chlorophyll
- Important component of nitrogenase enzyme essential for N2 fixation

Manganese

- Anonymous role like Fe Involvement in photosynthesis for evolution of O2
- Oxidation-reduction reactions and Enzyme activation (citric acid cycle)
- Mn can substitute for Mg in phosphorylating & group transfer (ETC
- Manganese helps in chlorophyll formation, Important in nitrogen metabolism

Zinc

- Involved in many enzymatic activities
- Zn required for synthesis of tryptophan-amino acid necessary for the synthesis of growth hormone
- Component of synthetic & natural organic complexes

Copper

- Important role in enzyme activity acceleration
- Protein & carbohydrate metabolism
- Helps in utilization of Fe during chlorophyll synthesis
- Synthesis of complex polymers like lignin & melanin. Indirect effect on nodule formation

Boron

- Primary role in Ca metabolism (Boron increases the solubility and mobility of Ca in plant
- Cell development in meristematic tissue, Proper pollination, fruit & seed set
- Translocation of sugars, starches, N and P
- Synthesis of amino acids and proteins, nodule formation, regulation of carbohydrate
- Pollen germination & pollen tube growth

Molybdenum

- Essential component of nitrate reductase enzyme which catalyses the conversion of NO3 to NO2
- Structural component of nitrogenase enzyme involved in N2 fixation by Azatobactor
- Role in absorption and translocation of Fe
- Involvement in protein synthesis

Chlorine

- Osmotic regulation & cation neutralization
- Maintaining leaf turgor
- Cl acts a co-factor in Mn containing O2 evolution for photosynthesis
- Cell elongation and stomata opening
- In absence of Cl photosynthesis rate reduced

Management of Nutrient Solution in Hydroponic System

1. pH and its management
2. EC and its management
3. Composition of nutrient solution
4. Temperature of nutrient solution
5. Oxygenation of nutrient solution

pH and its Management

The pH value indicates the relationship between the concentrations of free ions H+ and OH- present a solution and ranges between 0 and 14. Changing the pH of a nutrient solution affects its composition, bioavailability and speciation (Table 3) (Distribution of elements among their various physical and chemical forms like chelates, soluble complexes, ion pairs etc.).

Table 3: Nutrient Responses to change in pH.

Sr. No.	Nutrient	Responses to change in pH
1	Nitrogen	* In nutrient solution only NH3 forms a complexes with H+. * pH range between 2 and 7: NH3 is completely present as NH4. * Increasing the pH above 7.0, the concentration of NH4 decrease, with the concentration of NH3 augments (De Rijck G. & Schrevens, E. (1999) * At pH 8.5: Ammonia oxidation rate increases compared to nitrite oxidation rate that resulting in the accumulation of NO2 to toxic or harmful levels to plants.
2	Phosphorus	* Plant usable forms of phosphorus are strongly influenced by solution pH. * At pH 5 largest amount of available forms are HPO42- and H2PO4- ions * In acidic and alkaline solutions the concentration of available phosphorus decreases significantly. * At alkaline pH chemical available forms get complexed with Ca2+

3	Potassium	* Potassium is almost present as free ion in a nutrient solution with pH values from 2 to 9 but only small amount of K^+ forms a soluble complex with $SO4^{2-}$ or can be bound to Cl- (De Rijck G. & Schrevens, E. (1998).
4	Calcium	* Availability is at wider pH range but the presence of other ions interferes with their availability due to the formation of insoluble complexes. * As water naturally contains HCO3, this ion get converted into CO_3^{2-} when the pH is higher than 8.3. * When pH is less than 3.5, the H2CO3 and CO2 becomes equilibrium with each other.
5	Fe, Mn, Zn and Cu	* At pH higher than 6.5: Fe, Mn, Zn, Cu and boron becomes unavailable. (Tyson, 2007) * Boron is taken up by plants as boric acid and availability is high at acidic range or near neutral but not > 7.0.

Management of pH:

- The changes in the pH of a nutrient solution largely depend on the difference in the intensity of nutrient uptake by plants. Higher anion uptake than cation for example, uptake of NO3-N causes the plant to excrete OH- and HCO3- anions to balance the charge that increases pH value which is termed as physiological alkalinity (Marschner, 1995).
- Many times use of ammonium as N source in the nutrient solution regulates the pH and therefore nutrient availability is ensured. Breteler & Smit (1974) reported that ammonium depressed the pH of nutrient solution even in the presence of nitrate.
- The pH adjustment mostly requires to reducing the pH by adding acids. Regulation of pH is normally carried out by using nitric, sulphuric or phosphoric acid, and such acids can be used either individually or combined. The pH is closely related to the concentration of HCO3- and CO32-; when an acid is applied, the CO32- ion is transformed to HCO3- , and then HCO3- is converted into H2CO3.

Electrical conductivity:

The concentration of ions in solutions determines the growth, development and production of plants (Steiner, 1961). The nutrient salts dissolved in water exert a pressure called osmotic pressure (OP) which is colligative property of solution containing nutrients and it is dependent on the amount of soluble salts dissolved salts. The solutes present in nutrient solution reduces the free energy of water. An EC measurement can be a good indicator for availability of nutrient ions in the root zone from nutrient solution (Nemali and Van Lersel, 2004). The dissolved ion related to EC are Ca2+, Mg2+, K+, Na+, H+, NO3-, SO42-,Cl- ,HCO3-,OH etc. EC or total soluble ions are specific for each crop and dependant on environmental conditions like temperature and humidity (Sonneveld and Voogt, 2009) (table 4 and 5). Optimum EC values for most of urban agriculture or hydroponic system ranges from 1.5 to 2.5 dSm-1 while higher EC hinders or reduces water availability and nutrient uptake.

Management of Electrical Conductivity

- The change in electrical conductivity appears due to the uptake of water and nutrients by plants.
- Hence increase and decrease in the concentration of some ions in nutrient solution is observed during crop growth.
- It is observed that iron concentration decreased rapidly while that of Mg2+, Ca2+, and Cl- increased further, concentration of K+, Ca2+ and SO4 2- did not reach critical levels
- Instead, in an open system with recirculation of nutrient solution, an increase in the EC value due to the accumulation of high levels of some ions like bicarbonates, sulphates and chlorides is observed (Zekki et al. 1996). So, the recycling of nutrient solution represents a point of discussion.
- Moreover, the substrates can retain ions and consequently the EC increases. To reduce the salt accumulation in substrates, controlled leaching with water of good quality is an alternative (Ansorena, 2004).
- The use of mulching with polyethylene or polypropylene sheet reduces water consumption, increases the calculated water use efficiency and decreases the EC of the substrate; so the mulching is an alternative to control of EC too (Farina et al., 2003). (Tanji, 1990)

Table 4: Nutrient solutions and salinity levels as per crops.

Salinity group	Threshold EC (dS m^{-1})	Crops
Sensitive	1.4	Lettuce, carrot, strawberry, onion
Moderate sensitive	3.0	Broccoli, cabbage, tomato, cucumber, radish, pepper

Table 5: Optimum EC and total soluble Salts in Nutrient Solution

Sr.No.	Crop	Optimum EC (dSm^{-1})	TSS ($mg\ L^{-1}$)
A. Leafy Greens			
1	Lettuce	0.8 to 1.2	550 t0 800
2	Spinach	1.8 to 203	1260 to 1610
3	Celeray	1.8 to 2.4	1260 to 1680
4	Basil	1.0 to 1.6	700 to 1120
5	Mint	2.0 to 2.4	1400 to 1680
6	Pok –choy	1.5 to 2.0	10501400
B. Fruity vegetables			
1	Cucumber	1.7 to 2.65	1190 to 1750
2	Peeper/capsi-cum	1.8 to 2.8	1400 to 2000
3	Tomato	2.0 to 4.0	1400 to 2800
4	Broccoli	2.8 to 3.5	1960 to 2450
5	Cabbage	2.5 to 3.0	1750 to 2100
6	Zuccini	1.8 to 2.4	1860 to 1680

Composition of Nutrient Solution

Composition of nutrient is generally depends upon the requirement of crop. When a nutrient solution is applied continuously, plants can uptake ions at very low concentrations. So, it has been observed that a high proportion of the nutrients are not used by plants or their uptake does not impact the production.

No adverse impact was found on growth, fruit yield and fruit quality of tomato when concentration of nutrients is reduced by 50% (Siddiqi et al. 1998). However, it is also observed that in particular situations, too low concentrations do not cover the minimum demand of certain nutrients. On the other hand, high concentrated nutrient solutions lead to excessive nutrient uptake and therefore toxic effects may be expected.

There are different essential nutrient recipes developed by various authors as stated in table 6. Further , Fertilizers containing essential nutrients commonly used for nutrient solution is also stated in table 7.

Table 6: Essential Mineral Element Nutrient Concentration according to various authors

Nutrient	Hoagland and Arnon (1938)	Hewitt (1966)	Cooper (1979)	Steiner (1984)
mg L^{-1}				
Nitrogen	210	168	200-236	168
Phosphorus	31	41	60	31
Potassium	234	156	300	273
Calcium	160	160	170-185	180
Magnesium	34	36	50	48
Sulphur	64	48	68	336
Iron	2.5	2.8	12	2-4
Copper	0.02	0.064	0.1	0.02
Zinc	0.05	0.065	0.1	0.11
Manganese	0.5	0.54	2.0	0.62
Boron	0.5	0.54	0.3	0.44
Molybdenum	0.01	0.04	0.2	Not considered

Table 7: Fertilizers containing essential nutrients commonly used for Nutrient Solution

Fertilizers	Formula of Nutrient Salt	Nutrient Content	Solubility g L^{-1} at 20^0C
Calcium nitrate	$Ca(NO_3)_2.5H_2O$	N: 15.5; Ca:19	1290
Potassium nitrate	KNO_3	N:13; K:38	316
Magnesium nitrate	$Mg(NO_3)_2.6H_2O$	N:11; Mg:9	760
Ammonium nitrate	NH_4NO_3	N:35	1920
Monopotassium phosphate	KH_2PO_4	P:23; K:28	226
Monoammonium phosphate	$NH_4H_2PO_4$	N:12, P:60	365
Potassium sulphate	K_2SO_4	K:45; S:18	111
Magnesium sulphate	$MgSO_4.7H_2O$	Mg: 10; S:13	335
Ammonium sulphate	$(NH_4)_2SO_4$	N:21;S:24	754
Potassium chloride	KCl	K:60; C:48	330

4. Temperature of Nutrient Solution

- At high temperatures of the nutrient solution an increased vegetative growth to a greater extent than desirable is observed, which reduces fructification and may enhance pest attack. The temperature of the nutrient solution drastically affects nutrient availability, water and nutrient uptake and translocation of nutrients within the plant system.
- In tomato plants, rates of water and nutrient uptake by roots (which varied depending on solar radiation) were studied by Falah et al.,2010 and reported that high solution temperature (350C) in the long-term, solubility of oxygen was reduced, while enzymatic oxidization of phenolic compounds in root epidermal and cortex tissues were stimulated, but nutrient concentration in root xylem sap diminished, and the root xylem sap concentration of N, K, Ca became lower than those in the nutrient solution (Falah et al., 2010).
- Leaf length, leaf number and total fresh and dry biomass weights per plant were higher in plants grown at elevated temperatures, with optimum growth being recorded at 28 °C (Nxawe et al., 2009). Graves (1983) observed that at temperatures below 22 °C the dissolved oxygen in the nutrient solution is sufficient to cover the demand of this element in tomato plants.

Oxygenation of Nutrient Solution

The oxygen content is also affected by growing media. The consumption and solubility of oxygen increase when the temperature of nutrient solution increases (table 8) thereby enhancing relative concentration of CO2 in the root environment (Morard & Silvestre, 1996). Further, decrease in oxygen content below 3 or 4 mg L^{-1} of inhibits root growth and produces changes to a brown colour, which can be considered the first symptom of oxygen lack (Gislerød and Adams 1983).

Nonetheless, substrates under long cultivation periods usually present increase of organic matter content and microorganism activity, which could lead to an increase in the competition for oxygen in the root environment. Yet, roots are densely matted within the substrate, which alters diffusion and supply of oxygen (Bonachela et al., 2010). Generally 3% H2O2 @ 1 ml per litre was found beneficial for profuse root growth, nutrient uptake, boos plant growth, kills bacteria and also helps to fight root rot and fungi.

Table 8: Solubility of Oxygen in Water as Influenced by Temperature

Temperature(^{0}C)	Oxygen solubility (mgL^{-1} of pure water)
15	10.08
20	9.09
25	8.26
30	7.56
35	6.95
40	6.41

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Global Innovations in City Gardening for Food and Nutritional Security

R. Vasantha[1]

ABSTRACT

Today, the importance of both rural and urban areas in reconstructing food systems is growing. It is necessary to revisit how our food is grown, distributed and eventually ends up on our plates. From a production perspective, agro ecological practices and family farming must be viewed as a way of life whereas availability of safe, nourishing and culturally appropriate food for everyone is vital from a consumption standpoint.

Urban and periurban gardening will make cities sustainable and resilient which is the prime focus of the UN's Sustainable Development Goal 11. With an acknowledged status and duty legally required by the COAG, 1999 FAO worked proactively through its multidisciplinary initiative "Food for the Cities." (Makiko Taguchi and Guido Santini, 2019).

Innovations in City and Peri-urban gardens in different parts of world are ample. Urban farming contributes 30%, 50% and 85% of the vegetables consumed in Kathmandu, Karachi, and Shanghai respectively (FAO, 1996). The strategy for assisting the regional food system through creative vertical facades for seed gathering, green walls and floating greenhouses fits Shanghai's strategy adequately.

Many innovations in marketing of urban farming produce such as organizing farm visits, monthly 'healthy lunches' and guaranteed purchase of vegetables before harvest are seen in the city of Rosario, Buenos Aires.

Keywords: Urban Agriculture, City Gardening, Food Security, Nutritional Security

Introduction

Innovations in Urban Agriculture bring novelty in available plant cultivation systems and technologies. Building-integrated agriculture or Zero-Acreage Farming (or Z-Farming) is taking forms of rooftop agriculture and vertical farming. Rooftop greenhouses (mainly found in North America, Asia and Europe) and Vertical farming systems are often equipped with high end technology and integrate the production of quality fruits and vegetables, with services such as workshops and catering. (Francesco Orsini, 2020). The paper discusses innovative urban farming models of different parts of world for replication in similar geographical conditions.

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Global Cutting edge innovations in city gardening

Smart roofs for smart cities, Rotterdam: DakAkker in Rotterdam is the largest rooftop farm in Europe, is fitted with a 1,000 m2 smart roof that works as a sensor with a superior water storage capacity and is downpour-proof. When extreme rain is predicted, the smart control reacts by making extra water storage capacity available 24 hours in advance. The rooftop system also acts as an insulation layer reducing outside temperature by 30-40 degrees Fahrenheit. This smart urban roof grows organic fruits, vegetables, flowers, herbs, chicken and bees to protect biodiversity. Compost is made and used on the roof itself as well as sold as "worm tea" (liquid compost) to shops and consumers.

Consumption links of DakAkker: Bistro 'Op het Dak', the restaurant, located on the roof, uses the super fresh harvest of the DakAkker for its menu. The fruits, vegetables, and edible flowers are also delivered to other local restaurants, sold during festivals and in high season directly to visitors every Friday. All produce is delivered within walking or cycling distance, keeping the food chain as short as possible (Bright vibes, 2021).

Trash dump turned to a Agricultural Zone, Shanghai, China

Laogang in Shanghai has an enormous trash dump of about 6.5 sq km, of which 80% is converted into manure which is used in city's agricultural zone to produce about 55% of the vegetables and 90% of the green-leaf vegetables for city dwellers. (Eden green technologies, 2022)

Urban Plant Factory, Changzhi: World's most advanced seedling raising machine is located in Yuzhuang, Changzhi City. Tower has LFD spectrum technology, intelligent control of temperature, humidity and carbon dioxide concentration. In a total area is 35,000 square meters, workshops of vegetable seedling cultivation, vegetable production and a Chinese herbal medicine planting were found. The "Plant Factory" can raise more than 600,000 seedlings per batch at one time, and can raise 12 seedlings per year. The products meet the needs of various counties and districts in the city and also reach Shandong, Jiangsu, Zhejiang and other parts of China. (Smart farmer, 2021).

Vertical Indoor Farms of Gotham Greens, USA: The vertical farms are supplying the inhabitants of New York and Chicago with fruits and vegetables (Leafy greens and herbs, including lettuce varieties such as butter, California crunch, romaine, green and red leaf along with basil) grown without soil, pesticides and with an irrigation system based on reusing water. A soilless base is made using coconut coir, rock wool, peat moss or perlite. Water is continuously recycled, filtered and tested. Robotics, artificial intelligence (AI), computer vision, sensors, monitors, testing systems and controls are installed and farms rely on natural sunlight for photosynthesis. During winter months, when daylight is shorter, supplemental LED lights glow to optimize the total amount of light needed for growth. (Gothamgreens, 2023)

AeroFarms, USA: Newark, USA uses aeroponics to grow 250 types of leafy greens such as arugula, kale and spinach without sun or soil in a fully controlled environment. The technology enables year-round production with less water consumption and high yields per square metre. The rectangular gargantuan growing machine about 20-feet tall has a stack of growing beds with LED lights, each bed is 20-feet long (Malavika Vyawahare, 2016). In Paris, a startup called Agricool grows strawberries in cooltainers using similar aeroponics technology (Agricool, 2015).

Swale, the floating Food Forest on Barge: Mary Mattingly, the founder started a food forest on a barge, in New York City, USA utilizing marine common law to make her floating food forest legally and publicly accessible. This moving island, surprises and elevate peoples' senses due to its perennial native fruit trees and shrubs, leafy self-seeding annuals and salt loving grasses (The Barge, 2016).

Sharing Backyards, Canada: Through the initiative's website, those with unused property post their approximate location, and those looking for space to grow food locally can search locations nearby at no cost. Sharing Backyards is set up throughout Canada, the United States, and New Zealand. Support for starting and maintaining the shared backyards is offered by staff (Sandra MacGregor, 2022).

Transforming Shipping Containers to Cropboxes, Abudhabi: Crop box is a controlled environment agriculture system that produces leafy crops year-round. They are also designed to grow vegetables in 40-degree desert of Abudhabi heat by pairing old shipping containers and high-tech hydroponics. In Masdar City - an urban development project in Abu Dhabi - Madar Farms are using hydroponic systems that require much less water than traditional farms, to grow lettuce, herbs and brassicas. Plants are grown in a controlled environment inside the container, with nutrients coming from enriched water, with no pesticides. LED lighting with deep red and blue hues mimics sunlight and cycles on and off to simulate periods of day and night for the plants. The containers, which are 12.2 meters long and 2.4 wide, are stackable, durable and easy to modify (World Economic Forum, 2019).

Japan Food Mileage: Distance between food production and consumption sites is 644kms in USA, 50kms in Canada, 20-100kms in EU whereas it is within a cycling distance of 0.5 to 1 kms for 71-84% of consumption sites in Tokyo. Due to high prices for lands, only 10-30 sqmts of lands are leased out to urbanites for farming. Urban farm produce is sold in markets called Choku baayi Jyo (Rambabu P, 2023).

Tokyo's Food Garden in Corporate Office: The green space in corporate office building at Pasona, Tokyo, Japan totals over 43,000 sqft uses both hydroponic and soil based farming with 200 species including fruits, vegetables and rice that are harvested and served at the cafeterias within the building. Tomato vines are suspended above conference tables, lemon and passion fruit trees are used as partitions for meeting spaces, salad leaves are grown inside seminar rooms and bean sprouts are grown under benches and a rice paddy and a broccoli field in main lobby. These crops are equipped with HEFL, fluorescent and LED lamps, automatic irrigation system, an intelligent climate control monitors humidity, temperature and breeze. Seasonal flowers and orange trees are planted on the balconies between the double skinned façade (Inside flows, 2022).

Floating Dairy Farm, Rotterdam: The farm currently houses about 35 cows on a two-story floating platform in Rotterdam. Cows are fed food waste from the city and their waste is then used to create fertilizer for nearby fields. The farm is expected to produce about 800 liters of milk daily. It also has a floating chicken farm and a floating vegetable farm (Bright vibes, 2021).

Growing Mushrooms from Coffee grounds in Cities, Rotterdam: Rotterdam is growing oyster mushrooms on coffee grounds and coffee husk in an abandoned swimming pool in the city Centre, and also a Grow kit is developed and sold to people to convert their coffee grounds into food at home. Husk, stored in plastic bags is picked up for free every month. Mushrooms are sold for 10 Euros per kilo to restaurants and catering businesses and 15 Euros per kilo to consumers (RUAF, 2015).

Community Food Forests

L shaped Picasso Food Forest (Parma Italy) covers an area of about 4500 m2 and has the shape of two rectangles is hosting more than 185 trees, shrubs and more than 200 plant species and varieties. The barren grassland was transformed into a blooming green area where residents of the Picasso neighborhood meet, connect and forage their food. Melbourne Kensington and Per.ka, Parma, Italy, Sherett, Portland, USA (Melissa Manuel, 2021) are examples of other food forests

FAO efforts in the Poorest Country- Tegucigalpa, Latin America: the case of Honduras

FAO and the district mayor's office launched the "Pilot Project for Strengthening

Urban and Peri-urban Agriculture and Food Security" in Tegucigalpa, one of the poorest countries in the world. 1200 participants were given two-month weekly training on home gardening on low-cost and locally-adapted gardening technologies. Follow-up studies found that almost 90% of the people trained had established gardens and were growing up to 30 different species of plants. Tegucigalpa became a signatory to the Milan Urban Food Policy Pact and is committed to strengthening its food system (Makiko Taguchi and Guido Santini, 2019).

Women led Urban Growers Collective of Chicago

Urban Growers Collective is a Black and women-led, non-profit, urban vegetable farm in Chicago, Illinois. In partnership with After School Matters, Youth Corps teen job training program engages over 180 youth annually, teaching bargaining, leadership skills, communication skills, advertising skills etc. It cultivates eight urban farms on 11 acres of land, on Chicago's South Side. Produce is available at Fresh Moves Mobile Market, farmers' markets and in Collective Supported Agriculture program (Urban grower's collective, 2017).

TERRAE Contract Systems from Self-Production to Self-Employment.

Urban farming enthusiasts were trained in 3 stages empowering them from cultivation to marketing. In the first stage, each participant receive 50 hours of training in agro-ecology and is offered 50 square meters individual plot for 6–12 months and advised for self-consumption not sale. In the second stage, area is increased to 1,000 square meters and are trained in production for local markets they sign a contract with a local restaurant to provide seasonal vegetable boxes for 2–12 months. After one year of self-employed labour practices, the beneficiaries must register in the social security service under 3rd stage. These contracts are signed by the micro-farmer, the DILAS advisor, a local councilor and the holder of the restaurant. (Franco Llobera Serra Marian Simon Rojo, 2014)

Linking children and youth to Urban gardening in Liberia

4,500 students from 290 schools in Liberia received hands-on skills training in growing vegetable gardens and cassava fields on 60 hectares. Liberian youth (aged 16–35) were also linked to domestic and international markets. Seed money is placed into small businesses focused on ancillary services in the agriculture sector. School grounds of C.B. Harris Memorial primary school, Monrovia, Liberia grow half a hectare of okra, peppers, cabbage and other vegetables. Gardeners as young as six years old work with a teacher every day after school, learning the best way to plant seeds and harvest food (Nico Parkinson, 2014). The Askîy project is another example of learning Urban gardens for youth in Saskatchewan, Canada. (CHEP goodfood, 2016).

Tobacco Farmers turned to City Food Producers in Spain

Between 2010 and 2013, the Spanish Ministry of Agriculture and the trade union ComisionesObreras (CCOO) launched a pilot project called TREDAR for training unemployed people from the tobacco sector in organic agriculture. These newly trained micro-farmers entered into contracts with groups of at least 10 consumers in the capital city of Madrid who would pay 40 Euros per month in return for 20 kg of at least five seasonal vegetables. (Franco Llobera Serra Marian Simon Rojo, 2014)

Saline Desert Farm, Oman

Hortus Aquarius- saline desert farm simulates a semi-natural cultivation method. Seeds are allowed to germinate and grow for one week in fresh water and then for the next 4 weeks, seedlings are grown with salty effluent collected from circular aquaculture system of Aquapolis. After irrigation the effluent from the saline vegetable lagoons is collected in a basin and stored for further re-utilisation. The system secures year round availability of fresh saline vegetables. (Gilbert Curtessi Maarten Feberwee, 2014)

The Farmery, NC, USA

The Farmery is an innovative urban market that combines a retail grocery, a cafe and indoor agricultural systems that offers the customer an educational and stimulating food shopping experience. Here, urban consumers can participate in the harvest of crops and fish. The system uses aquaponics which has three components: a stream like flowing raceway tank, where biofilters convert wastes to nutrients and filter this water through vertical growing panels, where crops are grown. (Benjamin Greene, 2013). La Food Forest (Plettenberg Bay, South Africa) is a similar kind of food forest combined with Café, at La Vista Lodge providing the hotel guests with delicious, locally grown food. (Amos Kapenda, 2019)

Sky Greens, Singapore

In a small country where locally grown vegetables make up only 7% of consumption, imports majority of their food is from China, Indonesia, Europe and the United States. Sky Greens' founded by Jack Ng, is a low-carbon hydraulic water-driven urban vertical farm. The three storeys-high vertical systems produces 5-7 times more per unit area compared to conventional farms. Lettuces and cabbages are grown year-round using less energy and water. The produce is still priced competitively and found at grocery stores in Singapore (Skygreens, 2012).

Indian Innovations

Growing Food on Railway Tracks: Mumbai is a city that has little open space and also is one of the largest slums in the world. Indian Railway has leased its land along railway tracks for cultivation of vegetables and flowers to keep the land clean and useful (Vallabh Ozarkar, 2022). (Samrat Mukherjee and Kate Chaillat, 2013)

Urban Gardens for Cancer Stricken Children: The Earthen Routes initiative -run urban farm located inside the campus of Tata Memorial Centre for Cancer, Navi Mumbai, produces a variety of organic vegetables, with the help of volunteers, is distributed at no cost to the children being treated at the research facility. (Earthen Routes, 2022)

City Farming by Rural Farmers: Urban Mali Network in Bengaluru city employs 54 urban malis, the migrant farmers who set up and maintain gardens of different scales and sizes in the city and earn approximately Rs. 18,000 to 21,000 per month. (Saumitra Shinde, 2022)

Compost from City Waste feeds Fishes and Crops: In Kolkata, Agricultural labourers use aquatic plants and sunlight to treat the waste water and also use strips of land in the low lying area to compost the organic waste from the city. The treated water is used for pisciculture in 3500 hectares and vegetables are grown in 350 acres. 26000 urban poor work in this venture. (Monica Rand Varsha Gupta, 2018)

Digital Initiatives in Urban Farming: City residents in Bengaluru, Hyderabad and Surat can rent 600 sq feet of farmland through Farmizen, a mobile-based platform, to grow organic produce. Users can visit the farm anytime to grow and harvest chemical-free produce. Farmworkers oversee the plots. The app currently has 1,500 subscribers and 40 acres of land under cultivation. (Harshinivakkalanka, 2018)

Metro Farms in South Korea

In the skyscraper-studded metropolis, Seoul, urban farming community is a smart hydroponic farm placed in a Sangdosubway station, on Line 7, Metro Farm and in four more other stations throughout the urban center. Metro Farm is a sleek, glass-encased plant nursery housing rows upon rows of hydroponic growing trays. Under the glow of LED lights and the attention of an automated tech network, 30 varieties of organic edible plants, including microgreens, flowers, and sprouts are grown. It produces around 30 kilograms of fresh vegetables daily. Most of those go directly into the salad bowls and smoothies of the 1,000-odd customers who frequent Farm8's adjacent café. (Metrofarm, 2019)

Thammasat Rooftop on University Farm (TURF), Thailand: 22,000 square meters of “wasted space” on the rooftop at Thammasat University’s campus on the northern outskirts of Bangkok was transformed into the largest organic rooftop farm in Asia. TURF yields up to 20 tons of produce per year, including rice, fruit and indigenous vegetables and herbs. (WLA, 2020)

A vertical Farm tower, Mashambas feeding an entire town in Sub-Saharan Africa.

The tower was designed by Polish architects, farms on the upper floors and the other floors have kindergarten classrooms, a doctor’s office and a docking port for drones. The ground floor would include an open-air market, where farmers could sell their crops. Part of the tower was made of modular pieces, which would allow it to be taken apart and transported somewhere else (World Economic Forum, 2017).

Low Cost Innovations

India: Indian urbanites are making several low cost creative innovations to make their gardens attractive and relaxing. The list consists of mobile vertical towers for balconies, low cost drip, self-watering pots and innovations in making organic inputs, integrating several enterprises like poultry and fish with terrace gardens etc.

Sack Gardens, Kibera, Kenya: AIDS affected 32000 slum populations were allotted small plots and seeds for nursery raising. After the seedling attains 3 weeks of age it is transplanted in a unique sack with a stones spine with a volume of 0.1 to 0.5 m3. One sack holds 30-40 seedlings on top and sides. Households with access to 3-4 sacks can generate 33USD per month and also 2-3 times full meal (Peggy pascal and Eunice, 2009).

“Growing Pillar” (GP) and the “Growing Wall” (GW), Kenya: The vertical growing systems were attributed to saving lives during the period of post-election violence Kenya experienced in 2007-2008, when the community suffered massive food shortages. “Growing Pillar” (GP) is a cylinder (1/2sqmt width x 2 mts height) gives a minimum of nearly five square meters of growing surface, which is ten times greater than the occupied ground area. Growing wall is 50 cm in depth and 1 meter in height while the length may vary. Both utilize simple welded-wire fencing for the structure, fabric for the inner lining and high-quality compost and soil. Like the sack garden, the entire surface can be used to grow food. A vermicomposting component is added to the design. (Randall Coleman, 2009)

Terrace Pigeon Farming Dhaka, Bangladesh: Commercial Pigeon farming is done on terraces under semi scavenging system mainly for squab (tender meat) purpose. Crowned pigeon, Jacobin, Fantail Pouter, Swallow, Bokhara trumpeter and Frill back etc are expensive and fancy pigeons reared for decorative purpose (Ashraful Hoqueetal 2021).

Conclusion

The increased speed of migration into cities poses a barrier to access to healthy, nutrient-dense food for city dwellers. One solution to this challenge is the development and expansion of urban agriculture. Urbanites too have the chance to receive fresh, regional food thanks to city gardening. Nonetheless, consumers' good perceptions and acceptance of urban farming are necessary for urban agriculture to be effectively integrated into cities. Creation and upgrading of urban farmers' inventory and databases, R & D on Urban precision farming, encouragement and incentives to develop innovative crop management techniques and inputs that are both eco-friendly and economically viable are the need of the hour.

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A Critical Review of Vermi-Composting in Urban and Peri-Urban Waste Management Apropos Robust Environment

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ABSTRACT

Ever-increasing population growth, urbanization, and changing consumption patterns have led to an explosion in the amount of waste produced, especially in urban and peri-urban areas. Though urban organic waste contains relevant nutrients and organic matter, only 4% of global urban nitrogen (N) and phosphorus (P) sources are presently recycled. Through the vermicomposting process, using earthworms, organic wastes can be transformed into nutrient-enriched compost named vermicompost. Vermicomposting of urban waste, before land application, may be a sustainable waste management option, as the vermicast obtained at the end of the vermicomposting process is rich in plant nutrients and is free from pathogenic organisms. The vermicompost produced is both high in organic carbon (18.83-36.01%) and a potential fertilizer (1.16-2.58% N, 0.42-1.12% P, and 0.61-2.05% K). The nutrient profile in vermicompost is higher than traditional compost. It enhances soil fertility chemically, physically, and biologically. Vermicompost should be applied in moderate concentration to get maximum yield as high concentration application may impede growth due to the presence of a high concentration of soluble salt in vermicompost. The utilization of vermicompost produced from urban and peri-urban waste in agriculture will facilitate the growth of countries' economies by lowering the consumption of inorganic fertilizers and avoiding the land degradation problem.

Keywords: Earthworm, Waste Management, Urban Agriculture, Peri-Urban Agriculture, Vermicomposting, Solid Waste.

Introduction

Presently, solid waste management has become a worldwide concern. Day by day it is becoming more problematic due to rise in population, industrialization as well as changes in our lifestyle. The uncontrolled misuse of abundant

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resources has finally resulted in generation of a huge quantity of complex solid waste. Most of the waste generated is either disposed of in an open dump in developing countries or landfills in the developed ones. Landfilling as well as open dumping requires lot of land mass and could also result in several environmental problems. Waste management practices are necessary to keep the environment clean and green. Land application of urban/municipal solid waste (MSW) can be carried out as it is rich in organic matter and contains significant amount of recyclable plant nutrients. The presence of heavy metals and different toxic substances restricts its land use without processing (Singh et al., 2011). Vermicomposting of MSW, before land application may be a sustainable waste management option, as the vermicast obtained at the end of vermicomposting process is rich in plant nutrients and is devoid of pathogenic organisms (Suther, 2010). Utilization of vermicast produced from urban/municipal solid waste in agriculture will facilitate in growth of countries economy by lowering the consumption of inorganic fertilizer and avoiding land degradation problems. Urban/Municipal Solid Waste (MSW) is usually regarded as the waste that is generated from human settlements, small industries, commercial and municipal activities. Vermicomposting of urban/MSW can be an excellent practice, as it will help recycle valuable plant nutrients.

Vermicomposting as a way of Urban Solid Waste Management

Vermicomposting is a non-thermophilic process in which with a joint action of earthworms and mesophilic microorganisms organic wastes convert into a nutrient rich valuable end product called vermicompost (Bhat et al., 2017). Soil earthworms play crucial role in agriculture. They decompose dead organic litter by consuming it and releasing it as castings (Ali et al., 2021). The earthworms accelerate decomposition of plant litter and organic matter and improve soil fertility by releasing mineral elements in forms that are easily uptake by plants (Edwards, 1998). Although microorganisms are responsible for the biochemical degradation of organic matter, earthworms are crucial drivers of the process (Dominguez and Edwards, 2004). They by fragmenting and conditioning the substrate, alter its biological activity. In the vermicomposting process the earthworms aerate, fragment the substrate and thus it increases the surface area for microbes and modifies the microbial activity in organic waste residues for decomposition (Bhat et al., 2018). Vermiculture is a cost-effective tool for environmentally sound waste management (Pathma and Sakthivel, 2012).

Production Phase

The vermicomposting process different phases during the process are as follows (Garg, Gupta, 2009): (1) Initial pre-composting phase: The organic waste is pre-composted for about 15 days before being fed to earthworms. During this phase, readily decomposable compounds are degraded and the potential volatile substances are eliminated which may be toxic to earthworms. (2) Mesophilic phase: During this phase, earthworms, through their characteristic functions of breaking up organic matter, combine it with the soil particles enhance microbial activities and condition organic waste materials for the formation of organic manures. (3) Maturing and stabilization phase (Olle, 2019)

Raw Material for Vermicomposting

Cattle dung or farm yard manure (FYM) is used as raw material for vermicomposting, beside that any material that can be decomposed easily such as weeds, wastes (leaves and rind) of vegetables and fruits, crop residue, roughage of the animals as well as municipal wastes of organic origin could also be utilized for vermicompost preparation .The organic waste consumed by earthworms undergoes physical breakdown in the gizzard, which is then exposed to various enzymes such as protease, cellulose, lipase, chitinase, amylase, etc. secreted into lumen by the gut wall and associated microbes. the above enzymes cause breakdown of complex biomolecules into simple ones. Mucus secretions of gut wall provide structural stability of vermicompost. Only 5-10% of the ingested material is absorbed by earthworms for their growth and remaining is excreted as casting (Kumar et al, 2018) and by comminuting the organic matter they modify its physical and chemical status, gradually reducing its C:N ratio, increasing the surface area exposed to micro-organisms and making it much more favourable for microbial activity and further decomposition (Dominguez and Edwards, 2004). The behavioural activity of earthworms that are feeding, burrowing and casting, modify the physical, chemical and biological properties of organic matter and soil for plant growth and nutrient acquisition (Joshi et al., 2015).

Effect of Vermicompost on Agricultural Crop Performance

A. Yield: Studies on the production of important vegetable crops like eggplant (Solanum melongena), tomato (Lycopersicon esculentum) have yielded very good results. Vermicast produced higher garden pea green pod plants, higher green grain weight per plant, and higher green pod yield as compared to chemical fertilizer (Adhikary, 2012). The perusal of the data revealed that "Parthenium Vermicompost" applied at 5 t/ha enhanced the yield of eggplants (Solanum melongena. The use of vermicompost as a source of organic manure in supplementing chemical fertilizer is becoming popular among the farmers of the country. Vermicompost increases in crop yield probably because of higher nutrient uptake (Seethalakshmi, 2011).

B. Growth: Worms and vermicompost promoted excellent growth in the vegetable crop with more flowers and fruits development. Vermicompost can have dramatic effects on the germination, growth, flowering, fruiting and yields of crops (Mistry, 2015). Vermicompost stimulated growth of tomato transplants, with up to a 2.2-fold increase occurring in shoot biomass. Differences in growth were attributed mainly to differences in nutrient content of the potting mixtures, but some changes in physical and biological properties of the substrate could also be responsible (Tringovska, Dintcheva, 2012). Application of vermicompost increased seed germination, stem height, number of leaves, leaf area, leaf dry weight, root length, root number, total yield, number of fruits/plants (Joshi et al., 2015). (Table 1)

Table 1: List of parameters of various plants enhanced by vermicompost application

Sl.No.	Crops	Parameter enhanced	Reference
1	Wheat (Triticum aestivum)	Mean plant height mean stem-diameter, number of leaves per plant, number of spikes/ plant, spike length/plant, number of spikelets/spikes per plant, yield/acre, protein content, fat content, carbohydrate content, dietary fibers content, ash content Moisture content	Joshi et al. (2015)
2	Potato (Solanum tuberosum)	Net yield	Bhattacharya et al. (2012)
3	Maize (Zea mays)	Number of leaves, plant height, stem diameter, root volume, Mycorrhizal colonization, P content in leaves	Gutie´rrez-Miceli et al. (2008)
4	Groundnut (Arachis hypogaea)	Number of leaves, leaf area, plant weight, plant dry weight, root length, shoot length, N content, Mg content, Ca content, K content, P content, no. of seeds/plant	Mycin et al. (2010)

5	French bean (Phaseolus vulgaris)	Germination, height of plant, number of leaves per plant, length of leaves, width of leaves, number of pods per plant, length of root, number of nodules, above ground dry plant biomass, below ground dry plant biomass, yield per plot, number of seeds per pod	Singh and Chauhan (2009)
6	Mustard (Brassica)	Leaf area, leaf area ratio, Crop growth rate, net assimilation, harvest index	Banerjee et al. (2012)
7	Pea (Pisum sativum)	Number of leaves, root weight, root length	Khan and Ishaq (2011)
8	Marigold (Tagetes)	Plant weight, plant dry weight, P content, flower yield, number of flowers	Paul and Bhattacharaya (2012)

C. Nutrient content: Vermicast produced higher percentage of protein content and carbohydrates in garden pea as compared to chemical fertilizer. Application of vermicompost increased chlorophyll content, pH of juice, total soluble solids of juice, micro and macronutrients, carbohydrate (%) and protein (%) content and improved the quality of the fruits and seeds. Studies suggested that treatments of humic acids, plant growth promoting bacteria and vermicomposts could be used for a sustainable agriculture discouraging the use of chemical fertilizers (Joshi et al., 2015). Comparison of nutrient content of vermicompost and farm yard manure is given in Table 2.

Table 2: Comparison of nutrient content of vermicompost, FYM

Parameters	**Farmyard manure**	**Vermicompost**
pH	7.81 ± 0.01	7.82 ± 0.04
Organic matter (g/kg)	461.2 ± 1.31	495.5 ± 2.7
Total C (g/kg)	266.3 ± 0.51	286.5 ± 1.67
Exch. C/N ratio	18.5 ± 0.13	12.3 ± 0.13
Total N (g/kg)	14.4 ± 0.31	23.1 ± 1.0
Avail. P (g/kg)	6.59 ± 0.03	9.85 ± 0.10
Exch. K (g/kg)	8.87 ± 0.05	15.2 ± 0.19
Exch. Na (g/kg)	5.70 ± 0.01	6.03 ± 0.06

Exch. Mg (g/kg)	2.59 ± 0.06	6.74 ± 0.10
Exch. Ca (g/kg)	15.7 ± 1.31	23.8 ± 2.91
Ext Fe (g/kg)	5.59 ± 0.121	8.68 ± 0.14
Exch Cu (g/kg)	0.77 ± 0.01	0.97 ± 0.04
Ext Zn (g/kg)	8.31 ± 0.10	16.9 ± 0.17
Ext Mn (g/kg)	7.72 ± 0.12	13.6 ± 0.18

Source: Suthar 2010

d. Plant protection: The most significant observation was drastically lower incidence of diseases in worm and vermicompost applied plant (Table 3). Accordingly, vermicompost also protects plants against various pests and diseases either by suppressing or repelling them or by inducing biological resistance in plants (Sinha et al., 2013; Dunn, 2011).

Table 3: List of different pests/ pathogens controlled through vermicompost application in different crops

S.no	Crops	Pest/pathogen	Reference
1	Corn (Zea mays) plan	Earworm (Helicoverpa zea)	Cardoza and Buhler (2012), Joshi et al., 2014
2	Mustard (Brassica Juncea) plant	Aphid (Lipaphis erysimi	Nath and Singh (2011)
3	Cabbage (Brassica oleracea)	Earworm (Helicoverpa zea)	Little and Cardoza (2w011
4	Tomato (Lycopersicum esculentum) and cucumber (Cucumis sativus) plants	Green peach aphid, citrus mealybug and two spotted mites	Edwards et al. (2010a)
5	Cucumber (Cucumis sativus) and Tomato (Lycopersicum esculentum)	Beetles and hornworms	Edwards et al. (2010b)
6	Brinjal (Solanum melongena)	Meloidogyne incognita	Nath et al. (2011)

e. Human health: Organically grown fruits and vegetables especially on earthworms and vermicompost' have been found to be highly nutritious, rich in proteins, minerals and vitamins' and 'antioxidants' than their chemically grown counterparts and can be highly beneficial for human health. They have elevated antioxidants levels in about 85% of the cases studied. They have been found to be protective against several forms of 'cancers' and against 'cardiovascular diseases' (Sinha, 2012).

Conclusion

Disposal of the municipal solid waste is a serious problem worldwide. Land application of urban/municipal solid waste can be a good waste management technology as it is rich in organic matter and contains a significant amount of recyclable plant nutrients, but the presence of heavy metals and different toxic substances restricts its land use without processing. Composting of these wastes is a feasible option but compost resulting from the process is low in nutritive value and it is a time consuming process. Vermicomposting of solid organic waste from industrial as well as municipal origin can be a suitable alternative technology for managing this waste. As the end product is pathogen free, odourless and rich in plant nutrients as compared to conventional compost. Agricultural utilization of vermicompost will help in recycling the plant nutrients to soil and also avoid soil degradation. Vermicompost produced by the activity of earthworms is rich in macro and micronutrients, vitamins, growth hormones, enzymes such as proteases, amylases, lipase, cellulose chitinase and immobilized microflora. Vermicompost is optimal organic manure for better growth and yield of many plants. It can increase the production of crops and prevent them from harmful pests without polluting the environment. Application of vermicompost increased growth, improved plants nutrient content, and improved the quality of the fruits and seeds. The vermicomposting of these wastes will be very helpful in tackling the waste disposal problem as well it will be also useful in recycling the plant nutrients present and will convert this waste into useful resource.

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Urban and Peri-Urban Agriculture Practices in Different Countries: A Systematic Literature Review

Kaveya Pugazhendhi[1], Aisha Hameed[2] and Paul Mansingh J[3]

ABSTRACT

Urban and peri-urban agriculture (UPA) is the activities carried out on land and in other locations within the cities and their surroundings that produce food and other products through agricultural production and associated processes. A systematic literature review on the urban and peri-urban agriculture practices followed in different countries using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) method is presented in this paper. Using several search strings and advanced searches, 1014 articles were identified from the Scopus database. Later using inclusion, exclusion, and quality assessment criteria, 32 articles relevant to the subject were included in the study. This systematic review identified the UPA practices in nearly 20 countries like The Netherlands, Kenya, Italy, Nepal, India, Brazil, Ethiopia, Zimbabwe, Argentina, Nigeria, and a few more worldwide. The practices followed in the countries and the critical reasons behind the practices are analyzed in the study. However, in most peri-urban areas, agriculture is followed only for family consumption or for selling the produce in the local markets or communities. Vegetable gardening and mixed farming are the prevalent agricultural practices in urban and peri-urban areas. Co-operative model worker's gardens and collective plots of the shared garden are practiced in France that encourage the united farm work of villagers. UPA is reported to reduce the food miles and supply chain thereby reducing the carbon footprint. Farms cultivating many short-duration crops in a single field for multiple seasons increase soil fertility. Farming kits like 'Do-it-yourself' horticultural kits in India and 'Mushroom growing kits' in Switzerland and other such government kits were used to promote UPA. A greater number of studies were found in the eastern countries when compared with other countries around the world. Further research is required to identify the practices followed in other countries.

Keywords: Urban Agriculture, Peri -Urban Agriculture, Good Agriculture Practices

Introduction:

Urban and Peri-urban agriculture is a need to ensure the food safety and security of the growing urban population in the globe. Urban and Peri-Urban Agri-

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culture (UPA) is followed by different practices in different countries as per the need or demands of the people and the suitable environmental conditions prevalent in the country. However, most of the practices include the cultivation of vegetable and fruit crops (Lovell, 2010). UPA is practiced for satisfying the family needs or selling the produce in the local market. Roof top farming and vertical farming practices not only meet the food needs of the people but also reduce the impact of heat on summer days (De Zeeuw et al., 2011).

A systematic literature review is a formal and standard research method for finding, evaluating, and analyzing all studies that attempt to address related topics. A systematic review is a formal research study that follows a well-defined structure to find, review and analyze studies that attempt to answer associated questions. This SLR deals with the different agricultural practices followed by the urban and peri-urban places of different countries.

Methodology

The search was performed in the Scopus database. Various combinations of algorithms were considered, and the outcome of the research was used for the paper. Algorithms included the combination of keywords from each of the following search strings: a) "peri-urban agriculture" b) "urban and peri-urban agriculture" c) "urban and peri-urban agriculture practices" and d) "urban and peri-urban farming practices".

Initially, the screening was done based on the inclusion and exclusion criteria (Table 1). Later stages of article screening were done based on the title and abstract reading, where the studies related to a) Urban or peri-urban agriculture practices in a country and b) Different agricultural practices in an urban or peri-urban land area were included.

Table 1. Inclusion and Exclusion criteria

Criteria	Inclusion	Exclusion
Initial identification		
Literature type	Research articles	Review papers, Book chapters, series
Source type	Journal	Trade journal
Publication stage	Final	Press
Access type	Open access	Restricted access
Subject area	Agricultural sciences, Environmental and biological sciences	

Language	English	Non-English
Timeline	2013-2023	<2013
Screening		
Title and Abstract	Existence of predefined search strings in the title, abstract, keywords or introduction of the paper. Considered the agricultural practices followed in the urban and peri-urban area.	
Full text	Explained the urban and peri-urban agriculture practices in the State/ country.	

The number of studies from each database using the above-mentioned search strings was presented in table 2. The database search resulted in a total of 1014 articles. From the automation filters provided by the databases, 422 articles were marked as ineligible using the inclusion and exclusion criteria determined for initial identification (e.g. non-English, restricted access, review papers, etc.) and deleted from the records. From the remaining 1229 articles, using the Rayyan software, 337 articles were excluded after duplicate removal.

Further after screening the title and abstract 103 studies were eliminated for not having peri-urban agriculture, non-farmer population, and non-existence of predefined keywords in the title, abstract or keywords as a part of the paper. A total of 32 studies were chosen for quantitative analysis based on suitability, relevancy, and clarity of addressing socio-economic variables.

Table 2. Keywords used and total number of publications from databases

Database	**Search strings and search terms**		**No. of articles**
Scopus	Main search-ing terms	"urban" AND "agriculture"	1014
		"peri-urban" AND "farm"	31
		"peri-urban" AND "agriculture"	30
		"urban" AND & AND "peri-urban" AND " agriculture" AND "practices"	128
		"perl-urban" AND "agriculture"	47
		"peri-urban" AND "farm"	31
		"urban" AND "agriculture"	117
		"urban" AND "agriculture" AND "practices"	208
		"peri-urban" AND "agriculture"	4

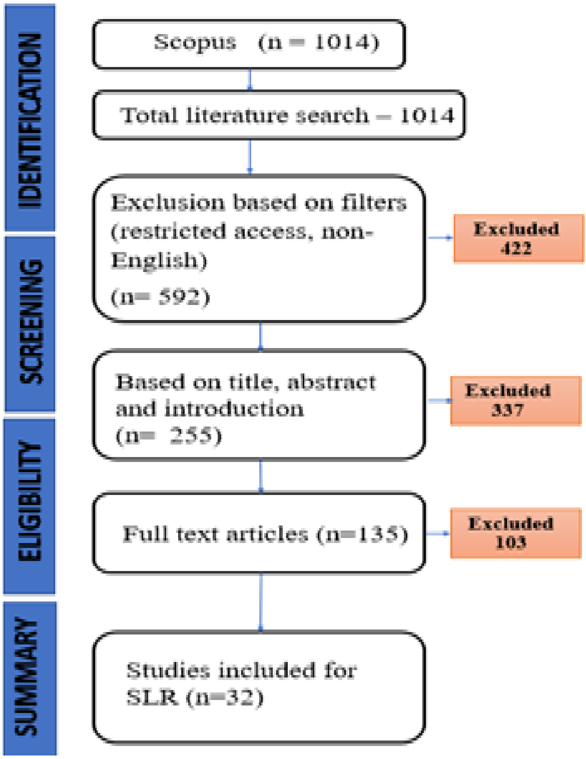

Figure 1: PRISMA flowchart depicting the number of studies inclusion and exclusion for identifying the Urban & Peri-urban Agriculture practice in different countries.

Results and Discussion

The focus of this study was to find the different agriculture practices followed in urban and peri-urban places around the world. In the peri-urban zone of Oosterwolde, Almere, The Netherlands, three types of agricultural practice are followed. Garden farming is practiced on smaller plots of land for kitchen gardening or poultry, while multifunctional agriculture is used for producing market gardens or livestock on larger plots of land. Conventional farming is carried out on even larger plots of land for national or global supply. The first two types are for local food needs, while the latter is for wider supply (Jansma et al., 2022).

In the urban and peri-urban regions of Nairobi, Kenya, people practice composting, open field farming, vegetable nurseries, various irrigation methods, farmyard manure, chicken rearing, multi-storey gardens, kitchen gardens, greenhouses, and cattle rearing mainly. In Turin, Italy, the protected areas of Stupinigi and La Mandria national parks are made greener by the woods and the oak-hornbeam groves for recreational purposes (Gottero et al., 2021). In the areas of Kirtipu, Madhyapur thimi, Tarkeshwor, and Harsiddhi of Kathmandu Valley, Nepal, people practice vegetable farming, tomato, carrot, and green leafy vegetables. They conduct monthly meetings and use manure-treated vegetables that give higher yields and prices (Rai et al., 2019).

In La Pintana and Lyon of France and Chile, there are workers' gardens and shared gardens, respectively. Lyon, France has over a hundred shared gardens for local and sustainable organic production. These gardens are based on a cooperative model of government policy and collective gardening and harvest. The involvement of local stakeholders is said to be the key to the success of this practice. (Silva et al., 2022). In Italy, UPA on rooftops and the ground is expected to meet the city's vegetable demand (Lucertini et al., 2021). In the Kensington peri-urban plots of Zimbabwe, people have shifted from cultivating maize to mixed farming with horticultural crops and livestock management due to climate change affecting cereal yields (Dube et al., 2021). Zero Acreage Farms numbering 73, in various cities across North America, have Asia, Australia, and Europe, had the potential to promote sustainable urban agriculture by using innovative practices, and farming technologies, and creating new patterns of food supply and urban spaces (Thomaier et al., 2015).

In Córdoba, Argentina, a total variety of 30 vegetable species were found across sampled farms, with 15 most common crops being grown. The practice of diversified farming aims to promote ecosystem functioning and related services such as soil fertility and productivity conservation, as well as crop diversity (Marinelli et al., 2023). In most parts of Nigeria, they practiced mixed cropping, which involved planting more than one crop on a single piece of land. Fluted pumpkin (Telfairia occidentalis) is primarily cultivated for its leaves and fruits in Nigeria (Oluwole et al., 2022). The text mentions that only images captured during the dry season with low to no cloud cover were chosen for analysis in Bolgatanga, Ghana. However, using dry season images may result in the misclassification of bare lands and farmlands as their spectral reflectance can appear similar (Kuusaana et al., 2022).

Agricultural activities continue to be practiced in the peri-urban areas of Sogamoso, where the soil is highly fertile, including in vacant spaces between residential and backyards and patios. The crops grown include various vegetables such as chard, chili pepper, celery, and fruits like apples, pears, and figs (Feola et al., 2020). Sixteen varieties of edible plants were grown using cultural techniques for pest control, which resulted in vegetables that were free from pesticides. In addition, converting household green waste into compost to improve soil nutrients and using rainwater and greywater for irrigation purposes are practiced (Gajbe et al., 2021). In Ethiopia, there is a need to improve milk production, and urban and peri-urban farms are crucial in achieving this goal. Peri-urban farms have more oxen and bulls than urban farms because they practice mixed-crop livestock farming. Common forages used to improve livestock feed quality include alfalfa, elephant grass, Rhodes grass, and sesbania (Balcha et al., 2022). Agriculture takes place through community gardens here. In Cuba, government policies encourage agricultural activities within the cities, including intensive vegetable gardens, gardens in companies and factories, and suburban farms, among other initiatives (Gomes et al., 2019).

In Andalucía, Spain, Collaborative SFSCs provide several benefits, including a variety of products for consumers, sharing of resources among producers, preservation of local food chain infrastructure, increased bargaining power for small producers, reduced competition between small producers, and mutual support to combat isolation and stress (Ochoa et al., 2020). Urban farming systems come in a range of technological levels, from high-tech options to low-tech ones, and are marketed to both professional farmers and consumers in other industries (Van-Tuijl et al., 2018). In Sunqiao vegetables, fruits, and herbs are grown vertically on skyscrapers. In Shanghai, more than half (56%) of the local population prefer leaf vegetables, which grows in hydroponic and aquaponic systems (Zareba et al., 2021).

Table 3. Urban and Peri-urban Agricultural Practices followed

Country	**Urban and Peri-urban Agricultural Practices followed**
Oosterwolde, Europe	Garden, multi-functional and conventional
Nairobi, Africa	Multi storey gardening, open field farming and vegetable nurseries
Kathmandu valley, Nepal	Vegetable farming
France and Chile	Permaculture, Shared Gardens
São Luís, Brazil	Intensive vegetable gardens, company and factory gardens, and suburban farms.
Venice, Italy	Roof top
Kensington peri-urban plots, Zimbabwe	Mixed farming
New York city	Zero Acreage Farming
Córdoba, Argentina	Diversified farming

Owo, Okitipupa and Akure, Ondo state, Nigeria	Mixed farming
Bolgatanga, Ghana	Irrigation-based vegetable production
Sogamoso, Colombia	Back gardens and patios
Funchal, Madeira island	Integrated kitchen gardens
Nagpur city, Maharashtra, India	Urban rooftop farming
Taipei, Taiwan	Zero acreage Farming

Summary and Conclusion

This systematic review identified the UPA practices in nearly 20 countries. The practices followed in the countries and the critical reasons behind the practices are analyzed in the study. In most peri-urban areas, agriculture is followed only for family consumption or for selling the produce in the local markets or communities. Vegetable gardening and mixed farming are prevalent agricultural practices. Co-operative model workers' gardens and collective plots of shared gardens are practiced in France that encourage the united farm work of villagers. UPA is reported to reduce the food miles and supply chain thereby reducing the carbon footprint. Farms cultivating many short-duration crops in a single field for multiple seasons increase soil fertility. Farming kits like 'Do-it-yourself' horticultural kits in India and 'Mushroom growing kits' in Switzerland and other such government kits were used to promote UPA. A greater number of studies were found in the eastern countries when compared with other countries around the world. Further research is required to identify the practices followed in other countries of the globe.

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Challenges of Food Security and Increasing Urbaniztion: Reliance on Peri-Urban Agriculture (PUA)

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ABSTRACT

As the world population is growing rapidly and urbanization is increasing, food security is becoming a major challenge. Accessibility, Affordability and Availability of food are the three core aspects of food security. Peri-Urban agriculture (PUA) can become an important source of nutritionally adequate and culturally acceptable food for urban populations. However, the problems like limited recognition, land conversion, water pollution and increasing competition from other sectors for limited natural resources pose a threat to the potential of PUA to contribute to urban resilience. Tackling food security needs analysis of all the different levels of a food system such as food production, processing, distribution and consumption. When assumed, high awareness of healthy food in PUA-derived markets, the loss of locally produced and highly perishable food is reduced due to shorter supply chains thereby contributing to the reduction in overall food waste. According to the projection, India's urban population would increase by a total of 400 million by 2050. Using peri-urban regions has emerged as the need of the hour, and innovations like vertical farming and hydroponics both contribute to an increased availability of nutritious food. Urban and Peri-Urban Agriculture (PUA) are generally not a choice; they are means of survival, providing people not only with food, but also a living. The abstract concludes by suggesting that peri-urban agriculture has the potential to contribute to a sustainable and resilient food system in the face of global challenges.

Keywords: Peri-Urban Agriculture, Urban Agriculture, Food Security, Urbanization, Supply Chain, Vertical Farming, Hydroponics

Introduction

Food production is not only constricted to Rural areas but ordinarily occurring in the cities and their boundaries. The attention to contribution of urban and peri urban agriculture has been grown, but it remains undervalued. Peri-urban areas are transition zones located between urban and rural areas, characterized by a mix of agricultural and non-agricultural land uses. PUA is a critical component of food security in many urban areas, providing access to fresh, nutritious, and affordable food. Urban agriculture is another alternative to peri-urban agriculture

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that can contribute to food security in cities. It refers to the production of food within urban areas, including backyard gardening, community gardens, and rooftop farming (Smit et al., 1996). However, urban agriculture alone cannot meet the increasing demand for food in urban areas. The increasing demand for food in urban areas has led to the expansion of peri-urban areas worldwide. PUA is a vital source of income for peri-urban farmers and provides food to urban populations. Moreover, the peri-urban agriculture is capable to shorten the carbon emissions and magnify the carbon sequestration, thereby alleviating the effects of climate change. However, PUA faces several challenges, including land-use conflicts, water scarcity, environmental pollution, and inadequate infrastructure.

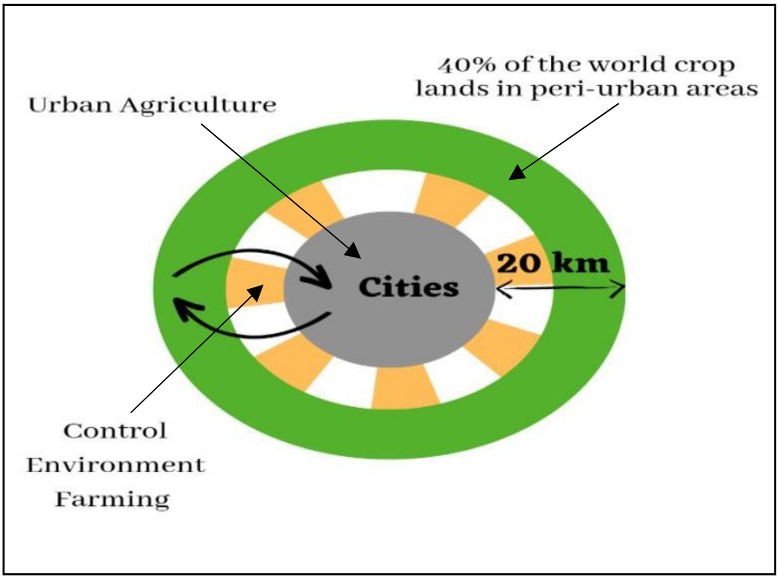

Figure 1. Location of urban agriculture (UA), peri-urban agriculture (PUA) and control environment farming

Background Information

The world population is growing at an alarming rate. Most of this population growth is centralized in urban areas and cities. Although many of those presently residing in cites, are facing the problems of malnutrition, Impoverishment and food insecurity in developing countries in the Global South.

The concept of urban and peri urban agriculture (UPA) refers to an industry located within or on the fringe of an urban area, using in-situ services, products and human as well as natural resources, to grow, to process and for distribution of agricultural products (FAO/WB,2008). For addressing the challenges of food security, the government has taken initiatives by providing the promising policy entry points to help the development of urban and peri urban agriculture.

National Land Utilization Policy

The goal of the national land utilization policy is to achieve improvement of livelihood, food and water security, and best possible realization of various developmental targets so as to ensure sustainable development of India, which also includes protection of agricultural lands from land use conversions so as to ensure food security and to meet consumption needs of a growing population and to meet livelihood needs of the dependent population. (Draft: National Land utilization policy, framework for land use planning and management, July 2013.)

Necessity of Peri-Urban Agriculture

With increasing urbanization and its population in the intermediary zones overlapping urban and rural areas the increasing food demands have to be met. The people residing in these areas are normally engaged in the agro based ventures, livestock cultivation and fishing. Therefore, the peri urban agriculture offers a fundamental strategy for building the resilience of a city's food supply.

The peri urban agriculture provides a source of fresh and healthy food for urban populations. There is an increased demand of food in urban areas with increase in population. In addition, due to reduced transportation time and distance between the production and consumption points, the carbon foot prints of food can be reduced and the fresh produce can be supplied.

PUA can provide the employment opportunities for both skilled and unskilled labor, and simultaneously it helps to individuals who have been displayed from rural areas or are unable to identify the employment in other sectors. Therefore, PUA is necessary approach to meet the increasing demand of food, to overcome the impact of climate change and for creating the employment opportunities as well as to promote the food security.

This review paper examines the various aspects of peri-urban agriculture, including its benefits and challenges, and discusses its potential as a sustainable solution for food security and increasing urbanization. The review also provides a critical analysis of the existing literature on peri-urban agriculture, highlighting the gaps and opportunities for future research.

Materials and Methods

Case Studies

The case study revealed the dynamics of Urban and Peri-urban agriculture in three major Indian cities, namely, Delhi, Mumbai and Hyderabad. The main focus is on the assessing the extent to which peri-urban agriculture facilitate food production and its impact on sustainability and well-being outcomes through food security in urban areas. Along with, it's also examined on the area utilization pattern, reasons and sources of motivation, models adopted, constraints and opportunities in urban and peri-urban (UPA) agriculture of diverse metropolis of India.

Figure 1: Location of the three cities on the map of India

Delhi

In administrative context New Delhi is the capital of India and a part of the National Capital Territory (NCT) with dense population of about 16 million (Census of India 2011) and geographically 'Yamuna' river and the Najafgarh drain water is the most significant water sources of irrigation for this whole region in purpose to carried out agricultural practices (Neelam et al.,2019) but, future is vulnerable due to lack of Government support and development of metro station along Yamuna bank (Harmanjot and Anuj, 2020).
The ten spots (Palla, Christian Ashram, Jagatpur, Wazirabad Barrage, Indraprasthan Power Station, Okhla Barrage, Noida and Basantpur) lies nearer to industrial area of Delhi, which are core source of contamination of water. Due to discharge of industrial effluents into the river increase level of metal contamination (Cd, Cr, Cu, Ni, Zn and Pb) which leads to accumulation of heavy

metals in soil which ultimately enters the vegetables, fruits and varied crops growing in fringes of the city and become constraint to nutritional security of urban residential (Arghya et al.,2015).

The study was conducted in the peri-urban environment of Faridabad city of National Capital Region (NCR) which undergoes land use transformation were the urbanization the key factor for catalyzing changes in land uses, land transactions, increased rural-urban migration and the overall transformation of land uses in peri-urban areas (Neha et al, 2011). associated air pollution threatens urban and Peri-urban (UPA) food production and its quality through gaseous air pollutants, particularly Sulphur dioxide, nitrogen dioxide and secondary photo- chemical oxidant, ozone (Agrawal et al; 2003). Recently, the issues in the peri-urban settlements shifted to new domains, including that urban agriculture, sustainability and even more importantly provision of urban infrastructure with related water management, energy management and waste disposal (Ravindran et al.,2011).

Concept of waterscape is to capture urban hydro-social flows continues to be theoretically and conceptually relevant in pointing out the interconnectness of economic, political, cultural and social processes embedded in water (Swyngedouw et al., 1999). Peri- urban Delhi, specifically the area around Ghaziabad, presents four keys 'problems' in terms of the conceptualization of waterscapes. The Peri-urban waterscapes do not fit into existing policy and planning models. They represent territories in-between urban and rural which are more than a simple mixing of the two (Wandl and Rooij, 2014). peri-urban spaces are seen as problematic and in a transition state towards a greater urban modernity by policy-makers. Still, they remain permanently and persistently in-between, because this serves the power dynamics between the poor and politicians, middle class employers and their laborer's (Lyla et al.,2015).

Mumbai

Mumbai, known as the commercial capital of India, becoming the fourth largest urban agglomeration in the world (Krishna and Govil, 2005; United Nations, 2010) having 9 million slum population (Census of India 2011). Result, to 'Urbanization of Poverty' characterized with poor provision for housing, water, sanitation, health, education and social security (UNDP, 2009).

Migration is an acute issue in Mumbai Metropolitan Region (MMR), Urban and Peri- urban (UPA) production in MMR play corner stone role in providing income generation through plenty of opportunities for migrant people and hence reduce urban poverty. To promote peri-urban (UPA) agriculture production (Harmanjot and Anuj, 2020) and create employment opportunities

Indian Railway started the "Grow More Food" with a motto to produce fresh vegetables near railway tracks of Central, Western and Harbor line to meet daily demand of urban people (Vazhacharickal and Buerkert, 2013).

The UPA in Mumbai started with Dr. Doshi's garden methods convenient to reduce spaces such as balconies and terraces which depends on locally available sugarcane waste, polythene bags and household organic waste. Mumbai Port Trust (MBPT) through the rooftop farming distributed fresh and healthy food to 3,000 employees per day (Chaitra and Amit, 2020).

Hyderabad

The Greater Hyderabad Area (GHA) is among south India's fastest growing urban conglomerations. With population of 6.8 million people (Census of India, 2011), has adopted an "infrastructure-led growth model" (Kennedy 2007).

The urban and peri-urban agriculture is the new trend that catching up in the city because of that more than 400 households in outskirts of the city currently self-reliant for vegetable needs of the family (Pranita et al. 2013). Due to increased access to information and extension advisory services of the Urban Farming Division (UFD) of Horticulture Department on implication of "terrace gardening" now urbanites have been habituated to work in garden as it gives a soothing impact from their "Business as routine" (Vincent and Suchiradipta, 2019). So, UPA can address food security and nutritional security of the urban and peri-urban dwellers (Veenita and Shirisha, 2022). Still there some constraints like crop choice, intensity of production, environment impact, water shortage in the urban fringes, nitrogen leaking, accumulation of chemical residues in farm produce and technologies in use in peri-urban farming. Through, studies on pesticide residues, reported high residual level in ground water in Hyderabad (Shukla et al, 2006). To overcome these challenges the policies in support to peri-urban farmers should not try to slow down on-going structural changes due to environment fluctuation because it's support leads to foster the supply of nutritional produce to urban people.

Conclusion

Peri-urban Agriculture also known as Multifunctional agriculture not only has the primary role of producing food and fiber but also functions in other dimensions as well. In these fringe areas of cities, the ventures of agriculture and its allied sectors can grow and propagate so as to ensure the food security in the urban areas. Not only this but it also helps in generation of employment for migrant people who have migrated from their homes (rural areas) to the urban areas in search of jobs. In conclusion, urbanization poses a significant challenge to global food security, and peri-urban agriculture is a critical component in addressing this challenge. However, PUA faces several challenges that threaten its sustainability and ability to provide food security for urban areas. Still the actions by government, Private sectors and people as a whole need to be taken to proceed forward with the food security issues in both urban and peri urban areas of developing countries.

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A Review on Utilization of Domestic Waste in Rooftop Vegetable Gardening

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ABSTRACT

Populations living in urban and peri-urban areas around the world are increasing rapidly. Rapid urbanisation is placing enormous demand on urban food supply systems and causing problems like a rapid decrease in green space and an increase in heat island effects in urban areas. Rooftop vegetable gardening can reduce the temperature of roofs and the surrounding air, help to lessen the urban heat island effect, and absorb carbon and noise. In some urban rooftop gardens, mineral fertilisers and pesticides are used. Researchers observed that compost can be used as a source of nutrients instead of mineral fertilizers. Moreover, it can control pests, weeds, and diseases; reduce soil erosion; and increase soil moisture content. Kitchen waste compost might be a suitable supplement in rooftop vegetable gardens because domestic garbage is common in every household in urban and peri-urban locations. In India, rooftop gardening is quite a new phenomenon. This review work will help to understand rooftop gardening and conduct research on rooftop gardens in the future.

Keywords: Domestic Waste, Rooftop Garden, Composting, Vegetable, Gardening, Waste Management.

Introduction

In the world, urban areas house 54 per cent of the total population, with that figure expected to rise to 66 per cent by 2050 (United Nations, 2014). Rapid urbanisation and population growth place enormous strain on urban food supply systems. Furthermore, many cities around the world are experiencing issues such as a rapid decrease in green space and an increase in heat island effects. Urban agriculture or rooftop farming is recommended as a potential solution to these problems (Smit et al., 2001). When food is produced locally, there is no need to travel long distances to obtain fresh and pure foods, which reduces the use of fossil fuel for transportation and, as a result, has a positive impact on the environment (SGUFS, 2014).

Rooftop vegetable production can help to reduce the temperature of roofs and surrounding air, which helps to cool a local climate (Ries, 2014) and can help to reduce the urban heat island effect (Hui, 2011). Rooftop farming can also help

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to reduce carbon emissions and noise pollution (Dubbeling, 2014). Rainwater is captured and absorbed by plants, reducing the impact on infrastructure (Ries, 2014). Rooftops with vegetation can be a great place to relax, and this type of farming can easily provide employment (SGUFS, 2014). Rooftop vegetable production contributes to biodiversity by providing habitat for a variety of insects and birds (Higher Ground Farm, 2019). Farming on urban rooftops is typically accomplished through the use of green roofs, hydroponics, organics, aeroponics, or container gardens (Asad and Roy, 2014). Different types of fertilizers, insecticides, and pesticides are used in agricultural production, but their widespread use harms human health, degrades the environment, and raises crop production costs. Currently, agriculture universities and research institutes are focusing on integrated pest and nutrient management through the use of various microbial natural resources as biofertilizers and by modifying several conventional practices (Sinha et al., 2010). Every day, various types of domestic waste are generated in homes, canteens, mess halls, and hotels. Domestic waste can be vegetable and fruit waste of different types (fruit, vegetable, and vegetable remains and peelings), eggshells and coffee sediments, tea and coffee filter bags, tainted food, non-liquid cooked food waste, bones, stale bread and biscuits, tissues, paper towels, and paper sacks that are biodegradable. Domestic waste can be composted by various microorganisms, such as bacteria, fungi, and actinomycetes, in the presence of oxygen. Humus can be used to grow vegetables on rooftops, which is extremely beneficial (Wilson, 2009).

Rooftop Vegetable Gardening

Rooftop vegetable production refers to the growth of numerous types of vegetables on city building roofs (Sustainability Television, 2019).Cultivation on the rooftops of buildings in urban areas is usually done by using green roofs, hydroponics, organics, aeroponics, or container gardens (Asad and Roy, 2014). The most fruitful form is hydroponics techniques using a specially designed greenhouse (Sustainability Television, 2019). Rooftop vegetable farming could benefit the environment and provide a significant proportion of vegetables for urbanites (Liu et al., 2016). Rooftop vegetable production also offers many environmental and social benefits to densely populated urban cities (Hui, 2011). By utilising rooftops for vegetable cultivation, it is possible to obtain social, economic, and environmental sustainability for buildings in urban cities. Because it can contribute to the development of urban food systems by enhancing local food production, meeting the nutrition demand of the people through access to nutritious food, reducing air pollution, increasing storm water retention capacity, improving public health, enhancing the aesthetic value of the urban environment, and amplifying community functions (Localize, 2007).

Worldwide Scenario of Rooftop Vegetable Gardening

The practice of producing vegetables on rooftops has been increasing in recent years to facilitate agricultural sustainability in urban areas. Rooftop agriculture allows urban areas to become more sustainable in their resource exploitation and to help develop food security for residents. Rooftop gardens are becoming an important part of the recent regeneration of urban agriculture and provide alternative spaces to grow vegetable products for urban markets (Ouellette et al., 2013).

The production of vegetables on rooftops should not be thought of as an alternative to massive-scale vegetable production in rural areas (Gaglione et al., 2010), but rather as an enhancement to the urban food movement by providing another source of local, fresh foods (Tomalty et al., 2010). Many urban areas are now producing over 20% of their vegetable needs within city boundaries. Urban agriculture is widely utilised in developing countries, although some cities in developed countries worldwide strive to source at least a portion of their food requirements locally (MacRae et al., 2010). The contributions of urban agricultural activities to local food supplies are now significant in several cities, including Italy (Bologna), the USA (Chicago, Cleveland, New York, Portland, and Seattle), China (Hong Kong, Shanghai), Canada (Montreal, Toronto, and Vancouver), Taiwan (Taipei), and Japan (Tokyo) (MacRae et al., 2010). In Bologna, if all suitable flat roof space is used for urban agriculture, rooftop gardens in the city would produce around 12,500 tonnes of vegetables annually, which would meet 77% of residents' needs for vegetables, and an estimated 624 tonnes of CO_2 would be captured each year (Science for Environment Policy, 2015). Lufa Farms, Montreal, produces over 25 types of vegetables, and production is enough to meet the needs of over 1000 people (Carrot City, 2014). The farm at Brooklyn Navy Yard produces more than 50,000 pounds of organic produce annually. The Gary Comer Youth Centre of Chicago grows 450 kg of food per year (Clarke, 2015). For urban agriculture to be most successful, there is a need to increase vegetable crop cultivation within city boundaries.

However, land that has traditionally been used for agricultural purposes within urban areas, such as vacant lots, is vulnerable to potential development. Thus, urban agriculture is challenged by the lack of available space in cities to meet current demands for locally produced foods. Green roofs can be used in this capacity to effectively replace green space lost during building construction. Therefore, rooftop agriculture (particularly green roof production systems) has become an attractive possibility to increase localised urban agriculture (Ouellette et al., 2013).

Rooftop Vegetable Gardening in India

Rooftop farming is increasing very quickly throughout the country. Nowadays, many people are interested in rooftop gardening, especially in city areas. Many have already turned their passion into a commercial endeavour. Retired government and private service holders, businessmen, and industrialists have passed their leisure time by getting involved in rooftop agriculture. Their efforts are helping to make the cities greener, despite the lack of cultivable lands there. Some people even rent others' roofs for the purpose. It's also expanding because people always prefer chemical-free organic vegetables and fruits. They can easily get organic and fresh food from rooftop gardening. Moreover, through the spread of greenery on rooftops, these people are also contributing to creating a healthy environment in urban areas.

Composting of Domestic Wastes

Composting can be defined as a natural process of 'rotting' or decomposition of organic matter by microorganisms under controlled conditions. Raw organic materials such as food garbage, animal wastes, crop residues, some municipal waste, and suitable industrial waste increase their suitability for application to the soil as a fertilising resource after having undergone composting. Composting can also be defined as a natural process that turns organic material into a dark, rich substance. This substance is called compost or humus (FAO, 2002).

Compost is a rich source of organic matter. Soil organic matter plays a vital role in sustaining soil fertility and, hence, in sustainable agricultural production. In addition to being a source of plant nutrients, it improves the physicochemical and biological properties of the soil (FAO, 2002).

Types of Composting

Based on the nature of the decomposition process, composting can be classified into the following types.

Aerobic Composting

Aerobic composting occurs in the presence of oxygen. Aerobic microorganisms break down organic matter and release carbon dioxide ($CO2$), water, heat, humus, and ammonia, the relatively stable organic end product in this process. Although aerobic composting may produce some intermediate compounds, such as organic acids, aerobic microorganisms decompose them further. The resultant compost, with its relatively unstable structure of organic matter, has little risk of phytotoxicity. The heat generated enhances the breakdown of proteins, fats, and complex carbohydrates such as cellulose and hemicellulose. Hence, the processing time is shorter. Moreover, this process destroys many microorganisms that are human or plant pathogens, as well as weed seeds, provided they undergo sufficiently high temperatures. Although more nutrients are lost from the materials by aerobic composting, it is considered more efficient, fruitful, and useful than anaerobic composting for agricultural production. Most of this publication focuses on aerobic composting (FAO, 2002).

Anaerobic Composting

Anaerobic composting takes place where oxygen is absent or in limited supply. Under this method, anaerobic micro-organisms dominate and improve intermediate compounds, including methane, organic acids, hydrogen sulphide, and other substances. In the absence of oxygen, these compounds accumulate and are not metabolised further. Many of these compounds have vigorous odours, and some present phytotoxicity. Anaerobic composting is a low-temperature process that leaves weed seeds and pathogens intact. Moreover, the process usually takes longer compared to aerobic composting. These drawbacks often offset the merits of this method, viz., the little work involved and fewer nutrients spoiled during the process (FAO, 2002).

Vermicomposting

The term vermicomposting refers to the use of earthworms for composting organic residues. Earthworms can consume practically all types of organic matter, and they can eat their body weight per day, e.g., 1 kg of worms can consume 1 kg of residue every day. The excreta (castings) of the worms are rich in nitrate and available forms of P, K, Ca, and Mg. The passage of soil through earthworms enhances the growth of bacteria and actinomycetes. Actinomycetes develop well in the presence of worms, and their content in worm casts is more than six times that of the original soil (FAO, 2002).

Vermicomposting of Domestic Waste

Composting of Domestic Waste can be carried out by the following steps:

Collection of Wastes

Domestic waste materials are collected from houses and hotel canteens, then air-dried and grinded into small pieces. This ground waste material is mixed with cow dung in the ratio of 4:1 (w/w) and is subjected to aerobic composting to start microbial activity. The moisture content of the materials is controlled at 60% to 70%, and this mixture is then transferred into plastic containers covered with paper that has holes to facilitate aeration to get the final composted material. This mixture is hand-manipulated at regular intervals and remoistened for sufficient microbial activity (Bharadwaj, 2010).

Earthworms Collection

When the temperature becomes constant and the colour of the mixture changes from brown to black, it is used as a substrate for vermicomposting. For vermicomposting, earthworms (Eisenia foetid) were collected.

Assessment of physicochemical properties

The material is analysed for different physicochemical attributes such as pH, organic carbon, total nitrogen, available phosphorus, exchangeable potassium, C: N ratio, and organic matter as per the methods suggested by other workers, as well as for earthworm number, biomass, cocoon production, and weight loss of organic substrate during the composting process. During the course of the investigation, the samples are examined at periodic intervals after 15, 45, and 75 days of vermicomposting (Bharadwaj, 2010).

Table 1. Effects of Vermicomposting on various Physicochemical Parameters of Domestic Waste (Bharadwaj, 2010)

S. No.	Parameters	Duration of vermicomposting			
		0 days	15 days	45 days	75 days
1.	pH	9.32	9.22	8.9	8.37
2.	Organic carbon (%)	7.25	5.265	5.078	3.696
3.	Total nitrogen (%)	0.241	0.301	0.361	0.771
4.	Available phosphorus (%)	0.110	0.12	0.16	0.18
5.	Exchangeable potassium (%)	0.0086	0.132	0.196	0.386
6.	C:N ratio	30.08	17.49	14.06	4.79
7.	Organic matter (%)	12.499	9.076	8.754	6.371

Benefits of Compost in Rooftop Gardening

The following sub-section describes the potential benefits of composting:

Nutrient Supply

Compost can be used as a source of nutrients instead of mineral fertiliser (Blanco et al., 2013). The quantity of substituted fertilisers depends on the content of nutrients in the compost and their application rate (Audsley et al., 2003; Hansen et al., 2006). Furthermore, compost is considered a fruitful option for phosphorous recycling (Cordell et al., 2009), which is a growing issue as a result of the foreseen lack of mineral P for agricultural fertilisation (Syers et al., 2008).

Carbon Sequestration

Sequestration of carbon into soil can be seen as the removal of carbon from the atmosphere and its relocation to save CO2 emissions (Blanco et al., 2013). The time horizon used in the assessment plays an essential role in estimating the benefit of carbon sequestration. A time frame of 100 years is considered relevant for estimating contributions to global warming (Favoino and Hogg, 2008).

Suppression of Diseases, Weeds, and Pests

Pests, weeds, and diseases can be controlled by using compost instead of herbicides and pesticides. It is also beneficial for the environment to reduce the use of herbicides and pesticides (Martnez-Blanco et al., 2013).

Minimise Soil Erosion

The utilization of compost could reduce soil erosion and thereby avoid losses of arable land (Blanco et al., 2013). The degradation of the soil occurs because of land transformation and land occupation (Saad et al., 2011). Because of soil erosion, carbon losses and net productivity reduce (Núñez et al., 2013).

Soil Moisture Content

One potential benefit of compost is to enhance the capability of soil to retain green water, i.e., rainfall and irrigation water stored in the soil as soil moisture, to decline irrigation and consumption of blue water, i.e., water from surface and groundwater resources. This may result in two different consequences: Blue water is saved, and crop yield could increase in those areas where irrigation water is not available (Blanco et al., 2013).

Biological Properties of Soil and Biodiversity

Changes in soil biodiversity after compost application might influence either positively or negatively (e.g., hydrological processes, nutrient cycling, and pest incidence), with consequences in terms of impacts associated with the substitution or compensation of those ecosystem services. However, data linking compost use, biodiversity, and ecosystem services do not exist apart from a first attempt at establishing a preliminary relationship (Nemecek et al., 2011). In addition, the effects of land management practises are highly variable depending on regional and scale-dependent factors (Bengtsson et al., 2005). An alternative approach is to consider biodiversity and ecosystem services as independent endpoint categories (Zhang et al., 2010).

Composting's Drawbacks

Composting is considered an environmentally clean method that allows, on the one hand, to recycle waste and, on the other, to obtain organic fertilizer. But it is not safe, especially for people involved in this process (Kokhia, 2013). Waste management using any technique involves many risks, which are described quite well by different scientists (Panikkar et al., 2004).

The labourers who are involved in the composting are often unaware of the hygienic composting criteria. Moreover, there may be an adverse impact that will facilitate the rejection of composting on the whole. Thus, it is necessary to shed light on the risks encountered during composting. Many kinds of bacteria (≈2000) and at least 50 species of fungi take part in the composting process (Kokhia, 2013).

In this process, not only bacteria, fungi, and actinomycetes are actively involved, but also invertebrates play a significant role. These are the main soil inhabitants: ants, beetles, and cutworms; fruit beetle larvae; millipedes; mites; nematodes; earthworms; earwigs; woodlice; springtails; spiders; enchytraeids (white worms); and others. Many soil microbes and worms participate in the process of composting material in terms of its physical grinding. These animals also help mix the various components of compost (Kokhia, 2013).

Earthworms play the main role in the last stages of the composting process and the further insertion of organic matter in the soil in temperate climates. Thus, composting is a complex, multi-step process. Each stage is characterised by its various consortiums of organisms (Shalanda, 2009).

Occupational hazards are associated with the composting process; these include pathogenic, allergenic, and microbial toxins. The sources of these hazards are common pathogens of faecal origin (bacteria, viruses, cysts, and eggs of intestinal parasites). The second danger is associated with the development of meso- and thermophilic fungi and actinomycetes, which play an important role in the degradation of waste. Among these microorganisms' infectious pathogens, allergic diseases are detected (Kokhia, 2013).

Epidemiological and experimental studies have proved that pathogenic mould can be developed potentially during the production of compost. This has very adverse consequences, especially for people involved in the production. A clear link between the atypical development of allergic rhinitis, conjunctivitis, and asthma and contact with the spores of fungi was detected (Kokhia, 2013).

Despite some drawbacks, composting is useful for managing domestic waste and producing organic manure for vegetable production as well as other agricultural activities.

Conclusion

The agricultural lands in India are decreasing due to human pressure for accommodation and food. In many parts of the world, the scenery is similar. Rooftop vegetable production may be a viable alternative to soil-based agriculture. If domestic waste compost can be used for a higher quantity of food production in urban areas, this will reduce the use of chemical fertilizers, pesticides, and hormones in food production. Rooftop vegetable farming is becoming more and more common in India, which is undoubtedly good news for the country. However, more research is required to determine the best ways to use waste on agricultural lands to address the nation's waste management issues.

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A Case Study on the Application of Hydroponics in Floriculture Sector

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ABSTRACT

Urbanization is increasing rapidly, with developing nations experiencing the fastest expansion. By 2030, there will be 4.98 billion metropolitan dwellers worldwide (UN, 2002). Urban horticulture is the practice of growing fruits, vegetables, flowers and herbs in confined spaces, such as unused plots, gardens, balconies and containers inside city homes (Zoysa, 2007). Food produced in urban spaces can harm the environment or food safety due to presence of contaminants, so the floriculture sector is being envisaged as an alternative there. Floriculture is an intensive type of agriculture with high income per unit area (Randhawa & Mukhopadhyay, 1986), making it a fast growing industry. Urban farming has faced difficulties due to the decline in land available per person, and will continue to shrink due to rapid urbanization, industrialization and iceberg melting. The presence of disease causing pathogens, nematodes, erosion etc. can cause serious problems to crop growth in soil based cultivation. Recently hydroponics has emerged as a potential alternative to produce green vegetables, flowers, seedlings, and herbs, mostly in periurban and urban areas. The primary benefit of soilless hydroponic cultivation is the year-round accessibility of green secure and healthy horticultural produce. To get a brief overview of the application of hydroponics system in floriculture crops globally as a tool of urban and periurban agriculture, a brief case study was carried out to trace the use of hydroponics in cut flowers like Rose, Gerbera, Chrysanthemum, Gladiolus, Lily etc and landscaping sector by studying research journals, books and the data was analyzed and represented to serve as baseline information to guide future research.

Keywords: Urban Horticulture, Soilless Cultivation, Hydroponics, Floriculture, Cut Flowers

Introduction

The world urban population is expected to double in 30 years, with 60% of the world's population expected to live in cities by 2030. To address this, ad hoc strategies are needed to ensure adequate food supply and distribution systems. Urban and peri-Urban agriculture (UPA) is the practice of producing food and other products through agricultural production and associated processes. Urban horticulture (UH) refers to the practice of growing fruits, veggies, flowers

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and herbs in confined spaces, such as unused plots, gardens, balconies, and containers inside city dwellings. Urban farming has been a worldwide activity since the beginning of urbanization, with farming enabling the development of cities and cities needing farming to support their populations.

However, if the resources required for food production in urban areas are handled improperly, it could harm the environment or even pose a threat to food safety. The floriculture industry is examined as a potential substitute for food production for the implementation of urban farming methods, as the amount of money generated per unit area from floriculture is significantly higher than that from any other form of intensive agriculture.

The International Trade Center (2013) has reported that worldwide floriculture exports have increased by 10% annually, while annual consumption is between US$40 and US$60 billion. Floriculture is a multi-billion dollar global business that produces bedding and garden plants, foliage plants, potted flowering plants, cut flowers, cut cultivated greens, and floriculture materials. Soil-based agriculture has faced significant difficulties since the dawn of society, such as the decline in the amount of land available per person. In some areas, such as metropolitan areas, there isn't any soil suitable for crop growing, or there aren't many fertile cultivable arable lands accessible due to unfavourable topographical or geographical conditions.

No-soil culture primarily refers to the hydroponic and aeroponic growing methods. The Greek words hydro, which means water, and ponds, which means labour, were combined to form the name hydroponics (Beibel, 1960). It is a technique for growing vegetation without soil using mineral nutrient solutions (Beibel, 1960). The primary benefits of hydroponics over soil culture include better regulation of nutrition, availability in areas of non-arable land, effective use of water and fertilizers, simplicity and low cost of medium sterilization, and higher density planting, which increases yield per acre.

Objective

- To get a brief overview of application of hydroponics system in floriculture crops globally as a tool of UPA.
- To account research directions followed till date that can serve as baseline information to guide future research.

Methodology:

Research findings and publications on the application of hydroponics in flowers from journals, books, reports etc. were studied thoroughly and the data was analyzed and represented here.

Result:

The method of growing plants, without soil while submerging their stems in nutrient solution, is known as hydroponics (Maharana and Koul, 2011). Common mediums include expanded clay, coir, perlite, vermiculite, brick shards, polystyrene packing peanuts, and wood fibre. Several studies have been conducted with the application of hydroponics in floriculture.

Case Study 1 - Gerbera

A. Tahhereh *et al.* (2020) conducted a study to investigate the effects of silica nanoparticle and Ca-chelate on gerbera under hydroponic conditions in Iran. Results showed that 20 mg/L and 60 mg/L nanoparticles resulted in the longest flower longevity, flowering acceleration and increase inleaf number, stem ash and lignin content. The treatment with 80 mg/L nanoparticle-SiO2 and 240 mg L Ca-chelate was found as the best treatment for increasing both protein content and degree of transparency.

B. A study was conducted in COH, Thrissur by Arathi, 2016 to find out the suitability and performance of five different gerbera cultivars, viz. Donna Ellen, Goliath, Stanza, Intense and Balance. Maximum plant height was recorded in Intense. Cultivar Balance took the minimum time (125 days) to open first flower. Flower stalk characters were less in hydroponic condition than in pot culture. Vase life (13.9 days) and number of flowers (6.3) were recorded maximum in Balance.

C. Khalaj et al. (2011) conducted a study on gerbera to determine the effect of different substrates on growth and yield. Fourteen treatments comprising different growth media were used and it was found that perlite, peat & expanded clay (25%+75%+5%) media produced maximum number of flowers per plant with best quality and shortest time (15months). It was also found that quality & yield of the crop have a strong relation with physic-chemical properties of the growing media. Cocopeat combinations produced good vegetative growth and good quality early flowers.

D. Savass et al. (2002) conducted a study on gerbera in closed hydroponics system to investigate the impact of silicon and nutrients under induced salinity. They found that the application of Silicon (1.25mM) in the nutrient media induced the production of flowers graded as class 1 with better quality and thicker flower stems. Increased EC resulted in reduction of flower weight and numbers and Si had no impact. Si was also found to improve mechanical strength of the stem and balanced nutrient solution by increasing Ca uptake.

E. Sharavani et al. (2018) conducted a study in Rajendranagar, Telangana to use hydroponics to create visible signs of macro and micro nutrient deficits in Gerbera. Individual macro and micronutrient deficiencies were incorporated with a complete nutrient formula minus one of the nutrients in tissue cultured Savannah gerbera varieties. Macronutrients such as nitrogen deficiency, phosphorus deficiency, potassium deficiency, calcium deficiency, magnesium deficiency, copper deficiency, boron deficiency, iron deficiency, zinc deficiency, and Manganese deficiency all showed visible signs of visual deficiency. Manganese was the only nutrient that did not manifest any visual deficiency symptoms.

Case Study 2 - Rose

a. Mattson and Leith (2007) conducted a study on hydroponically grown cut roses in USA to determine how macronutrient absorption varies in relationship to growth of new flower stems and test whether an existing mathematical model is suitable for describing nitrogen and potassium uptake across a crop cycle. Results showed that total N uptake decreased after harvest and remained the same for 5 days, then again decreased during 8-10th days and synchronically increased with flower stem elongation. K+ uptake decreased steadily for the first 12 days before increasing in time with stem elongation to reach maximum uptake rates of 0.05 to 0.09 mmol d-1 g-1 HDW as stems matured. Ca2+ uptake decreased just before harvest and remained low until day 7 of the new cycle, after which it increased until just before stem maturity. Mg2+ uptake increased, and it then started to decline right before harvest.

b. Farahi et al. (2013) researched to analyze the impact of polyamines on vegetative, flowering and post harvest life of rose cv. Dolcvita in hydroponic culture. They found that foliar treatment of polyamines had substantial impacts on floral stem length, fresh weight, vase life, flower bud girth, and length. The highest and lowest flower stalk lengths were measured in nutrient solutions containing 1.5mM spermidine and 100.66 and 71 cm, respectively, suggesting that polyamines have a significant impact on the qualities and properties of roses.

Case Study 3 - Chrysanthemum

a. Azeezahmed et al. (2016) conducted a study to determine the impact of different N-K concentrations on flowering of chrysanthemum cv. Mother Teresa. The treatments consisted of five nutrient solution concentrations (NSC), having N (50, 100, 150, 200 and 250 ppm) and K levels (40, 80, 120, 160 and 200 ppm) during vegetative stage, and 60, 110, 160, 210 and 260 ppm during reproductive stage. The optimal therapy was found to be NSC-V of N250 C K200 during the vegetative stage and N200 C K260 during the reproductive stage, resulting in the greatest number of blossoms.

b. Rai et al. (2017) investigated the salinity tolerance of 22 varieties of chrysanthemum at five different salinity levels (0, 50, 100, 150, and 200 mmol/L). Measurements of changes in various physiological and morphological parameters were used to determine salt tolerance. It was found that as the concentration of salt increased, the amount of chlorophyll a, chlorophyll b, and total chlorophyll decreased, with Pusa Aditya, Haldighati, Lalit, Little Pink, and Jaya having the highest levels. The degree of stress and variation affect how quickly dry weight decreases.

c. Rahman et al. (2022) conducted a trial to find out the best media for chrysanthemum cv. Rajkumari under hydroponic system in AAU, Assam. Seven growing media combinations, viz. coco peat, coarse sand, cinder, coarse sand cinder, coarse sand and coco peat, coco peat and cinder, coco peat, coarse sand and cinder as growing media and two different concentrations of nutrient solutions EC 1.5dS/m and EC 1.8dS/m were utilized and the best quality and yield of flowers were produced under coco peat + cider and EC 1.8dS/m nutrient media.

Case Study 4 - Gladiolus

a. Agina et al. (2018) conducted a study at Benha University, Egypt to examine the relationship between the source of nutrients and water flow rate to determine if it is possible to grow gladiolus plants in a wastewater fish farm using nutrients that are different from those used in conventional nutrient solutions. The findings showed that in effluent fish farms as opposed to nutrient solutions, plant height rose and the average duration of a spike was longer. Additionally, the nitrate concentration in the effluent fish farm considerably rose as the flow velocity was increased.

b. Singh et al. (2018) experimented to determine the effects of various growth regulators and various substrates on shoot and root development in cormels of gladiolus cv. American Beauty. Three different growth mediums were used: soil, sand, and hydroponics. Pre-soaking cormels in GA3 (50 ppm) and thiourea (0.2%) for 24 hours had a significantly greater impact on development and root characteristics than pre-soaking in distilled water. GA3 produced the maximum leaf length at 50 days and the maximum length of stems.

c. Jabbar et al. (2018) conducted a study to study the effect of cocopeat: perlite medium with three ratios (v/v) (1:1, 3:1 and 1:3) on some vegetative, flowering and biochemical parameters of two gladiolus cultivars. Results showed that most vegetative parameters such as plant height, leaf number and leaf area, flowering parameters such as spike emergence, spike diameter, spike length, and number of florets per spike, and biochemical parameters like chlorophyll a, chlorophyll b, soluble sugars and N, P and K (%) uptake in leaf were significantly affected by cultivars, media and their interactions.

d. Nosir W (2011) conducted an experiment in University of Aberdeen, UK to compare the effectiveness of three commercial fertilizers- Signral, 20-20-20; Nutrafin 23-33-24; and HeavyharvestBloom, Hydroempir for growth of Gladiolus in NFT system. Three purchased nutrients were used and Hoagland's solution was contrasted. The results showed that the gladioli corms demonstrated excellent adaptability to NFT cultivation during the two winter experiments, yielding high-quality blooms. This research will provide a new avenue for substituting ready-made hydroponic nutrition solutions with commercial nutrients.

Case Study 5 - Lily

a. Moghaddam and Nasir (2020) evaluated to study the effect of different concentrations of potassium on lily growth and postharvest life. A hydroponic experiment was conducted at Islamic Azad University, Tehran, Iran. The findings showed that most plant development parameters, such as shoot dry weight, declined with potassium consumption in nutrient solution, but improved at a potassium concentration of 6 mM.

b. Seyedi et al. (2013) inspected the effects of calcium concentration on qualitative & quantitative characters of Lilium cv. Tresor in Islamic Azad University, Rasht, Iran. The Asiatic Hybrid Lilium bulbs of the "Tresor" cultivar, which were used in the present study, were seeded at three distinct calcium concentrations: 2, 4, and 6 mM. The highest height of the plant, stalk diameter, height at which reproduction begins, number of buds, blossom diameter, and life of cut flowers were all generated by 6 mM calcium, according to a comparison of the data's mean values.

c. Traykova et al. (2021) conducted a study in a Bulgaria to accelerate the growth and multiplication of Lilium bulbs. Results showed that the weights of the original and end bulblets did not correlate. Flood and discharge hydroponic systems produced the best results, with the first 10 plants being effectively acclimated outdoors and flowered.

Case Study 6 - Gypsophila

Wahome et al. (2011) researched to determine the viability of producing gypsophila in various hydroponics systems. Three primary areas were used: elevated tray, ground lay bed, and bag culture systems. At 12 weeks after transplanting, plants grown in vermiculite produced the tallest seedlings (52.9 centimeters). Gypsophila plants cultivated in sawdust at 12 WAT nearly doubled in height compared to plants grown in sand. Sawdust produced the most branches per plant, with plants grown in sawdust in the bag culture hydroponics system producing the longest cut flower stems. The best vegetative development, blossom yield, and quality can be achieved by growing the plants hydroponically in bag culture.

Case Study 7 - Marigold

Sarmah et al. (2020) conducted a study on quality of marigold flowers grown under hydroponic system at AAU, Assam. Three levels of hydroponic nutrient solution (EC 1.0, EC, 1.5 dS/m, and EC 2.0) were used in five different hydroponic systems. When comparing the systems, NFT produced flowers of a higher caliber than any other system. Early bud and floral development among the nutrients were found to be superior in EC 1.0. This leads to the inference that the treatment combo of NFT and EC 1.5dS/m is best for marigold flower output of high quality.

Case Study 8 - Landscaping

Dhanasekaran D (2020) evaluated the performance of foliage ornamentals on different nutrient solutions, proposed by Hoagland and Arnon (1938), Cooper (1979), Saparamadu (2010), Mattson and Peters (2014), and control using irrigation water underneath a passive hydroponic vertical garden module. At 30, 60, and 90 days after sowing, physiological measures including chlorophyll content, membrane integrity (%), and relative growth rate were noted. Results showed that the foliage ornamentals grown under treatment T3 (Cooper's solution) recorded the maximum chlorophyll concentration and the other two viz., Wandering jew and Boat lily recorded the maximum membrane integrity content. T2 (Hoagland solution) also showed the highest relative growth rate, while T4 (Saparamadu's solution) showed the lowest relative growth rate.

Conclusion

The application of hydroponics in floriculture is vast. This review is an initiative to brief the same so that future research works can get a baseline perspective. Rose, Gerbera, Gladiolus, Lily are the ones where extensive research has been practiced utilizing hydroponics system, further works can be done to get the technique exploited and economical for floriculture sector.

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Urban and Peri-Urban Farming: Some Insights from a Developed Nation

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ABSTRACT

Rapid urbanisation is prominent in various parts of the world. This is an evident outcome of the overgrowing world population, and it also threatens the future food production system. This world needs more and more food items to feed its habitants. But unfortunately, food production does not show a directly proportional relation with the phenomenon of rapid urbanisation. It compels the scientists to think more about the urban and Peri-Urban Agriculture (UPA). UPA is getting much more attention nowadays, as it allows to grow the food items in urban as well as peri-urban areas. The main objective of this paper is to provide an overview of the UPA, including the possible existing barriers and challenges. There are the several ways to grow food items through UPA, but most of the available academic literatures did not focus significantly on the different existing barriers of this UPA. In this paper, the possible barriers of UPA have been divulged through the unstructured literature review of a bunch of previous excellent studies on UPA in the United States, alongside the different UPA project types as well as approaches. Lack of clear agri-inclusive ordinances is a valid problem towards implementing UPA, alongside zoning difficulties and limited access to land. The growing expenditures of the farmers as a part of UPA farming is also an issue or concern which rather exacerbated with no/very low funding opportunities. Reluctance of the farmers in attending the various farmers' training program is also a barrier here alongside the difficulty of the certification system. Smooth accessibility to the irrigation water and also the management strategy for the water run-off are the challenging tasks as indicated by urban farmers & planners. Insurance coverage is very limited in case of UPA which is also one of the solid challenges as faced by urban growers.

Keywords: Urbanisation, Urban Agriculture, Peri-Urban Agriculture.

Introduction

The growing population is indicated as the primary cause behind that phenomenon and such an explosive population is threatening the issue of food security as well. Food & Agricultural Organisation (FAO) has indicated a growing concern about the increasing urban population and the food security of urban

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dwellers in the next few decades. It has been predicted that the world's urban population will increase by 60% by the year 2050 and that suggests an absolute increase of 2.5 billion people (UNDESA/PD, 2013). In this context of growing urban poverty and food shortages, the urban and peri-urban agriculture (UPA) is getting much scholastic attention these days. As per the US Department of Food & Agriculture (USDA), urban agriculture is to establish and perform an agricultural practice in or near the urban space or a city-like setting. As per the concept of the United Nations, urban and peri-urban farming is the kind of farming activities in and around the cities that compete with various other activities for necessary resources such as water, land or energy (FAO, 1999).

Urban farming can also be defined as the production of food crops and rearing the livestock to feeding the local population (Goldstein et al., 2011; Castillo et al., 2013). This concept of urban agriculture can be linked with the notion of existing market and it can be said that an urban farm grows food items to sell those products to consumers, either commercial or non-profit with the help of their license. So, it is basically the organized agricultural activity within the city or at the periphery of the city sponsored by a public body, non-profit or private organisations (Hodgson et al., 2011; Oberholtzer et al., 2016). Urban agriculture not only addresses the issue of food insecurity, but it also helps to build up a local and regional food systems, address food waste reduction, community building and also the creation of new green space in cities (Goldstein et al., 2011; Heimlich, 2001). Commercial Urban Agriculture (CUA) also enhances the property values in the urban spaces which plays a role in financial advantages.

Urban farming is a vital component of the larger community food system. It acts as an important tool for providing nutritional security to the population, creating green spaces, generating new economic opportunities as well as making urban environment much more resilient. The main focus of urban farming is on the production of local food system and fill the existing gap in the food supply (Hodgson et al., 2011). The community-based food production system is associated with urban and peri-urban farming and that duly emphasizes the regional food component from the food supply standpoint (Horst et al., 2017).

Moreover, there is a regular discussion about the Sustainable Developmental Goals (SDGs) of the United Nations in every global forum and the 11th SDG indicate the notion of establishment of the more resilient, inclusive and sustainable cities. To address the issue of rural migration, nutritional security judged from the supply the side as well as fulfilling the 11th SDG, some of the developed countries like USA have implemented the UPA in different metropolitan areas of the country quite successfully. So, analysis of the UPA scenario of various urban areas of the United States can reveal the multifarious aspects of the UPA implementation and also allow the Agri-experts to identify the existing difficulties as faced the urban farmers & planners, particularly in the context of a developed nation. It will provide support to the urban planners of the growing urban spaces in developing countries as well as policy makers to figure out a concrete blueprint of the installation plan of urban and peri-urban farming.

Methodology

This paper is a comprehensive review of a bunch of the previous research studies performed in the domain of urban & peri-urban farming system, particularly in the context of developed countries like USA. This paper illuminates the multiple aspects of urban and peri-urban farming, including the different barriers as faced by urban farmers & planners during the implementation of that in the urban areas of the United States. This paper was prepared through the process of unstructured literature review and the finding as well as analyses from the various popular previous study reports on UPA were identified, analysed, screened and compiled briefly. A brief analysis of urban & peri-urban farming was performed throughout this study, particularly focussing on the various existing & identified barriers.

This study, being a review study, did not use any specific kind of statistical tools and applications like the quantitative research studies. No primary data has been collected and gathered as a part of this study. As it is a purely review-based study, it sets an objective of exploring the various types of urban farming and also the benefits of that towards various stakeholders. It also tried to set another objective to explore the different identified barriers of urban and peri-urban agriculture from the farmer's & planners' standpoints. The overarching goal of this research article is to sketch a broad scenario of the urban and peri-urban farming briefly and also to put together a list of suggestions as well recommendations as in regards to the implementation of UPA in developing countries like India. This study will allow novice urban farmers and urban farm planners a brief but transparent idea about urban & peri-urban agriculture, and the various barriers faced by the stakeholders during the implementation or installation process.

Results and Discussions

It is well established by the various findings, facts and data that the overall scenario of urban & peri-urban farming has changed significantly across United States as well as in other developed parts of the world. Base on the detailed analysis of the various academic and scientific literatures, it was observed that most of the respondents from the different American cities (including the farmers & farm planners) indicated a sharp increase in the growth of urban and peri-urban agriculture in last 10 years (Rogus & Dimitri, 2014; Reynolds, 2011). There was an increase in acreage in various urban spaces particularly in the southern part of the United States from one to 71 acres (i.e., 28.4 hectares), with a median increase of 7 acres (Fricano & Davis, 2020). Almost 70% of the Southern cities responded a thorough increase in urban agriculture which can be used to infer that there is a growth of urban farming activities (Goldstein et al., 2011; Fricano & Davis, 2020).

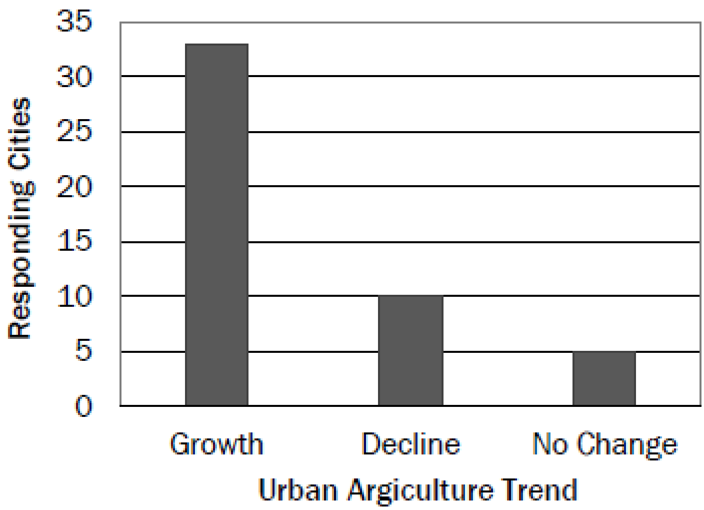

Fig. 1 Trend of Urban Agriculture in the Southern USA in the last 10 years (Fricano & Davis, 2020)

It was also found in several surveys that there are a range of types of urban farming projects as implemented by the urban farm growers in various cities of the United States. It ranges from the Community or Neighbourhood garden to the ranching areas for domestic cattle or other animals. The secondary data analysis suggested that the Community/Neighbourhood garden is the most numerous type of urban farming project as it has been implemented in most of the responding cities, followed by school gardens and different community supported agriculture projects (ACGA, 1998; Lawson & Drake, 2012; Oberholtzer et al., 2016; Fricano & Davis, 2020). Table 1 provides a comprehensive view of the various types of urban farming projects and their degree of implementation in various American cities. Table 1. Urban Agriculture Project Types and Table 1.

Table 1. Urban Agriculture Project Types and Preference Ranking

S. No.	Parameters	Duration of vermicomposting			
		0 days	15 days	45 days	75 days
1.	pH	9.32	9.22	8.9	8.37
2.	Organic carbon (%)	7.25	5.265	5.078	3.696
3.	Total nitrogen (%)	0.241	0.301	0.361	0.771
4.	Available phosphorus (%)	0.110	0.12	0.16	0.18
5.	Exchangeable potassium (%)	0.0086	0.132	0.196	0.386
6.	C:N ratio	30.08	17.49	14.06	4.79
7.	Organic matter (%)	12.499	9.076	8.754	6.371

(Source: Fricano & Davis, 2020)

So, it is quite evident from the existing literatures that the urban farming in the developed world, particularly in the United States is multi-dimensional as it does appear in many different forms and also in different places. The urban farms are located on the grounds or the rooftop, may use greenhouses or not and very interestingly, the food products (e.g., vegetables, fruits, flowers etc.) are gown on the soils or without using the soils (i.e., using hydroponics technique) (Kaufman & Bailkey, 2000; Rogus & Dimitri, 2013). Urban agriculture policy also plays a role in projecting as well as implementing urban farming successfully. The American cities with evidence of an increasing rate of urban farming in the last few years indicated the consideration of UPA in their land-use policy maps, comprehensive plan, and open-space plan quite a lot and also in their neighbourhood plan (Fricano & Davis, 2020). It is always important to consider urban farming in the policy matters to build up a robust strategy regarding its implementation. The local level planning is necessary to grow urban farming as identified in various literatures (Castillo et al., 2013; Fricano & Davis, 2020).

It is always important to consider the various obstacles as well as barriers in implementing the urban agriculture, because that will allow the urban farm planners in the developing countries like India etc. to take the sufficient precautions against those barriers. There are a bunch of factors which act as the barriers towards the growth of urban farming and sometimes become responsible for the decline of the urban & peri-urban farming. These include the issue of land access, lack of credit access, lack of municipal support for composting, lack of access to the irrigation water, and also a set of regulations regarding city plans, zoning or building code etc. without considering the issue of farming & farm related activities etc (Lovell, 2010; Rogus & Dimitri, 2014). Getting a proper market might become difficult sometimes and it also becomes a problem to gain the proper access to the consumers willing to buy the products and that can cause a decline in urban farming (Thibert, 2012). Many of the urban areas do not possess the necessary processing as well as marketing infrastructure and that affects the long-term viability of urban farm (Kaufman & Bailkey, 2000). It is evident that urban & peri-urban agriculture is a new concept and having the lesser knowledge about that causes difficulty in implementing this kind of farming in the urban space. Most of urban farmers or interest groups perform this kind of farming on an experimental basis using trial & error method.

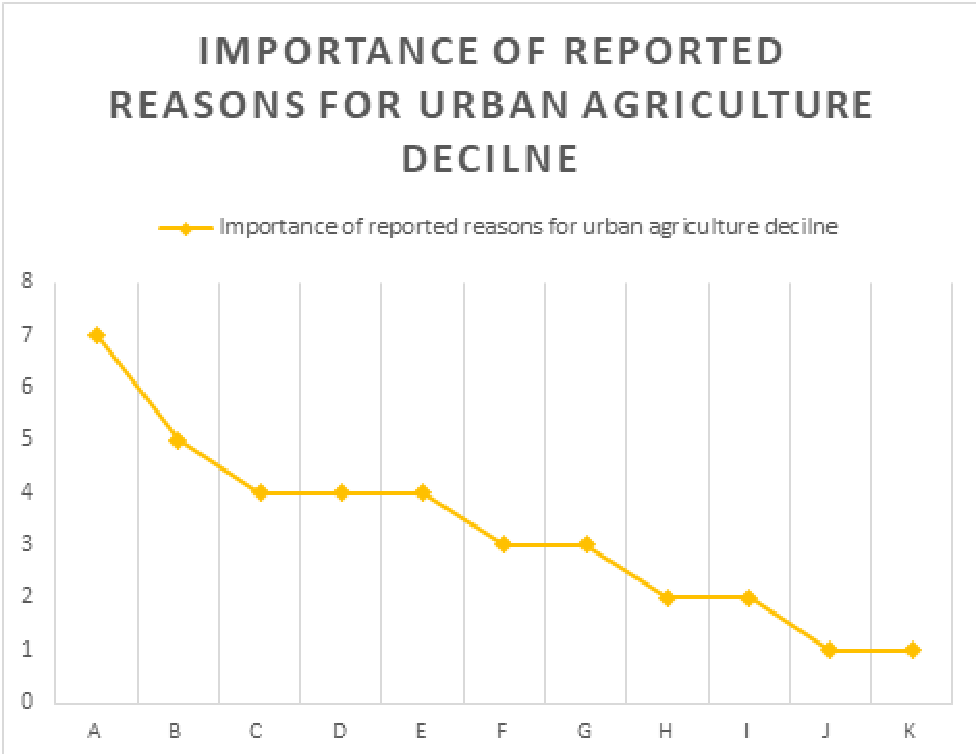

Fig. 2 Various existing causes for urban agriculture decline/barriers in Urban farming with their level of importance (Source: Fricano & Davis, 2020)

A=Conversion of previously owned land to other uses

B=Failure of site to sustain itself economically

C=Conversion of land for community redevelopment

D=Lack of funding

E=Changing city priorities

F=Conversion of land to parks or recreation facilities

G=Gardeners' lack of interest

H=Vandalism or theft

I=Gentrification

J=Lack of sites

K=Designation of urban growth areas

An important barrier of urban farming as identified in different literature is the lack of clear, agriculture-inclusive ordinances. Unclear and unfriendly ordinances make the farmers uncomfortable about implementing new urban farming operations as they consider these as unregulated activities (Heimlich, 2001; Hodgson et al., 2011; Castillo et al., 2013). Urban farming communities rather expect to have transparent as well as farmers' friendly ordinances about all agricultural activities and infrastructure development starting from creating a proper market to building greenhouses etc. Different evidences suggest that the farmers rely on an ordinance if that eventually protects the rights of the local food production (Castillo et al., 2013). Zoning was identified as one of the most significant barriers to implementing urban agriculture in a larger and commercial scale (Castillo et al., 2013; Covert & Morales, 2014). Restrictions on land usage is a common phenomenon in large cities and metropolitan areas and that's why, urban farmers confront with a bunch of legal obstacles while scaling up their farming activities. Some farmers have even identified zoning as the biggest problem as they do not get sufficient land for the farming. It is a common complaint that the zoning code in the urban spaces does not consider urban agriculture as a significant land use option (Goldstein et al., 2011; Castillo et al., 2013). Without the zoning code, the farmers need to apply for a special permit which is of course a burdensome task and that also does not ensure security like the specific zoning code. The special permit allows urban farmers to continue the UPA with much uncertainty.

Access to sufficient land for farming activities is one of the most crucial barriers as indicated in various previous surveys and scientific literature. Many farmers in the urban areas do not possess their land which eventually creates hardships for them to continue their farming jobs. Moreover, the growing population in the urban metropolitan areas is insisting the urban planners construct the various infrastructure and that is causing sorts of severe shortage of arable land areas for farming (Castillo et al., 2013). High-tech urban farming also becomes a difficult task to do with the constraints of lack of funding. The urban and peri-urban farming seeks more funding and more technical assistance has which become a problem many times (Covert & Morales, 2014). There is a very limited scope of receiving federal subsidy support, and there is a significant difference indicated between the urban farmers and the rural crop growers in receiving government support for the farming activities (Erickson, nd).

The farmers in the urban areas of the United States face the obstacle of getting the proper certification for growing food items like vegetables etc. Training facilities are not sufficiently available in many urban sites in the USA, but the USDA GAP certification is quite essential for being viable in the farming scenario (Fricano & Davis, 2020). It became more difficult for the organic growers as the organic certification process involves extraneous paperwork and spending a lot of money as a part of the application process. The market becomes inaccessible for urban growers without having proper certification for their profession, and that eventually creates a challenge for the existing urban farm producers (Heimlich, 2001; Horst et al., 2017). Moreover, water management in urban farms was also identified as a barrier in multiple scientific studies. Flooding problem, storm water and the lack of infrastructure to support that sort of problem have become a concern to many urban planners (Bleasedale et al., 2011; Krones & Edelson, 2011). That includes both the water access and water runoff. As farming suffers from various weather hazards quite frequently, it should come under the concern of insurance to protect the interests of the farmers. However finding an authentic company for getting insurance becomes an obstacle many times for urban growers as identified in various surveys. Alongside, paying the insurance premium becomes a problem for many urban farmers who farm on a small scale with a narrow profit margin.

Conclusion

Urban & Peri-Urban Agriculture has put itself in today's discussion at different global forums. Food & Agricultural Organisations (FAO) been considering this particular type of modern farming (including vertical farming, organic agriculture etc.) in their plan of actions in recent days, the growing urban population in the developing world along with an increasing rate of poverty rather pushes the need of such new ways of farming in the modern world. This paper presents a brief scenario of urban farming in the context of a developing nation, and most importantly identifies some crucial obstacles associated with the UPA. Planners and farmers in the developing world, such as in India can make a pre-assessment and analysis of these issues and take the necessary actions to promote urban & peri-urban farming. Though the context is different, still novice Indian urban farmers and urban planners can build up an idea about the nature of urban farming alongside the probable hindrances.

Urban and peri-urban farming holds different benefits including ensuring the local food production and maintaining the urban nutritional security. It is hard to get fresh farm produce in the urban sites daily, and UPA can address that issue potentially (Martinez et al., 2010). That solves the problem of malnutrition in the urban children, and also strengthens the local economy. It is recommended to include the UPA in the local comprehensive as well as regional planning of a particular city in India. Urban farming needs to be focused on solving the issues related to land selection and financing. The urban farming community is expected to initiate and execute the farming activities keeping the view of making their operations an enterprise, which would in turn ensure maintain the viability of their farm businesses.

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