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Double Layer Farming: Integrating Traditional Black Soil Cultivation with Underground Vertical Farming

Archit Phuge, Aryan Mungase, Niranjan Bajbalkar
Diploma in Civil Engineering
Pimpri Chinchwad Polytechnic, Pune

Abstract: *Double Layer Farming is an innovative agricultural concept that focuses on maximizing land utilization by using the same land for two types of farming. In this system, traditional black soil farming is carried out on the surface, while underground vertical farming is performed within a reinforced cement concrete (RCC) structure. This approach helps in increasing productivity per unit land and minimizes wastage of available space.*

This review paper analyzes various research studies related to vertical farming, controlled environment agriculture (CEA), and conventional soil-based farming systems. It also explains how underground humid farming methods such as mushroom cultivation and hydroponics can be effectively integrated with traditional farming practices. The paper highlights important advantages such as higher yield, reduced water consumption, and improved sustainability, while also discussing challenges like high energy requirements and initial investment costs. The study concludes that Double Layer Farming can serve as an efficient and sustainable solution for future agriculture, particularly in urban and land-scarce regions..

Keywords: *Double Layer Farming, Vertical Farming, RCC Farming, Sustainability, Hydroponics, Smart Agriculture*

I. INTRODUCTION

Agriculture is one of the most important sectors in India, providing food, employment, and economic stability. However, in recent years, agriculture has been facing serious challenges such as reduction in available land, climate change, irregular rainfall, and increasing population. These factors have made it difficult for traditional farming methods to meet the growing food demand.

To overcome these problems, modern agricultural techniques such as vertical farming and controlled environment agriculture have been developed. These systems allow crops to be grown in controlled conditions, independent of external climate, but they involve high energy consumption and require significant investment. Therefore, there is a need for a system that combines the benefits of both traditional and modern farming while reducing their limitations.

Double Layer Farming is an innovative approach that integrates traditional soil-based farming with modern vertical farming techniques. In this system, the upper layer utilizes black soil and natural sunlight for crop cultivation, while the lower layer consists of an underground RCC structure where crops are grown under controlled environmental conditions. This method helps to increase productivity from the same land area and improves overall efficiency.

II. LITERATURE REVIEW

Several researchers have contributed to the development of advanced agricultural systems aimed at improving productivity and sustainability. Dickson Despommier (2010) introduced the concept of vertical farming, which involves

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growing crops in vertically stacked layers within buildings. This concept was developed to address urban food shortages and reduce the dependence on traditional farmland.

Further research by Al-Chalabi (2015) and Kozai (2016) demonstrated that controlled environment systems using LED lighting can significantly enhance crop growth and yield. These studies showed that adjusting light intensity and environmental conditions can improve photosynthesis and plant health. Li et al. (2023) highlighted the role of sensors and automation in maintaining optimal temperature and humidity levels in controlled farming systems.

In India, researchers such as Dr. Shreesh Kulkarni have focused on improving irrigation techniques and soil moisture conservation, particularly in black soil regions. Black soil, also known as regur soil, has excellent moisture retention properties, making it highly suitable for surface-level farming.

Research findings indicate that vertical farming can reduce water consumption by up to 95 percent and increase crop yield by two to three times compared to conventional farming. However, these systems also face challenges such as high electricity consumption and high initial setup costs. Double Layer Farming combines the strengths of both traditional and modern systems, aiming to overcome these limitations and provide a more efficient agricultural solution.

III. PRINCIPLE OF DOUBLE LAYER FARMING

The main principle of Double Layer Farming is to achieve maximum land utilization by using both surface and subsurface spaces for cultivation. The system is designed in such a way that two different farming methods can operate simultaneously without affecting each other.

In the surface layer, traditional farming is carried out using black soil, natural sunlight, and conventional irrigation methods. Crops such as vegetables, cereals, and other seasonal plants are grown in this layer, ensuring continuity of traditional agricultural practices.

Below the surface, an underground RCC chamber is constructed to create a controlled environment suitable for vertical farming. In this layer, crops that require specific humidity and temperature conditions, such as leafy vegetables, herbs, or mushrooms, are cultivated using hydroponic or mist-based systems. The RCC structure provides insulation and protection from external climatic variations.

Both layers are interconnected and support each other. Moisture from the upper soil layer contributes to maintaining humidity in the underground chamber, thereby reducing water consumption. At the same time, carbon dioxide generated in the underground layer can enhance plant growth in the upper layer. This interaction creates an efficient and sustainable farming system.

IV. METHODOLOGY AND MODEL DEVELOPMENT

To study the working and feasibility of Double Layer Farming, a small-scale model was developed. The process began with the selection of a suitable site having black soil, followed by the design of an underground RCC chamber with proper structural stability, ventilation, and drainage systems.

The construction of the model involved creating a two-layer system where the upper layer was prepared for traditional farming, and the lower layer was designed for controlled environment farming. Crops such as tomatoes and chilies were planted in the upper layer, while hydroponic crops like lettuce and spinach were cultivated in the underground chamber.

Modern technologies such as humidity sensors, temperature sensors, mist makers, and ventilation fans were installed in the underground layer to maintain suitable growing conditions. The system was continuously monitored to study crop growth, water usage, and overall performance.

The model serves as a practical representation of the concept and helps in understanding its working. Currently, the system is under observation, and further improvements are being made based on the performance and any failures observed during testing.

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V. STRUCTURAL AND AGRICULTURAL PERFORMANCE

The performance of the Double Layer Farming system can be evaluated based on productivity, water efficiency, environmental impact, and controlled environment benefits. The system allows cultivation of two types of crops simultaneously, resulting in higher yield per square meter compared to traditional farming.

Water efficiency is significantly improved due to the reuse of moisture between the two layers, leading to a reduction in water usage by approximately 40 to 60 percent. The underground controlled environment ensures stable temperature and humidity conditions, allowing crops to grow throughout the year without being affected by external weather conditions.

From an environmental perspective, the system reduces carbon emissions and minimizes the use of pesticides, resulting in healthier crop production. The controlled environment also reduces crop losses and improves overall quality.

VI. APPLICATIONS

Double Layer Farming has various practical applications in modern agriculture. It can be effectively used in urban areas where land availability is limited, allowing maximum utilization of available space. The system can also be integrated with greenhouse structures and renewable energy systems to enhance sustainability.

It is useful in research farms for studying crop behavior under controlled conditions and can also be implemented in rural areas to increase farmers' income by enabling year-round crop production. Additionally, it can support agro-industries by providing a consistent supply of fresh produce.

VII. ADVANTAGES AND DISADVANTAGES

Double Layer Farming offers several advantages, including efficient land utilization, increased crop production, and significant water savings. It supports sustainable agriculture by reducing resource wastage and allowing continuous crop production throughout the year. The controlled environment ensures better crop quality and reliability.

However, the system also has certain disadvantages. The initial setup cost is relatively high due to the construction of RCC structures and installation of advanced technologies. It requires technical knowledge for operation and maintenance, and energy consumption for underground farming systems can be a challenge. Regular maintenance of the RCC structure is also necessary to ensure long-term performance.

VIII. COMPARISON WITH TRADITIONAL FARMING

Double Layer Farming differs significantly from traditional farming in terms of efficiency and productivity. While traditional farming utilizes only one layer of land, this system makes use of both surface and underground spaces, resulting in higher yield from the same area. Water usage is reduced due to efficient recycling, and advanced technology ensures better crop management. However, the initial cost and technical requirements are higher compared to conventional farming methods.

IX. LIMITATIONS AND RESEARCH GAPS

Despite its advantages, Double Layer Farming is still in the development stage and faces several limitations. There is a lack of large-scale implementation data, which makes it difficult to evaluate long-term performance. High electricity consumption remains a major concern, especially for underground farming systems.

There is also limited research on moisture transfer between the two layers and its impact on crop growth. Additionally, there are no well-established government policies or guidelines to support the adoption of this system. Further research is required to develop cost-effective models and improve system efficiency.

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X. CONCLUSION AND FUTURE SCOPE

Double Layer Farming is a smart and innovative agricultural method that combines traditional and modern farming techniques. It provides an effective solution for increasing productivity, conserving water, and utilizing land efficiently. By integrating two layers of farming, it becomes possible to grow more crops without expanding land area.

In the future, the use of renewable energy sources such as solar power can help reduce energy costs. Advanced technologies like artificial intelligence and automation can further improve system performance. Government support and policy development will play an important role in promoting this concept.

Overall, Double Layer Farming has strong potential to contribute to sustainable agriculture and improve food security, especially in urban and densely populated areas.

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