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All about Soilless Farming and Techniques: Review

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ABSTRACT: As per the current status of Population, Available arable land, and agriculture there is a need for improvement in the farming sector and vertical farming is the solution for this. Urban areas face problems like rapid urbanization, climate change, food security, and reduction in arable land so implementing vertical farming within urban areas helps to move a step toward sustainability. This review study helps to understand the concept and other useful parameters related to urban farming.

KEYWORDS: Vertical Farming, Hydroponic, Aeroponic, Nutrients,Vertical Gardening.

I. INTRODUCTION

Agriculture Sector is one of the major contributors to the Country's Economic Growth. The major Workforce is related to this sector directly or indirectly. Along with the economy, there is also one factor that should be focused and that is Sustainable Development in agriculture. There is a need for Research and Development to give innovative solutions to get the desirable productivity from farming to feed the growing population.

The agriculture sector indicates the growth in the past two years in which the largest employer of the workforce, accounted for a sizeable 18.8 percent in 2021- 22 in Gross Value Added (GVA) of the country registering a growth of 3.6 percent in 2020-21 and 3.9 percent in 2021-22. [1]

The physical factors which affect the agricultural process are climatic conditions including rainfall, temperature, sunshine, storm, strong wind, and frost, length of the growing season, soil, and topography.

The economical factors which affect the agricultural process are marketing cost, changes in relative values of farm products, availability of labor and capital, land value, the cycle of over and under production, and prevalence of pests and diseases.

Poor access to reliable and timely market information for the farmers, absence of supply & demand forecasting, poorly structured and inefficient supply chains, inadequate cold storage facilities and shortage of proper food processing units, and large intermediation between the farmers and the consumers.

One of the biggest issues facing the agricultural sector in India is low yield: India's farm yield is 30-50% lower than that of developed nations. Average farm size, poor infrastructure, low use of farm technologies and best farming techniques, decrease in soil fertility due to over-fertilization, and sustained pesticide use, are leading contributors to low agricultural productivity [2].

Water is a critical input for agriculture which accounts for about 80 percent of the current water use in the country. The share of net irrigated area accounts for about 49 percent of the total net sown area in the country and out of the net irrigated area, about 40 percent is irrigated through canal systems and 60 percent through groundwater. [1]

Agriculture is related to the rural environment is the basic consideration, but now a day's urban agriculture also plays a vital role in food production for a growing population. The need for food for the urban population is fulfilled by the urban agriculture concept.

1.1. Urban Agriculture

Urban Agriculture can be defined as the production of food like vegetables, herbs, and fruits for food and nutrition security of the growing population, for aesthetic and ornamental purposes, and employ residents. Urban Agriculture has covered all the important aspects such as social, economical, ecological, political, and most important is environmental.

The urbanization process brings a wide range of unwanted consequences, which go from the reduction of fertile lands to deforestation, air and water pollution, reduced drainage of the rainfall, and the creation of Peri-urban areas where socio-economic constraints are exalted and poverty is condensed. [3]

Urbanization, climate change, food security, and reduction in arable land are issues faced by today

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and in the future of the world. It has been estimated that by 2050 more than 70% of the world's population will live in urban areas. [4]

With the rising urbanization worldwide phenomena, it has been estimated that most of the world's population (>60%) by 2030 will shift to cities for urban dwellings. Interestingly in the same period (by 2030), the human population is expected to reach 8.6 billion from the current 7.6 billion and expected to rise further exponentially to 9.8 billion by 2050 and explode to 11.2 billion by 2100. [8]

Urban areas generate over 70% of the global greenhouse gases (GHGs) and half of the global waste, and they are responsible for consuming 75% of the world's resources. [4]

The per capita arable land worldwide was 0.42 hectares in 1960. It will be 0.19 hectares in 2050. In developing countries, the area gets even smaller, per capita arable land will be reduced from 0.33 to 0.14 hectares. For many individual countries, the option of farming more land does not exist in practice. [7]

Benefits:

1. Food and nutrition security: Very first and important point of view of urban agriculture is feeding the growing population with nutritious food.
2. Health: An easier access to fresh and nutritious food helps improve the health conditions of the urban population, especially the poor's.
3. Development of the local economies: Reduction in transportation cost and employing residents ultimately affects the development of the local economy.
4. Ecological aspects and environmental impact: [3]

i. Helps in the reduction of Climate Change and Carbon Sequestration.
ii. Reduction of UF (Urban Floods) and UHI (Urban Heat Island) supports the city's adaptation to climate change, reducing damage and health problems for the citizens.
iii. The presence of trees, as well as herbaceous species, reduces the suspended dust and the air pollution rate of many compounds, among which the nitrogen dioxide (NO2).
iv. Improving urban biodiversity.
v. Overall reducing the environmental impact related to both food transport and storage.
vi. Reducing the city waste: Waste management in urban agriculture can help to keep the urban environment clean and boost the production of fresh food through the production of compost from organic wastes and the recycling of inorganic wastes.
vii. Urban farming contributes to the reduction of the ecological impact of the cities by both waste recycling and reducing emissions for transport, packaging, storage, etc. since the production areas are close to the final consumers.

1.2. Vertical Farming and techniques

Vertical farming is the concept of growing crops mostly vegetables, ornamentals, and herbs on stacks of indoor shelves using artificial light and nutrient solutions, without much sunshine and soil. Vertical farming has the potential to sustain the ever-increasing world population, especially in the urban areas with nutritional supplements thus providing food security. [7]

Vertical gardens in ornamental horticulture, a component of vertical farming are also known as green walls, living walls, bio walls, or vertical gardens. It is a free-standing space or part of a building that is partially or completely covered and growing in an organic or inorganic medium and some cases soil also. [7]

Evolution of Vertical Farming [7]

During Pre - 20th Century 600 BC From the legendary Hanging Gardens of Babylon, built by King Nebuchadnezzar II, to nowadays "vertical Farm" is the journey of this technique. This Hanging Garden consisted of a series of terraces, stacked one on top of the other planted with several different types of trees and flowers. In 1150 AD, Aztec people used a form of hydroponic farming known as "chinampas" to grow crops in marshy areas near lakes in which many of these rafts were attached to form floating "fields." In 1627, the first time published theory of hydroponic gardening and farming methods stated Sir Francis Bacon established and explored the possibility of growing terrestrial plants without soil. In 1699, John Woodward using spearmint refined the idea of hydroponic gardening with a series of water culture experiments. He found that plants grew better in water having impurities than in distilled water. This led to his important finding that the plants derive important nutrients from the soil and other additives mixed into water solutions.

In the twentieth century, in 1940, the hydroponic system of growing crops on large scale was used for the first time in modern history during World War II. More than 8,000 tons of fresh vegetables were produced hydroponically on South Pacific Islands to feed the allied forces stationed there. In 1964, at the Vienna International Horticulture Exhibition, a vertical farm in the form of a tall glass tower was displayed.

In 1999, the concept of the modern vertical farm was given shape and developed in a class led by Drs Despommier and Carter, Professors of Environmental Health Sciences, Columbia University 2011. Despommier and his students

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developed the idea of a multi-story building in which layers of crops could be grown on each floor to feed the population of New York using only urban rooftop agriculture- in other words, a contemporary vertical farming tower. In the year 2010, he published a book entitled The Vertical Farm: Feeding the World in the 21st Century, wherein he laid down the principles and practices of modern vertical farming around cities, and inside buildings, instead of horizontal expansion on the ground. Unfortunately, his technique is still not practiced on a large scale worldwide. However, India has made a beginning in the 20th century mainly producing lettuce, a few leafy vegetables, strawberries, and herbs on small scale, besides hydroponic fodder, mushrooms, and poultry.

1.3. Vertical Gardening

Garden Wall/Bio Wall Garden wall is a type of vertical farming (garden) that is popular throughout the world including in India. Vertical gardens can be seen in public places mainly at airports, metro pillars/stations, river bridges, elevated roads, etc., in many metro cities in India. Multicolor evergreen foliage plants are preferred, although flowers and even leafy vegetables find a place in these wall gardens. Garden walls with seasonal leafy vegetables are the best option for indoor gardens. Availability of all-season plants, growing media, fertilizers, and watering are issues that need to be addressed for their commercialization.

Plants suitable for Vertical Farming [7]

1) Plants suitable for Vertical Farming (Food Production)

Although possible to grow any plant completely indoors, economics limits to few crops in vertical farming that have small growing habits (for maximizing the number of plants that can be grown in a limited space), are prolific producers (e.g. indeterminate tomatoes) or can be grown and sold rapidly (such as microgreens). Compatible crops for vertical agriculture today include lettuce, broccoli, spinach, chard, chive, palak (beet leaf), mustard greens, amaranths, parsley, coriander, mint, kale, basil, and other herbs (rosemary, fennel, thyme, oregano, and others), strawberries, mushrooms, micro greens and sprouts, summer squash, peppers, eggplants, tomatoes, cucumbers, muskmelon, algae, crop nurseries, ornamental foliage, and flower plants.

2) Plants suitable for Vertical Garden (bio/ living walls) [7]

Plants thriving well in the local climate are the best option. Besides, they should have compact growth providing thick and dense cover. Plants having short growth habits, shallow fibrous root systems, and a longer life cycle are best suited for this purpose. They also need to be capable of coping with both full sun and full shade according to the location. The most commonly used plants in bio/living walls are listed in table no.1.

Techniques in vertical Farming

1) Hydroponic
2) Aeroponic
3) Aquaponic

Benefits of vertical farming [8]

1) Less land use helps in less deforestation and ultimately in less erosion and flooding
2) Reuse the old structures for more production.
3) No effect of floods, droughts, and snow on crops, they get protected.
4) As the access to produced crops is easy it reduces vehicular transportation.
5) Less CO2 emission and pollution by decreasing reliance on coal-burning products.
6) Water is used more effectively.
7) More food production within the less area for feeding the more population for increasing food demand.
8) More productivity within less area as compared to the traditional method.
9) No use of chemical pesticides allows for growing the organic crop

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Table No: 1. Plants suitable for Vertical Gardening

Green facades	1. Climbers having faster growth and dense variegated foliage from ground to top are the best. 2. Hedera helix, Parthenocissu squinquefolia, Parthenocissus tricuspidata (Japanese creeper), Hydrangea anomalapetiolaris (climbing Hydrangea), Lonicera japonica, Jasminum officinale, Aristolochia spp., Clematis paniculata, Cissusrhom bifolia (Grape Ivy) Ficus pumila (Creeping fig) , Bignonia unguiscatii (Cat's-Claw Vine) , Polygonum baldschuanicum, Passiflora caerulea, etc.
Living wall	1. Plant species with dwarf nature, limited root volume, fibrous roots, resistant to wind, and good growth habit are ideal. 2. Dracaena marginata, Dracaena sanderiana, Phalaenopsis spp., Hibiscus spp., Gardenia spp., Nephrolepsis, Asparagus sprengeri, Kalanchoe spp., Fittonia spp., Scindapsus aureus, Asplenium nidus, Maranta spp., Cordyline spp., Chlorophytum spp., Haworthia spp., Tradescantia spp., Hydrangea, Nasturtium, Wisteria, Petunia, Clematis, Selaginella, Daisies, Bromeliads and even few vegetables like tomato, chillies, cucumber, pea, lettuce, etc.
Exterior wall	1. Selected plants should perform well under full sun shine or partially shade conditions. 2. Lavendulaangus tifolia, Thymus serpyllum, Rosmarinus or Salvia splendens, for full sunlight. Rex begonia, Arum, Davallia, Asplenium nidus, Fuchia for shady conditions.
Interior wall	1. Selected plants should perform well both under full shade or partially shade conditions. 2. Philodendron, Epipremnum, Aeschynanthus, Columnea, Saintpaulia, many species of Peperomia and Begonia or different ferns like Nephrolepis and Pteris.

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1.4. Techniques in vertical farming

1) Hydroponic

It is technique of soilless production through water and mixture of nutrients required for plant growth.

Techniques in Hydroponic [9]

There are many methods included under hydroponic which is classified under

1. Liquid Hydroponic
2. Media Culture

Techniques in Liquid Hydroponic

1. Circulating Method /Closed system / Continuous Flow Solution Culture
   i. Nutrient Film Technique (NFT)
   ii. Deep Flow Technique (DFT)
2. Non Circulating Method / Open system / Static Solution Culture
   i. Root Dipping Technique
   ii. Floating Technique
   iii. Capillary Action Technique

Techniques in Media Culture

1. Hanging Bag Method
2. Grow Bag Method
3. Trench or trough Method
4. Pot technique

List of crops grown under hydroponic system [11]

Type of crops	Name of the crops
Cereals	*Oryza sativa* (Rice), *Zea mays* (Maize)
Fruits	*Fragaria ananassa* (Strawberry)
Vegetables	*Lycopersicon esculentum* (Tomato), *Capsicum frutescens* (Chilli), *Solanum melongena* (Brinjal), *Phaseolus vulgaris* (Green bean), *Beta vulgaris* (Beet), *Psophocarpus tetragonolobus* (Winged bean), *Capsicum annum* (Bell pepper), *Brassica oleracea var. capitata* (Cabbage), *Brassica oleracea var. botrytis* (Cauliflower), *Cucumis sativus* (Cucumbers), *Cucumis melo* (Melons), *Raphanus sativus* (Radish), *Allium cepa* (Onion)
Leafy vegetables	*Lactuca sativa* (Lettuce), *Ipomoea aquatica* (Kang Kong)
Condiments	*Petroselinum crispum* (Parsley), *Mentha spicata* (Mint), *Ocimum basilicum* (Sweet basil), *Origanum vulgare* (Oregano)
Flower / Ornamental crops	*Tagetes patula* (Marigold), *Rosa berberifolia* (Roses), *Dianthus caryophyllus* (Carnations), *Chrysanthemum indicum* (Chrysanthemum)
Medicinal crops	*Aloe vera* (Indian Aloe), *Solenostemon scutellarioides* (Coleus)
Fodder crops	*Sorghum bicolor* (Sorghum), *Medicago sativa* (Alphalfa), *Hordeum vulgare* (Barley), *Cynodon dactylon* (Bermuda grass), *Axonopus compressus* (Carpet grass)

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Hydroponic (Deep Water Culture) Setup includes

1) Reservoir/ Growing Container
2) Water Requirement and water quality
3) Growing Medium
4) Growing Containers
5) Foam sheet
6) Nutrients
7) Plant / Crop selected
8) Air Stone and Air pump

Benefits [10]

1) Healthy and nutritious crop produce in soil-less farming technique which offers high yield from farming.
2) No chance of soil-borne insects and pests, diseases attack, or weed infestation to crops.
3) This type is a step towards organic food and there is no use of pesticides and chemicals.
4) Crops grow two times faster in hydroponics and yield is doubled leading to more production from the same amount of space.
5) No wastage of water as water is reversed used in this technique uses only 1/20th of water to crops compared to traditional farming.
6) Requires less labor.
7) No worries about changing seasons, crops can be grown all year round.
8) Environment-friendly practice, no harm to nature.

Limitations of system [10]

11) Requires technical knowledge
2) Water born diseases spread easily due to poor handling
3) Control parameters like pH, humidity, temperature
4) Initial Cost is high

2) Aeroponic

The term Aeroponics means to cultivate plants without using soil and water as a medium; by maintaining all the parameters essential for the growth of plants. The parameters are temperature, humidity, pH & electrical conductivity of a nutrient solution, etc. resulting in a conditioned environment. The benefit of using Aeroponics is the plant's healthier growth and nutritious fruit by consuming fewer amounts of nutrients and water. By adopting this technique fresh and healthier fruits can be produced throughout the year. In the recent decade, the Aeroponic system is used for growing potatoes and potato seed production. [12]

Variables in the aeroponic system research are [12]

1) micro-environment (temperature, humidity, pH)
2) the effectiveness of nutrition (spraying /fogging)

Techniques in Aeroponics[12]

1. Root Mist Technique
2. Fog Feed Technique

Aeroponic setup includes

The aeroponic setup includes include

1) Reservoir/ Growing Container
2) Water Requirement and water quality
3) Spray nozzles
4) Growing Medium
5) Growing Containers
6) Foam sheet
7) Nutrients
8) Plant / Crop selected
9) Pump

Benefits [12]

1) This technology gives a high yield with fewer space requirements.
2) Plants can be grown close together.
3) Fruits produced from the system are easier to harvest.
4) Local food production can cut down transportation costs.
5) Also saves water as it cuts down water consumption by 98 %.
6) Fresh and healthy plants can be grown at home; indoors or on rooftops.
7) Plants and root growth study in laboratories is easier for students and researchers.
8) Plants consume more oxygen under aeroponic conditions; more oxygen equals more plant growth.
9) Planting and harvesting can be done throughout the year.
10) Due to clean and sterile growing conditions, plant diseases and infections reduce.
11) In an aeroponic system, plant roots have proper space to grow well. So they don't stretch or wilt.
12) These systems can reduce water usage by 98%, fertilizer usage by 60%, and pesticide usage by 100%, all while maximizing crop yields.
13) Aeroponic plants are potentially healthier and more nutritious.

Limitation [12]

1) The whole system is based on power supply, hence cut-off in power may be responsible for the failure of crop
2) Power loss for a long period may cause irreversible damage
3) Initially, some training is required for system maintenance

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4) Sanitary conditions are required to be maintained regularly
5) The initial cost of the system is high

II. LITERATURE SURVEY

1) Economy Survey Of India 2021-22

The agriculture sector has experienced buoyant growth in the past two years. The sector, which is the largest employer of the workforce, accounted for a sizeable 18.8 percent (2021- 22) in Gross Value Added (GVA) of the country registering a growth of 3.6 percent in 2020-21 and 3.9 percent in 2021-22.

In this report, the need for sustainable agriculture through water conservation in irrigation and natural farming and the need to promote research and development to improve crop productivity, mechanization, etc. is highlighted.

Research and development in agriculture & allied sectors can play a major role in the realization of sustainable agriculture practice that efficiently meets the objectives of nutritional security and improvement in farm income.

2) Urban agriculture in the developing world : a review

(Francesco Orsini, Remi Kahane, Remi Nono-Womdim, Giorgio Gianquinto) March 2013

As demonstrated in the paper, the urbanization process goes along with increasing urban poverty and polluted environment, growing food insecurity, and increasing unemployment. Urban agriculture represents an opportunity for improving food supply, health conditions, local economy, social integration, and environmental sustainability altogether.

This review paper demonstrated the concept of urban agriculture, its evolution along with its pros and cons in the area of food and nutrition security, health, development of local economies, social inclusion, ecological aspects, and environmental impact.

As concluded in the paper, it is reasonable to expect not only from governmental organizations and local authorities but also from the private sector, the promotion of training and technical assistance for the actors of urban farming. The urbanized environment is bringing to the front a category of actors that is playing a role every day, also in developing economies: the consumers.

3) Urban and Peri-Urban Agriculture as a Tool for Food Security and Climate Change Mitigation and Adaptation: The Case of Mestre

(Giulia Lucertini, Gianmarco Di Giustino) May 2021

As demonstrated in the paper, Urban and peri-urban agriculture (UPA) are major contributors in Green House Gas emissions. UPAs can be considered as Edible Green Infrastructure (EGIs) able to produce food, but also support climate change mitigation and adaptation. Also, UPAs is considered an aspect of the Circular Economy.

Along with this UPA shows the following environmental benefits food security, Waste recycling, community empowerment and education, Climate change mitigation and adaptation, reduction in air pollution and soil erosion, biodiversity, and ecological and social sustainability.

Climate change mitigation, like CO2 reduction and sequestration, and climate change adaptation, like Urban Flooding and Urban Heat Island reduction, due to the new UPA areas' development were estimated.

In this research, the case study area is the City of Venice in northeast Italy of area 130.57 km2 is considered. At first; a map of all the urban and peri-urban available and suitable spaces for UPA was identified using a Geographic Information System (GIS). Then, the amount of food that can be produced in such areas was estimated, as well as how it can cover the needs of the urban population. The climate change mitigation and adaptation effects are given by urban agriculture, in terms of CO2 sequestration and reduction, water retention, and decreased temperature, were accounted.

As concluded in the paper, urban agriculture multifunctionality is considered a possible new urban foodscape; thus, some urban food policy recommendations and further possible research are suggested.

4) Policy Paper 89 Vertical Farming

(National Academy of Agricultural Sciences, New Delhi) May 2019

As demonstrated in this Policy Paper by NAAS, Vertical Farming is a solution to land scarcity and increasing food demand. Recently, the application of Vertical Farming in cities has emerged as an option to land-based farming for the cultivation of vegetables and ornamental plants in high-rise buildings the world over. It appears that the concept of the vertical farm in the urban areas could solve a lot of issues related to safe and nutritious food production and environmental degradation. Vertical gardens are being taken up enthusiastically in Indian metros too by growing plants in various soilless mediums. Optimally, vertical farming is required to be a cost-effective, sustainable, and efficient system to be adopted on a large scale in peri-urban areas.

This paper describes the history of vertical farming from the Pre-20th Century to beyond the 20th

century. Highlights of the sustainable vertical farming ventures in vogue in India under which include mushroom production, Garden wall/Bio-wall, Hydroponic fodder, Strawberry Vertical Farming, Cucurbits trained vertically, Micro-greens, Aquaponics, Farm containers, Poultry Production, Structures, and other engineering inputs in vertical farming, Commonly grown crops, growing mediums, water, and nutrient management efficiency Electrical conductivity and pH in Vertical Farming.

Also, this policy paper highlights the necessity of research and development in the area of vertical farming, major challenges for vertical farming, and key recommendations for improvement.

5) Vertical Farming to Sustain the Agriculture for Future Food Production and Supply: A Review

(T. Naga Srinivasa Reddy, Harshal Avinashe , Nidhi Dubey) December 2020

As demonstrated in this paper, Vertical farming provides sufficient food to the people. It helps food industries develop in the urban areas and reducing the poverty by providing jobs. Human well-being is enhanced and secure by vertical farming.

The General Structure of vertical Farming includes materials like Ethylene Tetra Fluoro Ethylene (ETFE), Lightning, Water requirement, Recycling, Dehumidification, Hydroponic, Aquaponic, Livestock Production, Controlled Environment systems, and Water management. Also, one basic design model is given in this paper. Along with this benefits and limitations of vertical farming are given.

6) Vertical Farming: A Concept

(Rashmi Maria Royston, Pavithra M.P.) May 2018

As demonstrated in the paper, the vertical farm is a world-changing innovation. The concept in which every town has its local food source, grown in the safest way possible. Smart farming makes a tremendous contribution to food sustainability in the 21st century. The reason is that environmental and water management affects plant growth directly. Vertical farming is considered a modern tool for feeding a large world population by the year 2050. Erecting a farm that is near the people it serves by the availability of cheaper, organic, disease-free crops alongside sustaining the limited natural resources.

As concluded in the paper, Vertical farming technologies are still relatively new. Companies are yet to successfully produce crops at scale and make it economically feasible to meet the growing food demand.

7) Vertical Farming: A Revolution to Sustainable Agriculture

(Carly Sills, Mandala, Isaac Serbin) Feb 2018

As demonstrated in the paper, According to the Vertical Farming Association, "It is estimated that by the year 2050, the world's population would increase to ten billion, and close to 80% of human settlements would be concentrated in and around urban locations"; with a growing human population, there is a growing need for sustainable practices, especially within agriculture. Vertical farming technology has the potential to impact the world economically, environmentally, and socially. The goal of this paper is to present the most efficient vertical farming technology using the best sustainable agriculture techniques to combat global issues caused by traditional farming practices and overpopulation. By farming inside of a building, one can decrease the amount of land, water, energy, chemicals, and transportation used to feed the world. Also give the solution to the problem of land use, water use, and chemical use along with social issues.

By spreading the use of this technology across the globe, engineers and farmers alike have the potential to save the environment from the detrimental effects of climate change and overpopulation.

8) Status of Vertical Farming in India

(Madhuri Shrikant Sonawane, Maharashtra State, India) Dec 2018

As demonstrated in the paper, agriculture in India is continuously molting. Newer technologies are coming up to face the challenges arising due to overgrowing population, water scarcity, climate change, labor scarcity, and urbanization leading to a reduction in arable land. Vertical farming is perhaps an intensive way of increasing food production with lesser lands.

Vertical farming is a solution to critical problems in Indian farming like lack of supply or oversupply of farm produce, overuse of pesticides, overuse of fertilizers, deteriorating soils, and even unemployability. Indian farmers are facing various problems like lack of electricity supply throughout the day, assurance of minimum support prices, no control over market glut, water scarcity, etc. The initial huge cost of infrastructure for a large-scale farm is a major hurdle for implementing vertical farming in India. Vertical farming in India has to face other challenges like public awareness, inclusiveness of the farming community, technical know-how, cost incurred in managing and mainlining the vertical farm systems, and also its economic viability.

9) Vertical Farming Proposal in India

(Singh Rohit Umashankar, Pandey Atul Pramod, Tiwari Sonu Dinesh, Soni Sanjay Mulchand) June 2020

As demonstrated in the paper, vertical farming is stacked on top of one another, instead of branching out horizontally. Vertical farming is the practice of producing food and medicine in vertically stacked layers, vertically inclined surfaces, or integrated into other structures such as a skyscraper, used warehouses, shipping containers, terraces, etc. The project study is restricted to proposing a self-sustained structure based on vertical farming using a modern farming technique of soil-less agriculture to counter the problems generated in current conventional farming i.e. horizontal farming practiced in India. The methodology of this project includes the study of vertical farming and hydroponic system. The project study also concludes the cost-benefit of vertical farming over horizontal farming. The project focuses on the use of the technique of hydroponic in vertical farming. The resulting social benefit from the project is that the future population gets fed with organic and nutritious food. The project implements optimum uses of resources such as land and water so that maximum output can be achieved to overcome food scarcity in the future. And Proposal for G+ 11 structures and G+ 3 warehouses is given in this study.

10) A Review on Scope and Potentiality of Vertical Farming in India

(Anil Kumar, Rajkumari Asha Devi, Pedada Sindhusha and Mishael R Marak) October 2020

As demonstrated in the paper, nowadays people are showing their interest in their health, and to meet their healthy food requirements, salad vegetables are the best options due to their nutritional values. Vegetables have a high number of health benefits. The vegetables can also be eaten raw in form of salad. The vegetables are also suited best under this structure as these are short duration and provide high net returns. These can be grown by using various growing substrates viz. perlite, coco-peat, vermiculite, etc. to enable fast-growing and high yield.

This paper gives a brief description of vertical farming background, needs, and present status of vertical farming in India. Data of techniques like Hydroponic, Controlled Environment Condition for vertical Farming. Some comparative data on the chemical nature of various growing media, yield a comparison between hydroponic and open field cultivation.

As concluded in the paper, the benefits of growing crops in the hydroponics system & controlled environment. When these systems are incorporated together and used in vertical farming to grow crops then the results are far better. So it can be said that vertical farming has a wider list of benefits over the other growing methods and is a better alternative to crop-growing as per the current scenario where the population is growing rapidly.

11) A Review of Vertical Farming Technology: A Guide for Implementation of Building Integrated Agriculture in Cities

(Fatemeh Kalantari, Osman Mohd Tahir, Ahmad Mahmoudi Lahijani and Shahaboddin Kalantari) 2017

As demonstrated in the paper, vertical farming technology needs to be manifest both in the agricultural technique and architectural technology together. In this study, technology as one of the important factors of Vertical farming is discussed and reviewed through a qualitative approach. The technologies offered can be a guide for implementation development and planning for innovative farming industries of Vertical Farming in cities.

This review paper gives the framework for the general structure of vertical farming which includes the material to be used, a Lightning system like natural, Solar, or LED; Water management for a system for requirement, recycling, and dehumidification; Energy required for the whole system; farming system, crop selection and introduction of smart devices.

As concluded in the paper, Vertical Farming has the potential way for sustainable progress to produce food or related services in urban areas. The goals and future vision have been planned to generate sustainable cities around the world. It simultaneously helps to reduce poverty, adds to food safety, and increases contextual sustainability and human well-being.

17) An Innovative Approach on Vertical Farming Techniques

(M. Jegadeesh, Dr. J. Verapandi) October 2014

As demonstrated in this paper, Vertical Farming is the advanced level of agriculture technology, this is the new way or approach in the advanced level and this paper deals with the methodology, harvesting technique, water management, and crop cultivation & yielding process. And some of the natural renewable resources are used such as windmills, solar, etc, where these are not similar to the normal agricultural process; some of the other practices have to be for the good yielding process.

The innovative approach in this article is the integrated technology in the vertical farming technique where the system has to be completely controlled with the computers and other embedded

systems such as sensors etc, but in our system, the integrated system has to be to analyze water, air and mineral maintenance. While if take the air quality management the crops and plants are needed the Carbon dioxide and this is supplied by the air management integration system, as plants have to develop healthily a separated separate system has to be created as well as the water and air quality also managed.

As concluded in the paper, thus the paper completely discusses the vertical farming structure, where it has to be completely made off with advanced technology such as artificial lighting systems, hydroponic systems, and efficient farming management in the urban areas. By collecting all these qualities the vertical farming may develop the well organized and gains a high amount of yielding in the agriculture

18) Opportunities and Challenges in Sustainability of Vertical Farming: A Review

(Fatemeh Kalantari, Osman Mohd Tahir, Raheleh Akbari Joni and Ezaz Fatemi)
June 2017

As demonstrated in the paper, the well-known advantages of growing food within the urban territory can be beneficial environmentally, socially, and economically. Vertical farms can also provide solutions for increasing food security worldwide. Also include environmental benefits of vertical farming as Resilient to Climate Change, Reduction of Water Demand, Energy Saving, More Productivity per Unit of Area, Reduction of Urban Heat Island, acting as a Sound Insulator, Reduction of Carbon Footprint, and the Effect on Air Quality.

As concluded in the paper, VF has got numerous advantages over traditional farming, which include more efficiency, adaptability, and environmental benefits, which are all made possible through carefully controlled systems of VF. In VF, no waste or pollution is involved; it enjoys high levels of potentiality.

19) All about Vertical Farming: A Review

(Gaganjot kaura , and Paras Chawlab) February 2021

This article summarizes the complete concept of an emerging area of agriculture with its various categories and techniques used throughout the world. Topics covered in this paper include environmental benefits of vertical farming, challenges to vertical farming, different techniques involved in VF, Design setup for VF, and reuse of different structures for VF. Commercial examples of a vertical system like Green walls, Cylindrical Growth Unit, Cylindrical Rotatory system, and also a list of existing farms is given in this paper.

As concluded in the paper, Vertical Farming can help boost food production numbers which will reduce food pressure from rural agricultural lands. Unoccupied, large areas in dense urban areas can be easily used to implement VF. Integration of VF with recent technological advancements like learning and data analytics techniques could prove to be useful. Work should be done this technique is available to every individual or house in urban areas so that they can grow their food without pesticides and also use this for gardening purposes.

20) Introduction of Hydroponic system and it's Methods

(Sagar J. Dholwani, Sagar G. Marwadi, Vandan P. Patel, Vijeta P. Desai) 2018

As demonstrated in the paper, due to rapid urbanization and industrialization as well as the melting of icebergs, and the impact of global warming, arable land under cultivation is going to decrease. Poor soil fertility in some of the cultivable areas, less chance of natural soil fertility build-up by microbes due to continuous cultivation, frequent drought conditions and unpredictability of climate and weather patterns, rise in temperature, river pollution, poor water management and wastage of huge amount of water, the decline in groundwater level, etc. are threatening food production under conventional soil-based agriculture. The purpose of this study was to determine the effect of factors on the feasibility of hydroponics cultivation through training and research.

The detailed information on the Hydroponic system is given in this paper. Also, a different method of hydroponic is explained along with its benefits.

21) Hydroponics : An upcoming and innovative way of future farming

(Madhuri Shrikant Sonawane) February 2018

The objectives of this research paper are to discuss different available techniques for soil-less culture, to give review the current methods for hydroponics, to discuss the benefits and disadvantages of soil-less culture over conventional open agriculture, and to review the potential for growth of hydroponics in India.

The hydroponic system is classified as liquid hydroponic and media culture mainly. The liquid hydroponic is divided into two categories:

1. Liquid Hydroponic

1) Circulating/ Closed/ Continuous Flow Solution
i. Nutrient Film Technique (NFT)
ii. Deep Water Culture (DWC)
2) Non-Circulating/ Open/ Static Solution
i. Root Dipping Technique
ii. Floating Technique

iii. Capillary Action Technique

2. Media Culture

1) Hanging Bag Technique
2) Grow Bag Technique
3) Trench /Trough Technique
4) Pot Technique

Also, a list of crops that can be grown in hydroponic technique, Nutrients required for crop growth, and pH scale that need to be maintained for different crops are given in this paper.

22) A Review on Plant without Soil - Hydroponics

(Ms. Mamta D. Sardare , Ms. Shraddha V. Admane)MAR 2013

As demonstrated on paper, in soil-less culture, plants are raised without soil. Improved space and water-conserving methods of food production under soil-less culture have shown some promising results all over the World.

As concluded in this paper, the vertical farming industry is expected to grow exponentially also in the future, as conditions of soil growing are becoming difficult. The urban concrete conglomerate is growing each day; there is no option but to adopt soil-less culture to help improve the yield and quality of the product so that we can ensure the food security of our country. However, Government intervention and Research Institute interest can propel the use of this technology.

23) Comparison between Growing Plants in Hydroponic System and Soil Based System

(Raneem Gashgari, Khawlah Alharbi, Khadija Mughrbil, Ajwan Jan, Abeer Glolam)
August, 2018

As demonstrated in the paper, the first system is the soil-based system (traditional), and the other is the hydroponic system. Two types of seeds were used, cucumber and Armenian cucumber. The planting system has a significant effect on plant growth; the hydroponic system has a higher growth rate. This result achieves the aim of this paper which is finding a planting system that can increase productivity to cover the food demand.

As concluded in the paper, this study aimed to examine an efficient technique for an alternative planting system which is the hydroponic system. The statistical experimental design approach was used to analyze and compare between traditional soil system and hydroponic system by planting two types of seeds: cucumber and Armenian cucumber in both systems.

24) Challenges And Possibilities In Hydroponics: An Indian Perspective

(Shailesh Solanki, Nitish Gaurav , Geetha Bhawani and Abhinav Kumar) November 2017

This review paper focuses on the information of hydroponics and its advantages, limitation, different techniques, and the nutrient requirement, challenges, and possibilities to bring soil-less farming in India to ensure its stability so that it may prove more beneficial for Indian farmers to grow crops that are 100% organic, toxic-free and of better quality.

25) Aeroponic Technology: Blessing or Curse

(Gagandeep Kaur, Dilip Kumar) July, 2014

As demonstrated in the paper, aeroponic technology, a soil-less culture can grow plants in a conditioned, pest and disease-free environment. Enhanced disease-free yield leads India to be a top grower and exporter in near future. The aeroponic system has the potential to produce enhanced vegetative growth without the use of any artificial hormones, pesticides, or insecticides. This soil-less culture can overcome all the constraints that are present in soil culture production.

As concluded in the paper, total agricultural water consumption by human beings is 70 percent of total consumed water. Out of that 45 percent is wasted due to gaudy irrigation techniques. By using aeroponic systems, we can save 98 percent of total water because of the recirculatory system. Fresh, clean, healthy, efficient, and rapid food production can be obtained from aeroponic systems throughout the year. Due to clean and sterile growing conditions, plant diseases and infections reduce to a great extent.

26) Modern Plant Cultivation Technologies In Agriculture Under Controlled Environment: A Review On Aeroponics

(Imran Ali Lakhiar, Jianmin Gao, Tabinda Naz Syed, Farman Ali Chandio& Noman Ali Buttar) 30 May 2018.

In the aeroponics system, plant roots are hanging in the artificially provided plastic holder and foam material replacement of the soil. The roots are allowed to dangle freely and openly in the air. However, the nutrient rich-water delivers with atomization nozzles. The nozzles create a fine spray mist of different droplet sizes intermittently or continuously.

In the aeroponics system, both air and nutrient solution temperature should be controlled for quick plant maturation. As temperatures rise, the chemical processes proceed at faster rates and deteriorate the enzyme activities. The optimum temperature range for all plants is 15–25°C. However, the temperature of the growth chamber should be no higher than 30°C and less than 4°C.

Aeroponics system is the application of plant growth without soil by delivering water nutrient solution in the air. The system is based on 100% available moisture in the growth chamber. In addition, the humidity is the amount of available water in the growth chamber as water vapor content. In the aeroponics system, humidity is the main component required for successful plant growth and development. However, plant growth is significantly affected by increases and decreases in relative humidity.

This review concludes that the aeroponics system is considered the best plant growing method for food security and sustainable development. The system has shown some promising returns in various countries and is recommended as the most efficient, useful, significant, economical, and convenient plant growing system than soil and other soil-less methods.

27) Overview of the aeroponic agriculture – An emerging technology for global food security

(Imran Ali Lakhiar, Jianmin Gao , Tabinda Naz Syed, Farman Ali Chandio, Mazhar Hussain Tunio, Fiaz Ahmad, Kashif Ali Solangi) January 2020

As demonstrated in the paper, traditionally crops are cultivated in soil-based open field systems. Soilless culture is one of the modern plant production systems, which involves much higher use of available resources. This study provides information about currently accessible soilless systems and discussed the aeroponic system. Compared to other soilless systems, aeroponic reduces water usage through continuous water circulation. However, the aeroponic is not entirely implemented among local farmers, and very few farmers have adopted the system due to the lack of research and technical information available in the literature. Therefore, this study was planned to provide information about the development and maintenance tasks required for practicing the aeroponic system. This study could provide knowledge to the researchers, farmers, and those people interested in practicing the aeroponic system.

28) Survey Paper on Aeroponics

(Ajay kumar D, Namratha S.N) July 2019

As demonstrated in the paper, Aeroponics is the method of growing plants in a medium without the use of soil. Here the plants are provided with a nutrient solution that contains macronutrients and micronutrients which contribute to the healthy growth of plants. This method allows for the faster growth of plants.

As concluded in the paper, Aeroponics is a method for the production of both airborne parts and roots as underdone materials for the herbal dietary supplement and phytopharmaceutical industries. Plants grow fast because their roots have access to a lot of oxygen 24/7. When grown in Aeroponic condition, since the environment is clean and sterile, chances of spreading plant diseases and infection in soil and other growing media is greatly reduced, and hence able to absorb more minerals and vitamins as the nutrient absorption rate is higher.

29) Aeroponics: A Review on Modern Agriculture Technology

(Reena Kumari and Ramesh Kumar) April 2019

As demonstrated in the paper, Aeroponic farming is a form of hydroponic technique and a type of vertical farming. This farming system empowered the producer to precisely control root zone nutrients, water regimes, and environmental conditions and have complete access to the roots throughout the life of the crop. Aeroponics appeared to be a highly feasible method for the production of both aerial parts and roots.

As concluded in the paper, the Aeroponic system has the potential to produce enhanced vegetative growth without the use of any artificial hormones, pesticides, or insecticides.

30) Getting to the roots of aeroponic indoor farming

(New Phytologist Foundation) 2020

Aeroponics involves the application to roots of a nutrient aerosol, which can lead to greater plant productivity than hydroponic cultivation. Aeroponics is thought to resolve a variety of plant physiological constraints that occur within hydroponic systems.

Identify future research areas to accelerate the sustainable intensification of vertical farming using aeroponic systems which include photosynthetic performance, oxygen availability, water relations, nutrient supply, Root developmental architecture under standardized aeroponic conditions for a key range of crops at a variety of developmental stages, and how this differs from hydroponic- and soil-based cultivation, the relationship between aeroponic droplet size, nutrient content, droplet deposition, and plant performance, relationship between aeroponic fertilization and daily (24 h) cycles, and how this relationship affects crop performance, the relationship between daily cycles of environmental conditions (e.g. lighting, airflow, temperature, humidity), and crop metabolism presents opportunities to adjust crop performance, appearance, nutrient composition, and flavor.

III. NEED OF STUDY

For securing the addition of food with less arable land for the growing population keeping future demand in mind there should be a requirement for technological innovation within the farming process, so to introduce the technology-based solution in farming. To reduce poverty in the country, in addition to environmental benefits, the addition of food safety, and increases sustainability and human being, vertical farming is important.

IV. CONCLUSION

Urban agriculture is defined as production of food like vegetables, herbs, and fruits for food and nutrition security of the growing population, for aesthetic and ornamental purposes, and employs residents.

Vertical Farming is one form of Urban Agriculture. The vertical Farming concept is getting very popular nowadays. Implementing the method within the urban area with technical support helps in large food production for the high consumption rate of the population.

Hydroponic i.e. production in water and nutrient solution; and Aeroponic i.e. production in air and nutrient solution misting is the technique of vertical farming.

For the development of a system for production, there is a need for proper management of micro-environment factors like pH, temperature, humidity, proper ventilation, electrical conductivity, and waste management.

For good production, the Optimum pH should be within 5.5-6.5. An optimum temperature range is within 20-30^{o}C. Optimum Relative Humidity is within 50-70%. Inert mediums such as gravel, sand, and sawdust are used as soil substitutes to provide support for the roots.

Seventeen elements are needed for the proper growth of the plants; nine of these elements are macronutrients (i.e. carbons, hydrogen, oxygen, sulfur, phosphorus, calcium, magnesium, potassium, and nitrogen) and are required in a comparatively large amount

Staying eight elements are trash elements known as micronutrients and needed in minute amounts, these are as follows: iron, zinc, copper, manganese, boron, chlorine, cobalt, and molybdenum.

With proper management and maintenance, one can get high production from these techniques.

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