

Review on Comparative Analysis of Geoponics and Hydroponics Cultivation Methodology for the Enrichment of Leafy Vegetable

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Abstract

Geoponics refers to growth of plants in soil, which is the traditional method of agriculture, While soil less cultivation stands for hydroponics (growing in water) and aeroponics (growing in air). In present scenario hydroponic techniques have proven to be far more efficient and crucial to geoponics. The current study provides a comparative analysis of geoponics (soil-based cultivation) and hydroponics (soilless, nutrient-solution based cultivation) to evaluate relative efficacy, enrichment and growth of green leafy vegetables in both the systems. The study emphasizes on the effectiveness of hydroponics techniques over traditional cultivation system. With increasing pressure on high yields, a tremendous demand is laid on supply, land and freshwater, as a consequences modern agriculture requires sustainable alternatives. Experimental findings demonstrate that hydroponic systems promote vegetative growth and increase overall crop yields by up to 25% compared to conventional geoponic methods. Furthermore, the hydroponic techniques achieve a remarkable water savings of over 90% through controlled, recirculating nutrient delivery. Nutrient management, monitored via electrical conductivity (EC) and pH balancing, ensures direct and consistent ion absorption, resulting in superior leaf coloration and higher moisture content. The present paper thus reviews the beneficial aspects of the soilless harvest.

Keywords: Geoponics, Hydroponics, Leafy Vegetables, Nutrient, Agriculture

Introduction

India, an agrarian economy, has historically relied on agriculture as the primary source of livelihood for a significant portion of its population. With over 50% of the workforce engaged in agriculture and allied activities, the sector contributes approximately 17-18% to the country's Gross Domestic Product (GDP) (Government of India, 2021). The dependency on agriculture makes India particularly vulnerable to climatic, economic, and policy-related fluctuations, necessitating a comprehensive understanding of its agrarian structure.(Min et al., 2023; Qureshi et al.,2024) The Indian agricultural system has evolved over centuries, influenced by traditional farming methods, colonial interventions, and post-independence agricultural reforms.(Macwan et al., 2020) The Green Revolution in the 1960s marked a significant transformation, introducing high-yielding varieties (HYVs) of crops, chemical fertilizers, and irrigation infrastructure, leading to self-sufficiency in food grain production (Swaminathan, 2006).(Farran & Mingo-Castel, 2006) However, the revolution also led to issues such as soil degradation, water depletion, and an increased dependence on synthetic inputs.(Kerns & Lee, 2017) The agricultural sector in India remains

crucial not only for food security but also for employment generation and rural development. Studies by Bhalla and Singh (2019) (Nisar et al., 2019; Wang et al., 2019) indicate that regions heavily dependent on agriculture exhibit cyclic economic patterns influenced by monsoons, global commodity prices, and domestic policy shifts. While the sector provides raw materials to industries and sustains rural economies, which is characterized by low productivity, small landholdings, and financial instability. (Mbiyu et al., 2012) India's agricultural dependence is closely tied to climatic factors, with over 60% of cultivated land being rainfed (Gadgil & Gadgil, 2006, Farran & Mingo-Castel, 2006). The erratic monsoon patterns, rising temperatures, and extreme weather events due to climate change pose a substantial risk to crop production. Research emphasizes the need for climate-resilient agricultural practices, including drought-resistant crops, improved irrigation methods, and sustainable soil management. (Hoseinzadeh et al., 2017; Schmutz et al., 2017)

The Indian government has implemented various policies to support agricultural growth, including minimum support prices (MSP), credit facilities, and digital innovations in farming. Studies highlight that while these measures have improved agricultural output, challenges such as market inefficiencies, farmer indebtedness, and the slow adoption of modern technologies persist (Chand et al., 2020). Technological advancements, including precision farming, genetic modifications, and AI-driven predictive analytics, are seen as potential solutions to enhance productivity and sustainability. (Singariya & Sinha, 2015; Traykova & Stanilova, 2020)

Medicinal plants have been an integral part of traditional medicine systems across the world, particularly in Ayurveda, Traditional Chinese Medicine (TCM), (Moyo et al., 2024) and indigenous healing practices. These plants contain bioactive compounds that exhibit therapeutic properties, making them essential for modern pharmaceutical applications. (Swain et al., 2021) The study of medicinal plants has gained momentum due to their efficacy, affordability, and fewer side effects compared to synthetic drugs (Kumar et al., 2018). The use of medicinal plants dates back thousands of years, with documented evidence in ancient texts such as the Atharva Veda, Charaka Samhita, and Sushruta Samhita in India. Similarly, ancient Egyptian, Greek, and Chinese texts highlight the medicinal benefits of various herbs. (di Agronomia Animali Alimenti Risorse Naturali Ambiente,) The World Health Organization (WHO) estimates that nearly 80% of the global population relies on traditional herbal medicine for primary healthcare (WHO, 2021).

Medicinal plants are rich in secondary metabolites, including alkaloids, flavonoids, glycosides, tannins, and terpenoids, which exhibit anti-inflammatory, antimicrobial, antioxidant, and anticancer properties (Ghosh et al., 2020). From local habitat and traditional food practice commonly, used leaves can be chosen for further studies. Active compound can be targeted for drug designing. (Annegowda et al., 2012; Reyes-Jurado et al., 2015). High vitamin and mineral content, lettuce (*Lactuca sativa*) is a delicious top leafy vegetable that is used in salads all over the world. Traditional soil-based lettuce cultivation, or geponics, is not enough to satisfy the year-round market need. But consumer's requests for fresh lettuce in the off-season alternative farming methods, such as the nutrient film technique, are only practical in this situation and hold great potential for production of leafy vegetable. (Qadeer, 2020). Hydroponic cultivation controls water, nutrients, and environment to boost plant secondary metabolites. This soil-free method increases medicinal compounds like alkaloids, terpenoids, and antioxidants compared to traditional farming, yielding cleaner and more reproducible pharmaceutical and cosmetic ingredients. Standardized raw materials supply stable anti-tumor, anti-inflammatory, and anti-infective drug precursors. Clean, pesticide-free medicinal herbs deliver potent dietary extracts for metabolic and respiratory support. Root and shoot

extracts (like *Populus nigra*) target skin microbiota and provide specialized anti-aging or antimicrobial properties.

India's status as a crop-dependent country underscores the need for a balanced approach that integrates traditional knowledge (geoponics technique) with modern agricultural innovations. (Gorman et al., 1980; Timofeeva & Kleshcheva, 2011) The existing literature suggests that while India has made significant strides in agricultural productivity, persistent challenges related to climate change, economic instability, and policy execution need to be addressed. (Fukuoka, Japan, 2018; Wimley, 2010) Future research should focus on sustainable agricultural models, technological adoption, and inclusive policy frameworks to ensure long-term agricultural resilience and food security. Geoponic agricultural technique is adopting the modern technology but still unable to fulfill demand of growing population. For any type of agricultural study, the traditional technique should always keep as standard as it has global adaptation since a long time back.

Scientific Research and Modern Applications

Recent research has focused on isolating active compounds from medicinal plants and developing plant-based drugs for various ailments. For example, artemisinin derived from *Artemisia annua* has revolutionized malaria treatment (Tu, 2015). Similarly, vinblastine and vincristine, derived from *Catharanthus roseus*, are widely used in cancer therapy. The demand for plant-based nutraceuticals and herbal supplements has surged due to their perceived safety and effectiveness. (Ríos & Recio, 2005; Silva et al., 2018). Numerous bacteria that play crucial roles in plant growth and development of plants. This study showed the dynamics and structure of plant microbiota as well as the functional abilities of isolated community members on plant growth. The utilization of appropriate delivery methods, formulations, the intelligent, knowledge-driven selection of microorganisms are required to achieve the required yield. The benefits of plant microbiota can be increased by choosing suitable farming methods and selecting plants that result in better interactions between the microbiome and the plant. Various approaches that employ a new generation of inoculants, as well as the implementation of agro-management techniques based on microbiomes and enhanced plant line techniques, may result in a better utilization of the plant microbiome. (Compant et al., 2019). Initial experiments on *Haberlea rhodopensis* soilless propagation utilizing leaves as starting material show promise in terms of plant development, yield and growth have been improved but seeds are not advised. The Green diamond vertical system benefited most from the perlite/agrolava substrate variation of the two studied aero-hydroponic systems, while the horizontal aeroflow was better suited when used with agrolava pebbles alone as substrate. To prevent rosette formation, a horizontal system portion with smaller pebbles should be utilized beneath the surface. Prior to soilless cultivation, IBA-treated leaves should be rooted in wet perlite for two months. This will help to synchronize the rosette formation process and ensure rapid growth of the rosettes, enabling their transfer to pots with soil mixture at the end of the second month. It would be preferable to use a lower dosage of IBA to ensure roots while preventing excessive production of tiny rosettes, boosting the survival of rosette growth. Reducing the duration of the soilless culture phase will also help prevent algal contamination. In nine months, the entire optimized process, which includes rosette strengthening in a greenhouse and development to a diameter of 10 cm, may be completed. Given their unique needs in relation to the environmental circumstances, plants are intended to be further grown in the ex-situ collection of IBER-BAS Institute of Biodiversity and Ecosystem Research at the Bulgarian Academy of Sciences. (Traykova & Stanilova, 2020). Soilless culture refers to any technique where plants are cultivated without the use of soil as a rooting medium and vital

nutrients are provided by irrigation water. One of the most resilient culture systems is hydroponics. The nutrient-rich fertilizers are provided by dissolving in the irrigation water in the right quantity. For generations, people have grown plants in various nutrient-rich water sources. Hydroponic plant cultivation involves a variety of methods that fall into two categories: active and passive methods. The most widely used hydroponic mediums are Perlite (heated silica that has expanded), Hydroton (honeycomb clay pebbles with ceramic shells), and Rockwool (melted balsamic rock spun into fiber). When using a hydroponic system, the nutrient solution supplies all of the vital plant nutrients. When it comes to growing plants, hydroponics can be very helpful, particularly in cities with limited space.(Macwan et al.,2020). Rosemary leaves, or aerial parts, are a significant source of phenolic chemicals, with significant differences between wild and produced samples. Every element examined—rosemary origin, solvent, and extraction methods—had a major impact. yield, TPC, TFC, MIC, and IC50 of the extracts. Principal component analysis revealed significant correlations between the three elements under investigation and good separation of the three factors on the first three components, showing that the solvent was the primary source of variability in their data. TPC, TFC, yield, and associated activity (MIC and IC50) all seem to be adversely affected by domestication. In terms of yield, TPC, and TFC, Soxhlet appeared to be more efficient, particularly when paired with methanol or ethanol as solvents. In light of the acquired results, domesticating rosemary led to a lower output of extracts, TPC, TFC, and, consequently, less significant antioxidant and antibacterial activity values. The investigated extracts may have significant applications as nutraceuticals, antimicrobials, and food preservatives.(Zeroual et al., 2021). Mangroves participate in basic processes including energy transfer and serve as a link between terrestrial and marine ecosystems. Energy fluxes will also be disrupted by ecological degradation in both environments. Therefore, maintaining the integrity of the mangrove ecosystem is crucial to safeguarding both the global terrestrial and marine ecosystems. Understanding of how microorganisms and plants adapt to anthropogenic perturbations and climate change. By shielding mangroves from these significant threats, the blue carbon store will grow and aid in the removal of more carbon dioxide from the atmosphere. In this regard, the blue carbon initiative has stepped up to protect and restore coastal ecosystems in recognition of their contributions to reducing the consequences of climate change worldwide. To obtain the appropriate direction required for project implementation, research, and policy priorities, the initiative has collaborated with the International blue carbon scientific working group and International blue carbon policy working group. Around the world, a number of initiatives are being created to protect coastal habitats for their valuable blue carbon. Using various "blue carbon" hot spots, advanced research is being conducted on the uptake, storage, and loss of carbon from "blue carbon" systems. As a result, it can be a different approach to rehabilitating nature. However, microbial processes are fundamental in controlling the global flux of major greenhouse gases including CO₂, N₂O, and CH₄ and respond quickly to any alteration in the local climate. It is well acknowledged that a number of microorganisms use greenhouse gases as energy sources to proliferate and change into less harmful forms. (Palit et al., 2022). This development will force a proprietor to display and manage the recognition of their homegrown produce, such as work thing flowers or another plant. The creation outline demonstrates that numerous efforts are underway to improve the internet of things, which will be used to increase the operational capacity and capability of plants and domesticated animals.

The second preferred position is that as it uses an essentially supportive agrarian vehicle for supplying sensor data, it doesn't need to worry about any particular intense thing for an adaptable sink. (Santillán-Aguirre et al., 2023). The importance of mineral-supplemented fluids, hydroponics—also referred to as

controlled environment agriculture—is a technique for growing plants and herbs without the use of soil. Agriculture biotechnology advances its capabilities in creating genetically modified plants to increase crop productivity and provide traits like pest and weather tolerance and the ability to cultivate seasonal foods all year round. Hydroponic farming uses 90% less water while producing high-quality crops than conventional agriculture. As a result, hydroponic farming may be seen as the agricultural industry's future. For effective crop cultivation in this situation, knowledge of hydroponic agriculture is essential. The various classes of hydroponic systems and the parts that make the framework's methodical components possible are well elaborated.(Monisha et al., 2023). An innovative idea to improve the production of sustainable and healthy food. is examined in a study on contemporary trends and practices in organic agriculture. In order to increase productivity and enhance crop quality, the research focuses on implementing contemporary methods like soilless farming and the application of agricultural analytics. By encouraging genetic diversity in crops and animals, it also strengthens their resistance to pests and diseases, underscoring the need of biodiversity protection. The study also highlighted the use of renewable resources and the enhancement of soil quality via organic fertilization. All things considered, the study offers a thorough understanding of new developments and contemporary methods that can raise the efficacy and efficiency of organic farming, with an emphasis on accomplishing social, economic, and environmental objectives in this regard. (Deif & Hussein, 2023). The factors and compromises involved in creating an aeroponic growing unit were examined in this research. Pressure swirl atomizers were used to produce atomization because of their ease-of-use activity. The fertilizer unit mixed and stored nutrient solution inside a pressure tank on demand in order to attain the supply pressures required for efficient atomization. However precise and independent management of the nutrient concentration between the two zones was not possible due to the unit configuration. The development it was discovered that the open grow tray and substrate were appropriate for both vegetative development and germination, but they also permitted a considerable amount of contamination from fungus and algae. This aeroponic culture unit's primary goal was to develop a quantitative growth model for several leafy green species. After that, this quantitative model would be applied to respond to whether aeroponics actually produces more than traditional hydroponic systems. Regretfully, the initial prototype was unable to provide an answer to this query. Nonetheless, the development process of an aeroponic system is presented in this paper method for growing leafy greens and describes the difficulties in designing and constructing this system, with particular attention to atomization, fertilizer dosage, grow tray/substrate, and growth monitoring as a crucial element. By sharing the design process and learning from trials, this technical activity that specializes in equipment development and testing will help other groups trying to build an aeroponic system save time and effort. (Min et al., 2023). The social and environmental issues facing contemporary agriculture, sustainable agricultural methods are crucial. Farming is being revolutionized by innovations like integrated pest control, precision agriculture, organic farming, agroforestry, and soil health management strategies to improve sustainability. These methods offer financial advantages and climate change resilience in addition to enhancing ecological health and resource efficiency. But putting these innovations into practice on a large scale comes with difficulties that call for funding, further research, and supportive policy. (Qureshi, 2024). The bacterial microbiome in hydroponic systems is crucial for increasing crop yields and reducing phytopathogen damage. Hydroponic-related beneficial and phytopathogenic microorganisms can coexist in the same taxonomic group. The complexity of the plant microbiome and the need for more research are highlighted by the fact that *Agrobacterium* strains' acquisition of a single plasmid can make the difference between benign and disease-causing consequences.

Observations of illness in commercial greenhouses form the basis of a large portion of the literature. It is essential for comprehension that the pathogens be isolated for additional research their plant pathology. To determine the pathogen density needed for disease, the variety of crops they can impact, and efficient disease management techniques, inoculation trials in crops are an expensive but essential procedure that should also become a separate area of study. Since rules restrict the use of antimicrobial agents and phytopathogens become more resistant, many of the present management techniques are becoming outdated.(Thomas et al., 2024). Throughout their growth stages, plants are subjected to a variety of stressors. Salinity, water shortages, wounding, mineral deficiencies, potting bag size, soil/root media density and type, soil pH, and the kind of production system used are the most common causes of these stresses. It is commonly known that several stressors hinder the growth and plants development, quality, strength, and output of horticulture crops around the world. Many studies in the literature have suggested using silicon-based bio stimulants to enhance the growth and development of commercial horticultural plants; however, there is a dearth of information in South Africa regarding the mechanisms underlying the recovery response of tomato (*Solanum lycopersicum*), lettuce (*Lactuca sativa L.*), and beetroot (*Beta vulgaris L.*), and kale (*Brassica oleracea L.*) cultivated in multi-stress environments with silicon-based bio stimulants and employing less expensive, environmentally friendly production methods. (Moyo et al., 2024). A complex agricultural production system and creative ways that have arisen as a result of the increased demand for water resources and, consequently, the food supply. The practice of soilless agriculture known as hydroponics entails cultivating plants in an aqueous environment or a soilless medium. like a system for aeroponic farming. Instead of using soilless media, hydroponic growing systems feed plants in water with mineral fertilizer solutions. On the other hand, aquaponics combines hydroponics and aquaculture. Numerous studies on commercial-scale aquaponics, hydroponics, and aeroponics production have demonstrated that these novel technologies may contribute to long-term food security. These agricultural farming methods may offer a sustainable substitute for producing different kinds of goods that use less space, fertilizer, and water while producing more per unit area. Water saving and the use of fewer or no agrichemicals are the main advantages of these contemporary production systems. which, when administered and particularly when ingested in food, were harmful to the human body.(Vyshnavi, 2024).The advancement of this system was possible only through cooperation of the government, policymakers, scientists, and agriculturalists, as well as the private sectors and industrialists, to involve young entrepreneurs in strategy planning, surveying, and imparting practical knowledge among youth farmers in order to bring about farming on a large scale. Hydroponics is a crucial agricultural technology that should be concentrated on, particularly in urban areas, because it offers investment stability, innovative ideas, and research strategies. Lastly, agriculture should continue to conserve resources rather than relying on planting and cultivation to ensure food security. In order to prevent soil deterioration and the depletion of arable land supplies, every drop of water should be used effectively. Hydroculture There are two advantages of farming, and people will soon realize how important fresh and wholesome food is to their everyday life. (Deshpande, 2025). By conserving water, optimizing space, and raising crop yields, hydroponic technology provides a sustainable solution to global food safety issues. Its software for business, dry regions, and urban farming Agriculture demonstrates its enormous adoption potential. Continuous advancements in automation, renewable energy, and nutrition optimization continue to demonstrate its viability in spite of obstacles such as high upfront costs, energy reliance, and technical constraints. The appropriate legislative backing and studies, hydroponics can change present day agriculture, offering a dependable and environmentally pleasant meals production machine. Hydroponics

will be crucial in determining the future of the global food supply as the need for sustainable farming increases. (Iqbal et al., 2025)

Conservation and Sustainable Use of Hydroponic cultivation system

The most intensive crop-production technique in use today is hydroponic culture, which is mostly utilized in both developed and developing nations to produce food restricted area. It is extremely productive, water-efficient, environmentally friendly, and feasible on a small amount of land. Growing up to 50% faster than soil is possible with hydroponics because it provides consistent and easily accessible nourishment. Additionally, it yields more than the traditional way. Research and experimentation in the fields of indoor and outdoor hydroponic gardening have increased as a result of the rapid growth of the hydroponics industry.(Swain et al., 2021). The increasing commercial demand for plants and plant product has led to concerns about overharvesting, habitat destruction, and biodiversity loss.(Annegowda et al., 2012) Conservation strategies such as in-situ and ex-situ cultivation, sustainable harvesting practices, and biotechnological interventions (tissue culture, genetic modification) are being explored to ensure the long-term availability of medicinal plants (Rao & Ravishankar, 2019). Hydroponics is an innovative farming technique that allows plants to grow without soil, using a nutrient-rich water solution instead.(Zeroual et al., 2022) This method offers numerous benefits, including faster plant growth, efficient use of space, and reduced need for pesticides and herbicides. Hydroponic systems can be set up indoors or in areas with poor soil quality, making it a versatile solution for urban farming and regions with limited arable land.(Calvo et al., Karabegovi et al., 2011)

One of the main advantages is the ability to control environmental factors like water, light, and nutrients, which can lead to higher yields compared to traditional soil-based farming. (Macedo et al., 2017)It also uses less water, making it a more sustainable option in drought-prone areas. However, the initial setup cost can be higher, and it requires a learning curve for those unfamiliar with the technology.(Becerril et al., 2007; Hoseinzadeh et al., 2017; Janssen et al.,) Overall, hydroponics represents a promising alternative to conventional agriculture, offering the potential for more sustainable, efficient, and productive farming practices.(Ganan et al., 2009). Hydroponics is a modern and innovative agricultural technique that involves growing plants without soil, instead using a water-based solution rich in essential nutrients.(Minbiole et al., 2016) This method has gained significant attention in recent years due to its potential to revolutionize the way we grow food, particularly in urban environments and areas with poor or depleted soil quality.(Cushnie & Lamb, 2005)

Advantages of hydroponic technology

- **Fast Growth and Higher Yields:** Plants grown hydroponically tend to grow faster than those cultivated in soil, as it requires optimal control of nutrient levels and environmental factors like light and water. This often results in higher yields, making hydroponics particularly beneficial for commercial growers and urban farms.(Compant et al., 2019; Duran et al., 2016)

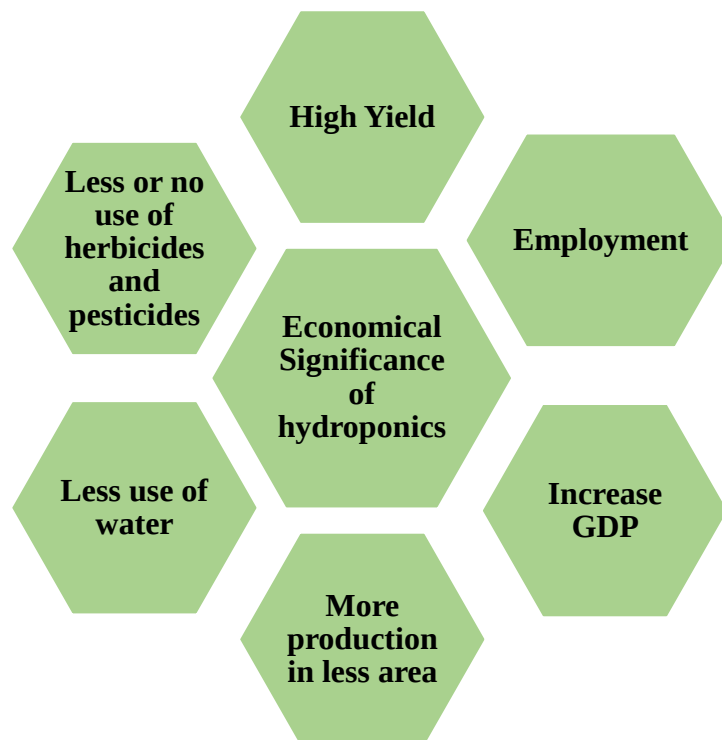


Figure No. 1: Flow Chart showing Economic significance of Hydroponics

- **Water Efficiency:** Hydroponic systems use less water compared to traditional soil-based farming. Since water is recycled in a closed-loop system, it's far more efficient, which is pivotal in water-scarce regions or during drought conditions.(Compant et al., 2019)
- **Space Efficiency:** Hydroponics can be set up vertically or in compact spaces, maximizing limited areas like rooftops, basements, or even small indoor spaces. This makes it ideal for urban environments where there is scarcity of arable land.(Compant et al., 2019; Swain et al., 2021)
- **Fewer Pests and Diseases:** Less use of herbicides and pesticides is key benefit of hydroponic techniques. Without soil, hydroponic systems are less prone to pests and soil-borne diseases. This reduces the need for harmful pesticides, as a consequence the food produced is healthier and most important to be environmental friendly.(Compant et al., 2019)
- **Customizable Growth Environment:** Growers have complete control over the growing conditions, including light, temperature, and nutrient mix. This level of control can produce consistent results and allows for year-round cultivation, regardless of external weather conditions.(Deshpande, Thomas et al., 2024)

Disadvantages of hydroponic technology

- **High Initial Investment:** Setting up a hydroponic system can be costly, especially for larger-scale operations. Equipment like grow lights, pumps, reservoirs, and nutrient solutions can add up quickly, which may prove to be a barrier for the set-up of the system. (Macwan et al, Qadeer, 2020)
- **Technical Knowledge Required:** Hydroponics demands a certain level of expertise to maintain the system properly. Growers need to monitor nutrient levels, pH, water quality, and other factors, which can be complex for beginners.(Qadeer, 2020; Vyshnavi).

- **Dependency on Technology:** Hydroponic systems are often reliant on technology for water circulation, temperature regulation, and lighting. If there is a power failure or a malfunction, it could lead to plant stress or even crop failure.(Iqbal et al., 2025; Margaret Chiipanthenga, 2012)
- **Energy Costs:** While water usage is minimal, hydroponic systems often require artificial lighting, especially in indoor setups. These lights can increase energy consumption, especially when using high-efficiency LED grow lights or other energy-intensive systems.(Margaret Chiipanthenga, 2012)

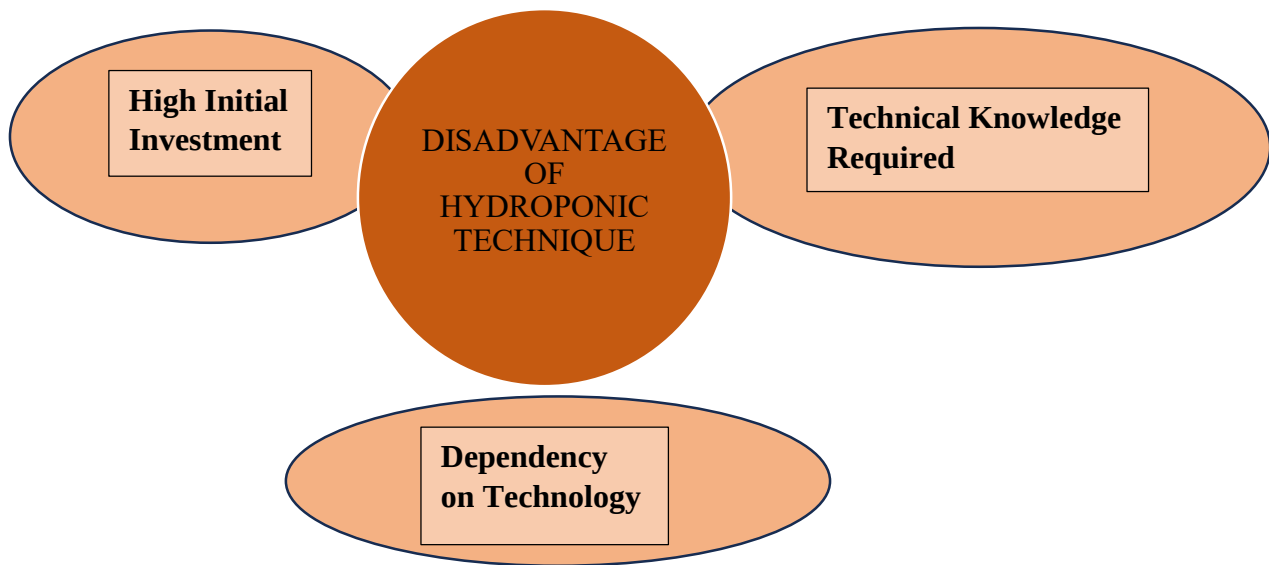


Figure No 2: Flow Chart showing Disadvantage of Hydroponic technique

Hydroponics represents a promising solution to many challenges in modern agriculture, including water scarcity, space limitations, and the need for sustainable practices. It offers the potential for higher productivity and an eco-friendly approach to farming. (Swain et al., 2021) However, the high startup costs and technical challenges may make it difficult for some to adopt, especially on a large scale. Despite these challenges, hydroponics has the potential to play a major role in the future of food production, especially in urban areas and regions facing agricultural limitations.(Qadeer, 2020; Swain et al., 2021)

Table No. 1 Represent Difference between Traditional agriculture and Modern agriculture

S.No.	Traditional agriculture	Modern agriculture (Hydroponics)
01	Uses simple hand tools, wooden plows, and farm animals with high manual labor.	Uses modern technologies, drones, and sensors with very little manual work.
02	Uses natural local seeds saved from past harvests and organic compost.	Uses high-yielding variety (HYV) seeds, genetically modified organisms (GMOs), and highly standardized growth medium.
03	Relies mostly on seasonal rain and keeps soil safe with crop rotation.	Uses modern storage system which requires continuous monitoring.
04	Depends heavily on local weather, seasons, and natural climate.	Runs in controlled indoor spaces or greenhouses safe from bad weather.

05	Traditional works best for large grains and heavy root crops like wheat, rice, and potatoes.	Hydroponics works best for leafy greens, herbs, and tomatoes.
06	Traditional has low setup costs but higher ongoing labor or weather risks.	Hydroponics has high setup costs for gear and power, but lower ongoing water waste
07	Water usage: Traditional uses massive amounts of water with high waste.	Hydroponics recycles water and uses up to 90% less.
08	Growth speed: Traditional is slower due to natural cycles.	Hydroponics feeds root direct nutrients for faster growth and higher yields
09	Space: Traditional needs large open fields.	Hydroponics stacks plants vertically to save space.

Table No. 2 Shows Various types of crops grown through hydroponic techniques

S.No.	Plant species	Plant family
01	Lettuce	Asteraceae
02	Chichory	Asteraceae
03	Spinach	Amaranthaceae
04	Kale	Brassicaceae
05	Arugula	Brassicaceae
06	Basil	Lamiaceae
07	Cilantro	Apiaceae
08	Mint	Lamiaceae
09	Parsley	Apiaceae
10	Tomato	Solanaceae
11	Pepper	Piperaceae
12	Cucumber	Cucurbitaceae
13	Strawberries	Rosaceae
14	Celery	Apiaceae
15	Bok choy	Brassicaceae
16	Dwarf peas	Fabaceae
17	Corn	Poaceae
18	Coriander	Apiaceae
19	Reddish	Brassicaceae
20	Swiss chard	Amaranthaceae

Different types of Hydroponics Techniques

The Nutrient Film Technique (NFT) is an active hydroponic technique in which a continuous, very slow stream of nutrient-rich water passes by the bare roots of plants in slanted channels. This is most adopted technique for the growth of leafy vegetables. Deep Water Culture (DWC) is a straightforward hydroponic technique called deep water culture (DWC) involves hanging plant roots directly into a nutrient-rich, continuously aerated water solution. Ebb and Flow (Flood and Drain) a well-liked hydroponic technique that refill a reservoir after occasionally flooding plant roots with a nutrient-rich solutions. A wick system is a passive hydroponic system.

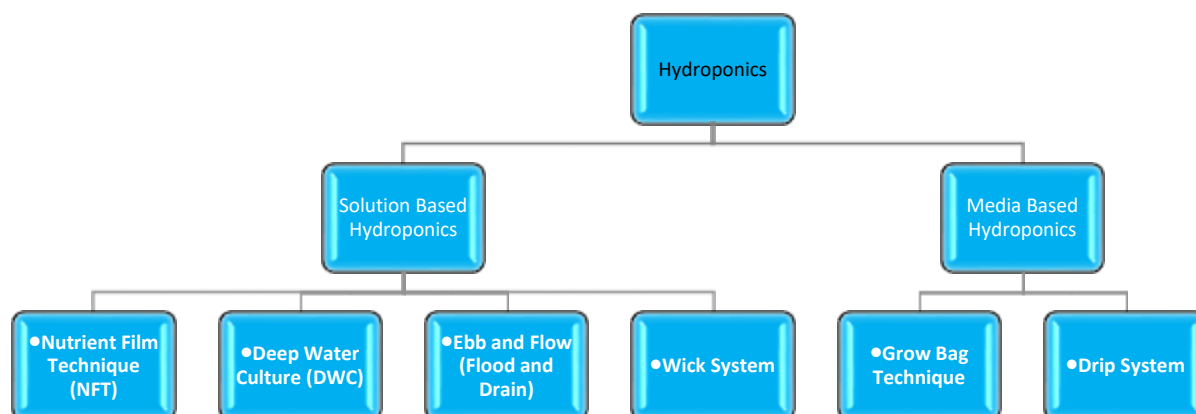


Figure No. 3 Different types of Hydroponic techniques

This system is self-watering solution that absorbs water and nutrients from a reservoir to plant roots through capillary action using an absorbent pipe or cloth strip. Grow bags are bags need to be kept in a sunny position and seeds or seedlings were planted and need to watered them frequently. A drip system is a water-efficient micro-irrigation technique that provides nutrients and water to the plant's root zone gradually. (Deshpande, n.d.; Macwan et al., n.d.; Mariyappillai et al., 2020; Swain et al., 2021b)

Conclusion:

Soil is the most readily and abundantly available naturally occurring medium for plants which requires sufficient water, air, nutrients, space and other essential factors. The practice of soil base cultivation has many difficulties because of anthropogenic activities such as industrialisation, urbanization, in addition sudden natural calamities like earthquake, soil erosion, torrential rain etc. also changes the climatic pattern which in turn affects the fertility of soil. In addition to this, excessive chemical usage in agriculture also contributes to soil fertility and quality deterioration. A break through in this traditional cultivation was introduced through hydroponics which is nothing but a soil less cultivation technique. The method of cultivating plants without soil but with additional nutrients in sand, gravel, or liquid is an emerging technology which is going to replace traditional cultivation method to some extent. There are several types of hydroponics set up discussed based on the requirement of plants and availability of resources. Standardization of set up and solution is crucial to gain maximum output. Hydroponics system of cultivation can be accepted universally as it can fulfil demand of high yield with less water, less space and minimum use of chemicals.

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