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Hydroponics – Sustainable Farming

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Abstract

As per FAO by 2050 the global population is projected to reach 9.8 billion with 66 percent of the population living in urban areas. An agricultural area of 593 hectares of land is required to feed the population. Present agriculture faces the huge task of satisfying the demand and it can nowhere match reaching the demand for food worldwide in future decades. The prime challenge in basic practices are climate calamities along with soil fertility issues, excessive water, and nutrient requirements. Hence Technology must permeate the Agricultural sector to explore innovative alternative sustainable methods as solutions against food insecurity, resource conservation and to mitigate the negative impacts on the Ecosystem. Hydroponics is a new sustainable method of soilless farming in controlled Environmental conditions producing high-quality yields of crops.

Index Terms: climate calamities, Food security, sustainable, high yield, resource efficient, optimum fertilizer, Agriculture 4.0.

1. INTRODUCTION

This article discusses scope, methods, advantages, limitations, potential and possibilities, setup factors, challenges, costs vs benefits, and future research in the field of Hydroponics. Basically, it is a subset of horticulture which is based on hydroculture, HYDRO means water and pono means labor. This unique innovative grow system controls the balance of nutrition, humidity, and temperature and uses a ten percent fraction of water than conventional methods, producing a High qualitative yield. The plants grow faster and healthier since the nutrients are delivered to their roots through water in the form of an aqueous solution. The major risk of climate calamity in unconventional farming is mitigated by meticulously controlled micro environmental conditions for plant growth.

1.1 METHODS

Elements of photosynthesis like Sunlight, water nutrients, and Carbon Dioxide are artificially substituted by tailor-made LEDs and soil-free mediums like coco peat, rice husk, perlite, sand, gravel, vermiculite, rock wool, etc. Proper drainage, aeration, recirculation and water-holding capacity provide moisture to plants and facilitate nutrient movement to roots. Multiple forms of hydroponic methods are emerging as media culture and solution culture. Circulating methods like NFT, DWC, Dutch bucket system, Aeroponics and Aquaponics, etc are in common practice. The poly houses and technologies adopted range from basic low tech design models to fully automated high tech systems. Farm settings and size can be categorized as indoor , outdoor , community and commercial application setups.

1.2 ADVANTAGES

High-yield, healthy, clean, and pest-free, eco-friendly crops are produced with less labor and space. Since the roots do not take up much room, more crops are produced on a given surface. Seeds do not need to make their way through the soil mechanically hence allowing for faster maturation and crop development leading to short cultivation cycles. Ensure food security in extreme drought areas and areas of low soil quality. Abandoned lands and landfills can be reverted as natural ecosystems, food parks, and vertical gardens. As against conventional farming, they use fewer resources to reduce greenhouse gas emissions, carbon footprint, and agricultural waste without use of fertilizers .

1.3 LIMITATIONS

Lack of Educational awareness and training in the agricultural sector and heavy investments may lead to intense risks. Maintenance and monitoring of sensors and digital systems need expertise, skill, and support. Financial support from governments and subsidies given is too less for the set-up costs. Technical know-how standards, and knowledge are the roadblocks of this promising urban farming. Plumbing systems and automation, such as sensors, controllers, water pumps, lighting, Consultant's fees, and equipment to control temperature, and purify water all need installation and maintenance costs. Generating plant nutrition and integration of Artificial Intelligence, Data Analytics is a real challenge.

2.0 POTENTIAL AND POSSIBILITIES

Hydroponic modular farming can be used to grow the following.

TABLE 1: Types of crops and yield

Vegetables	Carrots, cucumber, tomatoes, peas, onions, Beans, bell peppers, cantaloupe
Cereals	Rice, maize
Flowers	Marigold, roses, chrysanthemum
Herbs	Parsley, mint, chives, sage, basil
Greens	Lettuce, spinach, basil, celery
Fodder	Barley
Fruits	Strawberries, bananas, cherries, blueberries,
Cash crops	Ginger, turmeric, saffron

Soil-based farming in India grows 10 - 20 tons of tomatoes, greens, and 20 -25 tons of berries and leafy greens per acre. The hydroponic systems can grow 180-200 tons of tomatoes,50 tons of berries, and 300 to 400 tons of leafy greens per acre.

2.1 GLOBAL SCENARIO

Countries like Japan, Indonesia, Africa, Israel, Canada, US, and Singapore are proactive with this fastest-growing sector for overall economic development. In India Hydroponics is walking ahead with infantry stages but significant growth is seen to happen in the near future. Researchers, scientists, and urban planners, have noted the crucial role of these modular farming methods to manage domestic demand as vertical farming in urban landscapes. The food demand of the local population is satisfied and has economic perspectives along with ample Job opportunities. Singapore City plans to reach the 30 by 30 goal using GO GREEN towers to satisfy the country's 30 percent nutritional needs by using a vertical garden Hydroponic system in 2030.

2.2 SETUP TYPE

TABLE 2: **Setup details and suitability Analysis**

Method	Suitability
DWC-Roots supported in water troughs . 50 lakh per acre	Used in tropical climates, a simple setup, pump with a timer , large plants
NFT -Roots are supported in shallow channels 80 lakh per acre	Stacked as Vertical gardens, lightweight, small space. shallow root plants
Dutch bucket model - Roots supported by media 20 lakh per acre	containers /pots , tubings for water supply , Large spaces large plants
Aeroponics- Roots hung in the air	The solution is Misted in frequent time intervals, used in drought areas. fodder crops
Aquaponics- fish and plants are grown together	Used in coastal areas with saline water.

2.3 DATA AND DISCUSSION

As per KRISHI JAGRAN hydroponic farming guide, investment cost for 5000 square feet is around Rs 20,00,000 for one time setup of a polyhose shelter, pipes,water tanks, pumps, coolers and gadgets i e Rs 400 per square foot and Rs 16 as per cycle investment .

Operational costs for the same includes seeds, electricity fertilizers, labour and maintenance packing and transportation as Rs 80,000 per month.

Considering one time crop production for lettuce 2200 kg per cycle with market value of Rs 350 value of yield is around Eight lakhs and profit margin per cycle is 7 lakhs per cycle excluding the operational cost of Rs 8000 per cycle . The profit margin per square foot is Rs 140 per cycle .

TABLE 3:Comparative Analysis of farm set ups

Feature	City hydroponics Bangalore	sp consultants Belgaum	krishi jagran guidelines
Farm size	1000 SQ M	2000 SQ M	500 SQ M
Investment	DWC 55 L	NFT 45 L	NFT 20 L
Operational cost	10 Lakhs /Year	Rs 30,000 per cycle /crop	Rs 80,000 per cycle
Yield	2000*10 20000 KG (!20)	1000 KG (60)	2200 KG (350)
Price	24 Lakhs /year	Rs 63,000	7.7 Lakhs

Net Profit	14 Lakhs/ year	Rs 33,000 Rs /cycle per crop	7 lakhs

Smaller farms and vertical farms with automation and high value crops can be more profitable than larger farms and may have significant outputs. Market Demand, pricing, and distribution networks play an important role in returns . Hence the success of a unit depends on location selection of crops and market access.

2.4 FACTORS

LIGHTING: The site selected should have the highest natural light levels. LED's and the modulations in intensity of spectrum enable effective plant growth.

TEMPERATURE: The temperature should be maintained in summer without the use of fans and winters are to be managed with porous polyester to reduce night heat loss. For maintaining temperatures, the elevation of the site should be optimum.

HUMIDITY: The optimal relative humidity during the clone's rooting can be 70-80%. During the transition from germination to the vegetative phase the RH value is 40-60% and during the blossoming phase the RH is 40-50 %

ELECTRICAL CONDUCTIVITY: EC meters which are highly influenced by temperature adequately tested across several EC treatments, prove the photosynthesis effect on leaves is higher between 1.8- 2.4 EC.

ENERGY: Natural gas, propane, fuel oil, electricity and solar are types of energy sources.

WATER QUALITY: Chemical parameters of water like PH, alkalinity, calcium, magnesium, and chlorine salts concentration should be checked. plant growth depends on the pH range in soilless agriculture 5.5 and 6.5

2.5 FACTS AND FUTURE SCOPE

1. Hydroponics in India requires greenhouse building, trays, and lighting systems that may cost 70,000 rupees per 1000 Square feet Area.
2. It is expected to reach a global market of 25 billion US $ with a CAGR of 15.6% in 2027. In India, it is expected to reach a 13.53 % CAGR.
3 Closed systems of NFT and Media based hydroponics can save 90 percent water, 85 percent fertilizer, and 250 percent increase in productivity.
4 Crops produced by NFT systems are of high quality and productive.

5 NASA is researching extensively on Hydroponics during space missions as an Ecological support system for astronauts in zero gravity environments using Aeroponics.
6 Pharma and Nutraceutical industries planning for clean, toxin-free herbs (ginger, turmeric, Shatavari , ashwagandha) in CEA approaches
7 In 2023 budget Agricultural Accelerator fund is announced to boost agriculture startups with innovative solutions.
8 Punjab agricultural university gets a national patent in hybrid hydroponic technology for growing tomatoes.
9 NUTRIFRESH is a startup yielding 1100 MT of fruits and veggies in 10 acres satisfying the food needs of Mumbai and Pune cities.
10 Green rush organics is an aquafarm that grows 6000 plants in an 80 square feet area under the BETTER INDIA program.
11. Some success stories of hydroponics farming can be considered as the confidence booster of any grower who is willing to set up this innovative hydroponic system.

1. Aqua Farms, Chennai: Rahul Dhoka,
2 Letcetra Agritech, Goa: Ajay Naik,
3 Urban Kissan, Hyderabad: Vihari Kanukollu, Dr. Sairam, and Srinivas Chaganti .
4. Future Farms, Chennai: Sriram Gopal,
5 Rise Hydroponics patel vivek Shukla, Ahmadabad
6 Nutrifresh Farm Tech , Pune.

2.6 AGRICULTURE 4.0

Hydroponics fits perfectly within the frame of Agriculture 4.0, as large companies are investing in indoor vertical farming, Artificial intelligence, and Plant Biology to grow an extensive line of products in commercial agriculture, pharmaceutical industries, and Nutraceutical industries. With the support of advanced and disruptive technologies and sound scientific knowledge, a new mode of precision agricultural practice is soon to emerge globally. Steps for the integrated approach need a wide understanding of the need of the project, analysis of the market, self-need or entrepreneurship, and choosing the automation level in the future to design the same. Proper Technology and processing units should be procured, tested, and made available to end users. With all these means of precision modernization, Hydroponics has the ability to support the Food Security Strategy now and in the future. Several organizations have explored coming out with Food Processing Computers technologies to improvise automation and control the environmental parameters in closed/open systems that can affect plant growth.Agriculture 4.0 aims to implement AI and IoT in regular practice, as shown in the key plans below.

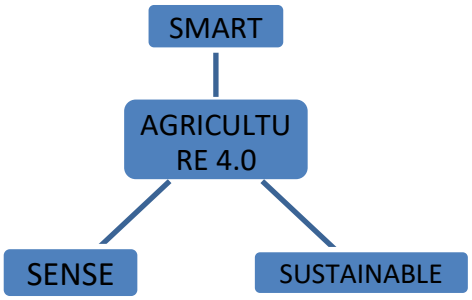

Fig 1 Concepts of Agriculture 4.0.

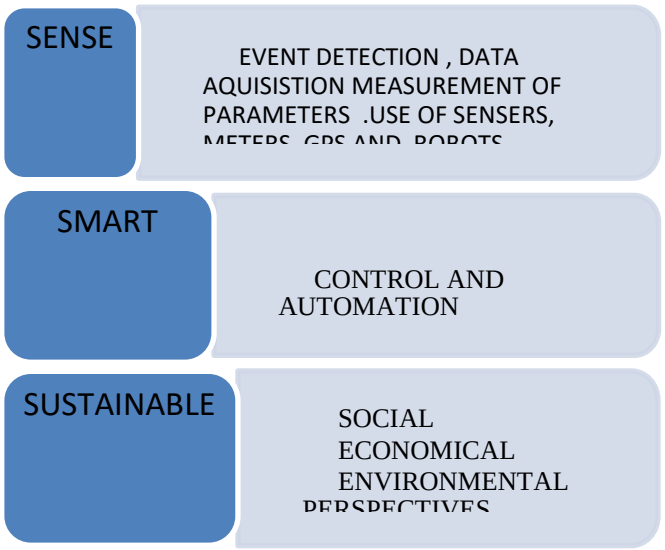

Fig 2 Modernization concepts towards Sustainability.

2. SUMMARY

Hydroponics is essential agricultural technology to be focused especially in urban areas as they offer investment stability, pioneering ideas, and research strategies. The progress of this system is only possible through the collaboration between the Government, policymakers, scientists, and agriculturalists, private sectors, and industrialists to involve young entrepreneurs in planning strategies, performing surveys, and creating practical knowledge among youth farmers to bring about farming on a large scale.

Finally, Agriculture is not cropping and cultivation for food security, but it should sustain to conserve resources. Every drop of water should be efficiently utilized, and soil degradation towards the decline of arable land sources should be avoided. Hydroponics Farming has dual benefits, it is not far when people will understand the importance of Fresh & Nutritious Food in their daily lives.

ABBREVIATIONS

DWC Deep Water culture.
NFT Nutrient Film Technique.
CEA Controlled environment agriculture
IoT Internet of things.
AI Artificial Intelligence.

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AUTHOR'S BIOGRAPHIES

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Price	24 Lakhs /year	63000 Rs	7.7 Lakhs

Net Profit	14 Lakhs/ year	33000 Rs /cycle per crop	7 lakhs

FARM SIZE AND INVESTMENT 2023 SQ M	0.5 ACRES	1000 SQ M (10000 SQ FT)
SET UP FRAME) 45 L	NFT (A	DWC 55 LAKHS
CROPS CELERY 7000	LETTUCE,	SPINACH, LETTUCE 20,000
YIELD (45 DAYS) 120 GM /PLANT	1050 KG	2000 KG
PRICE 100 PER KG /REVENUE	63000 Rs	2.0 LAKHS = 24 LAKHS ANNUM
OPERATION COST (39 %)		2 .5 LAKHS PER ANNUM
MANPOWER /NUTRIENTS	30,000	3+3 LAKHS
PROFIT 21= 7 lakhs	33000x	14 LAKHS PER ANNUM
	6 years	4 years
WAGHMARE	SAGAR	CITY GREENS BANGALORE