Soilless Farming Techniques for Sustainable Food Production in Nigeria

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ABSTRACT

In the face of escalating food insecurity, climate change, and land degradation, sustainable innovations in agriculture are urgently required, particularly in developing nations like Nigeria. This study, conducted in 2024, examines the role of soilless farming systems, namely hydroponics, aeroponics, and aquaponics, as sustainable alternatives to conventional soil-based agriculture. The primary objective is to evaluate how soilless farming can enhance food security, climate resilience, and sustainable agricultural development in Nigeria, in line with global Sustainable Development Goals (SDGs) such as SDG 1 (No Poverty), SDG 2 (Zero Hunger), and SDG 13 (Climate Action). A qualitative methodology was used, employing a comprehensive literature review of recent academic journals, institutional reports, and international data sources from 2013 to 2024. The review identified key benefits including year-round cultivation, efficient water and nutrient use, and reduced reliance on arable land. It also revealed challenges such as limited awareness among farmers, high initial investment costs, inadequate infrastructure, and weak regulatory support. Findings show that soilless farming, if properly implemented, can improve agricultural productivity, reduce environmental degradation, and create employment, particularly for urban youth. The study concludes with recommendations for government policy reforms, increased private sector investment, and capacity-building initiatives to accelerate the adoption of soilless farming practices in Nigeria.

ractices in Nigeria.

Keywords: Soilless Farming, Food Security, Hydroponics, SDGs, climate change

INTRODUCTION

Addressing the need for food requires the ability to increase agricultural output, through adopting more technological advanced systems of food production which will cover the demand for food while utilizing lesser cost and reduced natural resource consumption. Developing countries with specific reference to Nigeria struggle the most with food insecurity as a result of several factors (Olunusi, 2024). Despite decades of several development interventions and programmes aimed at increasing agricultural productivity, there has continuously been a dearth in optimal food production which has resulted in lower yield, poor quality of food produced and reduced income for farmers. This has undoubtedly reduced the enthusiasm and interest for young people to key into the diverse opportunities available in the agricultural sector (Bello et al., 2024). With the rise in climate change, there will be a direct effect on the availability of food through its increasingly adverse impacts on crops and animal productivity and health, and fish stocks, especially in sub-Saharan Africa and South Asia, where most of the world's food insecure live (FAO). There is a potential impact of climate change on soil properties (Habib-ur-Rahman et al., 2022). Countries have begun to experience its effect which manifest as land degradation, low soil fertility, desertification, soil erosion and severe weather conditions; hence the need for soilless farming as a medium for sustainable food production.

Soilless farming and addressing the SDGs Enhancing sustainable food production plays a key role in achieving some of the Sustainable Development Goals (SDG) (Lakhiar et al., 2025). The SDGs are a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity (UNDP) (Urata

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et al., 2023). The adoption and investment in soilless farming will play a major role in ensuring that the SDGs which aims to end poverty and hunger by 2030 can be achieved especially in Nigeria and other developing countries. The goals such as Goal 1- No poverty, Goal 2- Zero hunger, Goal 8- Decent work and Economic growth, Goal 15- Life on land; shows the importance of how promotion of sustainable agriculture can better enhance livelihood especially in the age of technological advancement. Soilless farming touches on the three dimensions of sustainability which are; economic, environmental and social (Gonnella & Renna, 2021). "A sustainable farming system should be a profitable business that creates mutually beneficial relationships among workers and the surrounding community, and contributes to the sound management of the land and other natural resources"(Ambayoen et al., 2024). To achieve the SDGs, emphasis should be placed on the importance of adopting innovative and technologically driven solutions to agriculture especially farming. According to the FAO, Sustainable food and agriculture have great potential to revitalize the rural landscape, deliver inclusive growth to countries and drive positive change right across the 2030 Agenda (De Bruin & Holleman, 2023).

Problem Statement

Soilless farming, also known as hydroponics, holds great potential for sustainable food production in Nigeria. However, the implementation of this technology faces several significant challenges that need to be addressed in order to maximize its benefits and overcome limitations. Limited awareness and understanding among farmers, policymakers, and the general public about the potential of soilless farming hinder its widespread adoption (Amusan & Adeleke, 2023). There is a need to bridge the knowledge gap and educate stakeholders about the principles, benefits, and techniques of hydroponics. Access to quality inputs such as hydroponic systems, nutrient solutions, and suitable crop varieties is a major concern. The availability and affordability of these key components can be a barrier for small-scale farmers or those in rural areas. Ensuring a steady supply chain of reliable and affordable inputs is crucial to encourage adoption and expansion of soilless farming methods. The lack of appropriate infrastructure for soilless farming poses a challenge. This includes the absence of specialized greenhouses, controlled environments, and adequate water and electricity supply. The development of infrastructure tailored to the needs of hydroponics is essential to facilitate its mainstream integration into agricultural practices in Nigeria (Fadairo, 2023). The scarcity of skilled professionals and technicians in soilless farming practices is limiting its growth (Amusan & Adeleke, 2023). There is a need for training programs, workshops, and capacity-building initiatives to equip farmers, technicians, and agricultural extension workers with the necessary knowledge and skills to successfully implement and manage soilless farming systems.

Regulatory frameworks and policies related to soilless farming in Nigeria are still underdeveloped or nonexistent. Clear guidelines and support from the government are required to address legal and bureaucratic obstacles, provide incentives, and create an enabling environment for the adoption and promotion of soilless farming practices (Nwanojuo et al., 2025). Addressing these challenges and finding innovative solutions will contribute to the successful integration of soilless farming into Nigeria's agricultural sector. By raising awareness, improving access to inputs, developing suitable infrastructure, enhancing human capacity, and establishing supportive policies, soilless farming can become a sustainable solution to increase food production and contribute to food security in Nigeria (Olabinjo & Opatola, 2023).

2023).

Justification

Soilless farming allows for precise control over essential factors like nutrient content, water supply, and pH levels. This level of control enables farmers to optimize plant growth, resulting in higher yields and reduced use of fertilizers and pesticides (Balliu et al., 2021). With the implementation of soilless farming, Nigeria can significantly lower its environmental footprint and address concerns related to soil degradation and water pollution caused by conventional farming practices. Soilless farming is not affected by seasonal changes or unpredictable weather patterns, making it a reliable and consistent method of food production throughout the year. This aspect is particularly important for Nigeria's food security, as it reduces the vulnerability to climate-related disruptions and ensures a stable supply of fresh produce. Soilless farming promotes efficient water

usage, a critical aspect considering Nigeria's water scarcity issues. By utilizing recirculation systems, the technique minimizes water wastage and can significantly decrease the amount of water needed compared to traditional farming methods. A review on soilless farming for sustainable food production in Nigeria is justified due to its potential to address the country's agricultural challenges. Implementing soilless farming techniques can enhance food security, mitigate the impacts of climate change, conserve water resources, and reduce environmental degradation. It is crucial to explore and promote such innovative and sustainable solutions to meet Nigeria's increasing demand for food while ensuring a brighter and more resilient agricultural future.

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Study Objectives

The broad objective is to assess the impact of soilless farming for sustainable agricultural production while the specific objectives are to:

1. explain the concept of soilless farming and
2. identify challenges faced by farmer for adopting soilless farming in Nigeria;
3. identify future for soilless farming in Nigeria; and
4. examine the need for Soilless Farming**.**

METHODOLOGY

This study employed a qualitative research approach using a systematic literature review to gather, analyze, and synthesize existing knowledge on soilless farming and its role in sustainable food production in Nigeria. The research was conducted by reviewing secondary data sources, including peer-reviewed journals, academic publications, government reports, international organization databases and reputable online resources. A structured search strategy was applied using keywords such as “soilless farming,” “hydroponics in Nigeria,” “sustainable agriculture,” “food security,” and “climate-resilient farming.” Sources published between 2013 and 2024 were prioritized to ensure relevance and inclusion of recent developments in the field.Data collected from the selected literature were analyzed thematically. Common themes were identified around the benefits, challenges, potential, and policy implications of soilless farming. The findings were organized to highlight Nigeria-specific insights, followed by global comparisons where applicable. Based on the synthesis of the reviewed literature, conclusions were drawn and recommendations proposed to address identified gaps in practice, policy, and research.

LITERATURE REVIEW

Concept of Soilless Agriculture

Definition of Soil less Farming

Soilless farming in simple terms is growing of crops without soil, it is important to note that soilless farming isn’t a way to replace soil but rather to complement soil (Fussy & Papenbrock, 2022).). Soilless culture can be defined as “any method of growing plants without the use of soil as a rooting medium, in which the nutrients absorbed by the roots are supplied via the irrigation water” (Bihari et al., 2023) The nutrients to be supplied to the crop are dissolved in appropriate concentration in the irrigation water and such solution is referred to as “nutrient solution” (Al Meselmani, 2022). Soilless farming possesses a potential method of growing plants without the use of soil; in which the nutrients required for growth are supplied through other means. Soilless farming is a sustainable way for youth especially in populated urban areas with interest in the sector to explore because it has proved to be less rigorous, more efficient, high yielding and supports non-seasonal food production- through the inclusion of technology and artificial intelligence. This will no doubt create more

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interest among youth in farming as well as be helpful in the actualization of SDGs Goal 1, 2, 8, 9 and 12 (Rahmadi & Sanjaya, 2024).

Soilless farming is defined as the plantation of crops without the presence of soil. It uses the natural soil component or nutrient solution as a growth medium for plant roots. Rather than using natural soil, it's more necessary to conform to the atmospheric conditions required for the growth and development of various crops, particularly the fundamental conditions needed for root increase, including the presence of aeration, moisture, nutrition, temperature, and cultivation that accept these basic conditions to foster the growth of crops without soil. It is the cultivation of plants in an enclosed environment with the aim of producing fruits (Joshi et al., 2022).

Objectives of Soilless Farming

i. To promote sustainable food production in Nigeria

ii. To curb the climate change problem in Nigeria

iii. To encourage Nigeria youth involving farming

iv. To address the challenges soil degradation, declining soil fertility

Types of Soil less Farming

Hydroponics

The definition of hydroponics has been broadened to mean "the cultivation of plants without soil'' (Naresh et al., 2024). In hydroponics, plants are grown in an inert medium such as rocks or coco coir fibre, and they are fed a solution containing a perfected mix of primary, secondary and micro-nutrients. Almost any kind of plant can be grown hydroponically, including veggies, herbs, fruits and flowers (Atherton & Li, 2023)

Aeroponics

Aeroponics is the process of growing plants in an air or mist environment without the use of soil or an aggregate media. This is an alternative method of soil-less culture in growth-controlled environments. Aeroponics system refers to the method of growing crop with their roots suspended in a misted nutrient medium (Priya & Priya, 2025)

Aquaponics

Aquaponics is a combination of aquaculture (fish farming) and hydroponics (plant growing without soil). It is a closed-loop recycling fresh water system between fish and plant (Kyaw et al 2017). Aquaponics provides a solution to the main issues these two systems face; the need for sustainable ways of filtering or disposing of nutrient-rich fish waste in aquaculture and the need for nutrient-rich water to act as a fertilizer with all of the nutrients and minerals needed for plants grown through hydroponics (Shreejana et al., 2022).

Challenges faced by farmer for adopting soilless farming in Nigeria

While developments in more advanced countries show that they have moved beyond mechanized farming to technology-driven farming, Nigeria still largely depends on rudimentary farming appliances such as hoes, cutlasses and others to carry out farming activities (Olorunnisola, 2021). Despite the effort of the government to import farming machineries, some of these implements are not climate smart, as carbon emission from these machines has an adverse effect on the environment (Kehinde et al., 2024). Nigeria's inability to develop technologically in the agricultural sector is as a myriad of challenges affecting the country. Some of which includes:

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i) Poor infrastructure

Lack of infrastructure has greatly hindered the development of Nigeria. One of the major infrastructural challenges that will greatly affect the involvement of youth in soilless farming is lack of stable power supply. Nigeria has continued to suffer from epileptic power supply and this poses a threat to running a successful soilless farming business. In as much as soilless farming uses lesser energy to run, it requires stable power supply to run certain equipment especially air pumps or water pumps (Mir et al., 2022). Presently, the state of electricity supply in Nigeria is still low and this will hinder the successful running of the business.

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ii) Initial cost of investment

Despite how potentially lucrative soilless farming can be, it is quite capital intensive especially for young people who have not grown their capital to a certain level. This challenge is further emphasized by the limited number of funding opportunities available for young people to access loans, grants or other funding facilities. This is especially true for agribusiness and crop production in particular because of its high-risk nature. In an interview with Ventures Africa, Alhaji Bello a fish farmer in Ibadan noted that installing a fully functioning hydroponics farm requires a certain amount of dedication and money. “Set-up cost two million naira (about USD 5,500) for an 8 x 30-meter space’’.

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iii) Technical Know How

Soilless farming requires a good level of technical and scientific knowledge to successfully carryout crop production, however there is a shortage of skilled personnel to address this. This implies that transfer of knowledge and practical skills in this area will be challenging (Fuentes-Peñailillo et al., 2024).

Future for soilless farming in Nigeria

Despite the challenges and limitations involved engaging in soilless farming, there are still prospects for young people to explore the soilless farming space. For remarkable progress to happen in the agricultural sector, there is need for a transition into a more technological advanced and sustainable farming system. This can be achieved through collaboration of different stakeholders in the sector who are willing to invest the adequate resources required as this is a huge investment. The government, private sector and non-governmental organizations have a role to play in ensuring this is achieved.

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The government

In its bid to diversify the economy and re-focus on the non-oil sector should create an enabling environment for businesses to thrive. This can be achieved by ensuring Agri-friendly policies which will ensure that bottlenecks and bureaucracies that frustrate prospective investors are removed. According to the FAO, a fundamental premise for delivering sustainable food and agriculture is the creation of an enabling policy environment and the need for sectoral ministries to change the way they work and coordinate policies across government (Agarwala et al., 2022). In addition, infrastructural development such as electricity and means of transporting farm produce should be worked on. Nigeria can tap into the large-scale investment in renewable energies as a means to produce electricity for businesses and individuals.

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Private investors

Private sector can get involved in this sector, can invest funds to start up or scale up farms already practicing. This can be done through venture capitals and agricultural incubation hubs to ensure that funds available go to the right people. The private sector can further support in the provision of grants and loans; which is already happening but on a small scale. Also, private manufacturers can get involved by locally producing or fabricating equipment required for farming. This will reduce cost of importing and also create jobs for local manufacturers.

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Non-profit sector

Non-profit sector can provide donor support by collaborating with government and private sectors in the building and transfer of skills and knowledge. Also, they can be involved in upscaling innovation, supporting research and development, advocate for suitable agricultural policies, ensure collaboration among stakeholder (Kazanskaia, 2025). The opportunities are diverse within the Soilless Farming value chain. More jobs can be created directly or indirectly in training and capacity building, sales of input, farm production, farm support, facility maintenance, research and development. This farming system will make agriculture more youth friendly, less dependent on weather, more healthy food growth, increased economic gain which will lead to more jobs available and most of all improving livelihoods for farmers.

Need for Soilless Farming

Soilless farming has been discovered to proffer solution to the problems being faced by tradition soil farming (Fussy & Papenbrock, 2022). The major advantage with such a system is the absence of weeds and other soil borne pests, no toxic pesticide residue, better use of water, better control over nutrient and oxygen, increased crop quality and yields.

i. Higher Productivity

In line with the need for food production to rise faster than population growth to ensure food security and nutrition improvement, crops grown under soilless farming techniques have been studied and observed to better and faster as they expend energy in leave and fruit development rather than in the development of roots systems in search for nutrients in the soil as in the case of geoponics.

ii. Reduced Labour Requirement

The labour requirement in soilless farming is lesser as there is no soil to till, plough or ridge, no weeding to be done, no watering and requires less for pest control especially in greenhouses.

iii. Not Season-Bound

Plants grown in soilless farming are not affected by the season as they are constantly fed with the required nutrient and water to grow.

iv. Low Management Cost

cost of running the systems is usually low especially for the NFT system because these are kept running almost entirely automatic and each input is expected to last for years.

v. No Weed Competing

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Since soil is not used, with all seeds carefully selected, soilless farming has no weed or weeding problem. This saves cost on herbicide and spraying.

Vi No Soil-Borne Pest and Disease

Plants under soilless planting system can be attacked by pest and diseases too but not usually as much as that of soil farming as most soil and diseases are known to be soil-borne. Soilless farming has been observed to have little pest and disease issue.

Vii No Expensive Machinery Required

Since the system doesn't involve land ploughing, ridging, tilling, clearing, windrowing therefore no big expensive machineries like tractors, bulldozers, combine harvester needed.

viii. Precision in terms of Nutrient Supply

Excessive use of fertilizer know with geoponics is not the case in soilless farming as nutrients are either released based on plant requirement or are recycled or reused in most cases.

ix. Pollution

Pollution of the surrounding air and water body close to farmlands has been discovered to be as a result of indiscriminate use of fertilizers and other chemicals which are sent to the environment by the wind or runoff.

x. Water and Land Conservation

less water and land are used up in soilless farming due to reduced evapotranspiration, no indiscriminate use of water for irrigation, no need for the traditional spacing standards and more is produced with lesser space.

xi. Support Life in Space

Research shows that soilless farming has been tested and adopted for use in space jets and other planets since there is no soil for planting.

xii. Better for Research Purpose

This system is specifically good for research purpose since precision is usually high and can easily be controlled. With this method one can measure the exact amount of nutrient or water or light required for plant to grow or to develop certain characteristics in them.

xiii. Adaptability to Greenhouse and Vertical Farming

In develop nations soilless farming is usually practiced in greenhouses and are sometimes grown vertically especially in land scarce countries like Singapore and China.

CONCLUSION

Nigeria is a country currently facing the effect of climate change. Desertification, land degradation, flood, erosion among other natural disasters is affecting the yield and productivity of farmers who make up the bulk of the population; hence decreasing the income of farmers and negatively affecting their livelihood. To ensure food security, it is important that collaborative effort is made by all stakeholders to ensure that the future of farming is protected. Soilless farming is the future for agricultural revolution and youth inclusion in farming for Nigeria.

RECOMMENDATIONS

For soilless farming to be successful, a lot has to be put in place. Government will need to see it as a major part of the nation's food production chain so as to include it in policy making. Grants and loans should be provided with private public partnership to encourage youths and entrepreneurs to invest money and resourcefulness into this emerging agricultural sector. It should be viewed as a means of achieving equality, reducing unemployment and supporting people in waterlogged regions of the country so they too can feed themselves and be a part of the nation's food producer. Power problem should be speedily addressed as it not only affects agriculture but all other sectors of the economy. Also, government, private investors, companies manufacturing equipment for soilless farming and all stakeholders should not only encourage but assist research and training of all interested on the technicalities involved.

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