


Chapter 7

Vertical Farming and Hydroponics Leveraging Smart Technologies for Urban Agriculture

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ABSTRACT

As urbanization accelerates and arable land becomes increasingly scarce, vertical farming and hydroponics have emerged as innovative solutions for sustainable food production within metropolitan environments. This chapter explores the technological advancements driving vertical farming and hydroponic systems, focusing on the integration of smart technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and cloud-based monitoring. Through IoT-enabled sensors, real-time data on environmental conditions—such as humidity, temperature, and nutrient levels—can be continuously monitored and adjusted for optimal plant growth. AI-driven analytics enhance predictive maintenance and resource optimi-

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zation, minimizing waste and maximizing yield. Furthermore, automated climate control and LED-based grow lights replicate natural growing conditions, enabling year-round cultivation independent of weather variations. Case studies from global urban farming projects are presented to illustrate the transformative impact of these technologies on food security and sustainability.

INTRODUCTION

The global population is projected to reach nearly 10 billion by 2050, with more than 68% of people expected to live in urban areas. This rapid urbanization, coupled with dwindling arable land and the adverse impacts of climate change, is posing a significant challenge to food security. Traditional farming methods, which rely heavily on vast expanses of land and seasonal weather patterns, are increasingly unable to meet the rising demand for food. As cities grow, the gap between food production and consumption widens, leading to increased transportation costs, food wastage, and carbon emissions. In response to these challenges, innovative agricultural practices such as vertical farming and hydroponics have emerged as sustainable alternatives, leveraging smart technologies to optimize growth conditions and maximize yield within limited spaces.

What is Vertical Farming?

Vertical farming is an advanced agricultural method where crops are cultivated in stacked layers, often integrated into multi-story buildings, warehouses, or specially designed structures. Unlike traditional horizontal farming, vertical farming minimizes land use by growing plants in vertically inclined surfaces. This method can be implemented in urban settings, significantly reducing the need for long-distance transportation and ensuring fresh produce is readily available to urban populations.

The primary advantage of vertical farming lies in its ability to control environmental factors such as temperature, light, humidity, and nutrient supply. By using controlled environments and automated systems, vertical farms can produce crops year-round, regardless of external weather conditions. Advanced technologies such as LED grow lights mimic natural sunlight, while climate control systems maintain optimal growing conditions, enabling faster growth cycles and higher yields per square foot compared to conventional farming.

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