

# SUSTAINABLE URBAN FARMING USING HYDROPONICS

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**Abstract-Hydroponics represents a method of agriculture that eliminates the need for soil, utilizing a nutrient-dense water solution to facilitate plant growth, particularly in environments where space is limited. By incorporating humidity and temperature sensors within the system, it is possible to automatically maintain optimal conditions for plant development, thereby enhancing yield and resource efficiency. Furthermore, the use of artificial lighting through luminous bulbs ensures that plants receive adequate light for photosynthesis, even in situations of reduced natural light or in areas with minimal sunlight exposure. This approach is environmentally sustainable, as it consumes up to 90% less water compared to traditional soil-based farming and eliminates the necessity for harmful pesticides. The combination of sensors and lighting not only increases agricultural productivity but also reduces the carbon footprint associated with food transportation, thereby promoting sustainable agricultural practices. Hydroponic systems can be adapted to various scales, from small community gardens to large commercial urban farms, thereby fostering local food production and enhancing food security in urban settings. This methodology offers a promising pathway toward resilient, efficient, and sustainable urban agriculture by integrating hydroponics, environmental monitoring, and artificial lighting.**

Keywords- Hydroponic, Water solution, Enhancing yield, Artificial lighting, (key words)

## I. INTRODUCTION

As the urban population continues to expand globally, the importance of sustainable food production within cities becomes increasingly critical. Urban agriculture, especially hydroponics, presents a viable solution by utilizing water-based, soil-less systems to grow crops in limited spaces. The integration of technology, including humidity and temperature sensors, as well as artificial lighting through luminous bulbs, can significantly improve crop growth efficiency while minimizing resource waste

.Hydroponics effectively reduces water consumption and land use, making it particularly suitable for urban settings. Nevertheless, to achieve optimal growth conditions indoors,

it is essential to meticulously monitor and adjust various environmental factors. Humidity sensors play a vital role in ensuring that plants receive adequate moisture, while temperature sensors help maintain an ideal climate, which is essential for nutrient absorption and overall plant health. Luminous bulbs simulate sunlight, enabling photosynthesis even in dimly lit urban environments. Collectively, these technologies establish a controlled ecosystem that facilitates year-round crop production, lessens environmental impact, and aligns with sustainability objectives.

By incorporating sensors and artificial lighting, hydroponic urban farming systems can be automated and fine-tuned, rendering them a practical and efficient solution for providing fresh produce in urban areas. This method not only bolsters local food security but also encourages sustainable practices, conserving water, minimizing waste, and lowering the carbon footprint associated with conventional agriculture.

## II.LITERATURE SURVEY

Hydroponics, a method of agriculture that does not utilize soil, has emerged as a viable solution for sustainable urban farming, effectively tackling significant issues such as limited land availability, inefficient resource use, and food security concerns. This technique employs nutrient-enriched water solutions for plant cultivation, thereby removing the necessity for soil and allowing for meticulous management of growth conditions. Studies indicate that hydroponics can conserve up to 90% more water than traditional farming practices and reduces dependence on chemical substances such as pesticides and fertilizers, rendering it an eco-friendly option. Its compatibility with vertical farming designs optimizes space in densely populated urban environments, while its capacity for year-round crop production guarantees a steady food supply. Furthermore, by fostering local food production, hydroponics lessens the environmental consequences associated with long-distance food transport and strengthens the resilience of urban food systems in response to climate change and increasing population pressures.

## III.METHODOLOGY

This initiative aims to establish a sustainable urban agriculture framework utilizing hydroponics, supported by renewable energy sources. The framework incorporates sensors, renewable energy technologies, and an effective nutrient

distribution system to provide an environmentally friendly method for cultivating plants in urban settings. The approach details the design, execution, and enhancement of the system, prioritizing resource efficiency and ecological sustainability while promoting optimal plant development.

#### Key Themes in the Literature:

**Resource Efficiency:** Hydroponic farming is recognized for its superior utilization of water, nutrients, and spatial resources when compared to conventional agricultural practices.

**Urban Food Security:** Hydroponics presents a viable solution for enhancing local food production, particularly in food deserts or regions with restricted access to fresh produce.

**Social Impact:** Numerous urban farming projects focus on fostering community involvement, education, and empowerment, thereby strengthening local food systems and diminishing dependence on industrial agriculture.

**Technological Integration:** Recent advancements in automation, data analytics, and the Internet of Things (IoT) have rendered hydroponic systems more practical and scalable within urban settings.

#### Journals and Conferences:

- Urban Agriculture & Regional Food Systems Journal
- International Journal of Agricultural Sustainability
- Frontiers in Environmental Science: Urban Sustainability

These publications illustrate the interdisciplinary character of urban hydroponics, merging aspects of agriculture, sustainability, technology, economics, and community development.

#### System Design and Components

The hydroponic system is engineered to be self-sufficient and appropriate for urban environments, featuring elements that promote optimal plant growth. The DHT sensor is employed to monitor temperature and humidity levels, ensuring the maintenance of ideal environmental conditions, while the soil moisture sensor observes water levels within the nutrient reservoir. A water pump is responsible for circulating the nutrient-rich solution, and a 12V induction bulb supplies artificial lighting during periods of insufficient natural light. The system operates on solar energy, enhancing energy efficiency and minimizing dependence on non-renewable energy sources.

#### Renewable Energy Integration

To ensure sustainability, the system is equipped with a solar panel that harnesses renewable energy. A battery and charge controller are integrated to store surplus energy and manage its distribution, guaranteeing uninterrupted operation even in overcast conditions or at night. The energy requirements for each component, including the water pump and induction bulb, are meticulously calculated to select a solar panel that efficiently meets the system's energy needs.

#### Hydroponic Design and Nutrient Circulation

The hydroponic system is designed to ensure effective nutrient distribution through methods such as the Nutrient Film Technique (NFT) and Deep Water Culture (DWC). Adequate spacing is maintained to guarantee that plants receive sufficient light and nutrients. Regular monitoring and replenishment of nutrient levels in the reservoir are conducted to promote robust growth. This design minimizes water waste and enhances plant yield, making it ideal for urban agricultural practices.

#### Testing and Optimization

The system is subjected to comprehensive testing across various environmental conditions, including diverse weather patterns and stages of plant growth. Critical metrics such as solar panel performance, water consumption, and sensor precision are evaluated to pinpoint areas for enhancement.

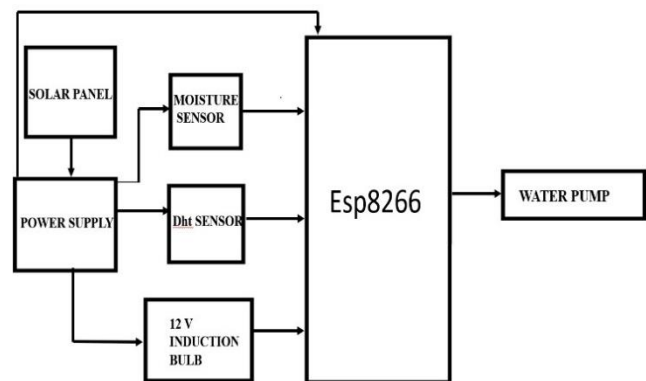
Manual modifications are implemented to optimize resource use and improve plant growth rates, ensuring the system functions effectively in a range of urban environments.

#### Environmental and Economic Impact

The sustainability of the system is evaluated by analyzing energy savings from the solar panels and water conservation in comparison to conventional farming techniques. A cost-benefit analysis assesses the project's economic feasibility, taking into account the reduction in energy and resource expenditures. The findings underscore the system's potential for expansion in larger urban farming projects, thereby supporting food security and environmental sustainability.

This approach offers a clear framework for the design, implementation, and optimization of a sustainable urban farming system utilizing hydroponics, harnessing renewable energy while simplifying operations by excluding IoT integration.

#### IV.SYSTEM DESIGN



#### COMPONENTS

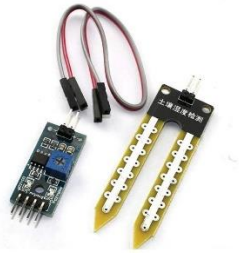
##### 1. DHT Sensor

The DHT sensor, which stands for Digital Humidity and Temperature sensor, plays a vital role in monitoring the environmental conditions essential for plant development. It accurately gauges the temperature and humidity levels within a hydroponic system. These measurements are crucial for maintaining an ideal growing environment, as plants flourish within specific temperature and humidity parameters. The information obtained from the DHT sensor can facilitate the automation of heating or cooling systems, thereby promoting energy-efficient climate regulation.



##### 2. Moisture Sensor

The moisture sensor is designed to assess the water content present in the growing medium or nutrient solution. Although hydroponics utilizes water instead of soil, it remains imperative to monitor moisture levels to prevent both waterlogging and dehydration of plant roots. This sensor enables effective water management, minimizing waste and conserving water resources, which is vital for sustainable practices.



### 3. Water Pump

The water pump is essential for the distribution of the nutrient-rich solution within the hydroponic system. It guarantees that each plant receives a sufficient amount of nutrients and oxygen, which are crucial for optimal growth. The operation of the pump can be automated through the use of sensors and a microcontroller, thereby enhancing energy efficiency and ensuring a consistent water flow for improved performance.



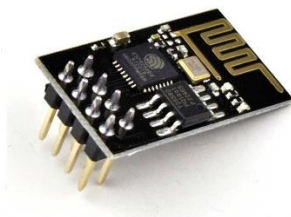
### 4. 12V Induction Bulb

The 12V induction bulb serves as a source of artificial lighting, which is vital for the process of photosynthesis, particularly in indoor settings or areas with limited natural light. These bulbs are characterized by their energy efficiency and longevity, making them suitable for eco-friendly initiatives. The emitted light spectrum can be modified to align with the various growth phases of plants, thereby increasing yield while minimizing energy usage.



### 5. ESP8266

The ESP8266 is an economical Wi-Fi microcontroller that facilitates data collection, processing, and communication within the hydroponic system. It links sensors, such as DHT and moisture sensors, and actuators, like the water pump, to a centralized control system or a cloud-based platform. This microcontroller enables real-time monitoring and automation through Internet of Things (IoT) integration, allowing users to manage and observe the system remotely via a smartphone or computer. This capability promotes efficient resource utilization and bolsters the sustainability of the system.



## EXISTING SYSTEM

Sustainable urban farming utilizing hydroponics is an emerging sector that emphasizes the integration of agricultural practices within urban environments to tackle issues related to food security, environmental sustainability, and community resilience. Below are several significant topics associated with this domain, along with noteworthy publications and methodologies

## 1. Establishing the Urban Hydroponic Farming System

**Grow Space:** Implementing a vertical or stacked hydroponic arrangement can enhance spatial efficiency.

**Reservoir:** Employ a nutrient-enriched water reservoir that delivers water directly to the plant roots.

**Plant Medium:** Choose suitable mediums, such as clay pebbles or coconut coir, which provide adequate support for root anchoring.

## 2. Sensors and Essential Components

**Humidity Sensor:** This device measures the moisture level in the air, facilitating adjustments to prevent excessive dryness or humidity.

**Temperature Sensor:** It monitors the surrounding temperature, ensuring conditions remain optimal for plant development.

**Luminous Bulb (Grow Light):** This artificial lighting source can be modified according to the specific needs of the plants, particularly beneficial in environments with limited natural light.

## 3. Control and Monitoring Mechanism

A basic microcontroller (Arduino) can collect data from the sensors and manage the lighting system.

**Humidity Management:** Based on readings from the humidity sensor, a small humidifier or dehumidifier can be activated to maintain a consistent environment.

**Temperature Regulation:** The temperature sensor can trigger a fan, heater, or cooling unit as necessary to control the ambient temperature.

**Lighting Control:** The luminous bulb can be programmed to replicate natural day-night cycles, with lighting durations adjusted to meet the photoperiod requirements of the plants (e.g., 12-16 hours of light for most leafy greens).

## 4. Automation and Scheduling

**Watering Cycles:** Establish a routine for the delivery of water and nutrients to the plants.

**Lighting Schedule:** Utilize a timer to manage the luminous bulb, optimizing energy consumption while aligning with the plants' natural growth patterns.

**Data Logging:** Continuously record data from the humidity and temperature sensors to discern trends, allowing for system adjustments based on the specific needs of the plants.

## 5. Sustainability Improvements

**Water Reclamation:** Establish a closed-loop system for water recycling, thereby reducing water waste.

## PROPOSED SYSTEM

The proposed system seeks to establish a sustainable urban agriculture solution by incorporating a solar-powered hydroponic framework for cultivating plants. By harnessing solar energy, the system diminishes dependence on non-renewable resources while facilitating the efficient functioning of essential elements such as water pumps, lighting, and nutrient distribution. This approach aims to enhance resource utilization in urban farming, offering a self-sustaining and environmentally friendly method for food production in urban settings.

### 1. Collection and Preparation of Components:

The system will assemble vital components, including a solar panel, battery, water pump, induction bulb, DHT sensor, and soil moisture sensor. The solar panel will be positioned to harness solar energy, while the sensors will track environmental factors crucial for plant development, such as humidity, temperature, and water levels. The selection of components will prioritize energy efficiency and compatibility to ensure seamless operation of the system.

### 2. Solar Energy Conversion and Storage:

The solar panel will serve as the main energy source for



the system, converting sunlight into electricity to power the water pump, induction bulb, and any additional automation features, such as an ESP8266 if necessary. A battery will store surplus energy generated during sunny periods, guaranteeing continuous operation of the system even during nighttime or overcast conditions. A charge controller will regulate the energy flow to prevent overcharging and protect the battery from potential damage.

### 3. Hydroponic System Configuration and Nutrient Flow:

The hydroponic setup will incorporate methods such as the Nutrient Film Technique (NFT) or Deep Water Culture (DWC) to supply water and nutrients directly to the roots of the plants. A water pump will facilitate the circulation of the nutrient solution from a reservoir to the plants. An induction bulb will replicate sunlight during times of inadequate natural light, thereby providing the essential conditions for photosynthesis and plant development.

### 4. Energy Management and Automation:

The system will be engineered to automate essential operations, including the activation of the water pump when the moisture sensor indicates low water levels and the illumination of the induction bulb when natural sunlight is lacking. The solar energy system guarantees that all operations function autonomously, enhancing energy efficiency and promoting optimal plant growth. This automation contributes to a low-maintenance system that operates with high efficiency.

### 5. Energy Consumption Monitoring and Optimization:

Continuous monitoring of the solar panel's output alongside the system's energy consumption will be implemented to evaluate overall efficiency. Modifications will be made to enhance the energy utilization of each component, ensuring that the solar panel generates sufficient power to meet the system's requirements without unnecessary waste. Various environmental conditions will be tested to identify the optimal size and configuration of the solar panel for achieving maximum efficiency.

### 6. Water and Nutrient Management:

The system will track water and nutrient levels to maintain ideal conditions for plant development. A water pump will provide a steady supply of nutrient-enriched water, while the system will reduce water consumption through effective recirculation, making it particularly suitable for urban areas where water resources may be scarce. The nutrient solution will be replenished and modified as necessary to align with the plants' needs.

### 7. Environmental and Economic Impact:

The sustainability of the system will be assessed by analyzing the energy savings derived from solar power and water conservation in comparison to conventional farming practices. A cost-benefit analysis will take into account the initial investment, energy savings, and potential income from crop production in urban locations. The findings will illustrate the economic feasibility of solar-powered hydroponic systems for urban agriculture and their scalability in larger urban settings.

By incorporating solar energy into urban hydroponics, this proposed system presents an environmentally friendly, energy-efficient, and sustainable approach to urban agriculture, decreasing reliance on traditional power sources while improving food security in metropolitan areas.

### WORKING

The solar-powered hydroponic system functions by capturing solar energy through a solar panel, which transforms sunlight into electrical energy. This energy is utilized to operate essential components of the system, such as the water pump, induction light, and various sensors. A battery stores the solar energy for use during times of insufficient sunlight, including nighttime and overcast days, thereby guaranteeing uninterrupted operation. The water pump delivers a nutrient-

rich solution to the plant roots through hydroponic methods like Nutrient Film Technique (NFT) or Deep Water Culture (DWC), thereby enhancing the efficiency of water and nutrient distribution. In conditions of low light, a 12V induction bulb is activated to replicate sunlight, ensuring that the plants receive adequate light for photosynthesis. The system is equipped with sensors, including a DHT sensor for monitoring temperature and humidity, as well as a soil moisture sensor to assess water levels in the reservoir. These sensors provide real-time information, facilitating the automation of critical functions. When moisture levels decrease, the water pump is automatically activated to ensure that the plants are sufficiently hydrated. The system operates autonomously, promoting efficient resource utilization, reducing water waste, and fostering plant growth. Continuous performance monitoring and necessary adjustments guarantee that the system functions at its best, contributing to a sustainable and energy-efficient approach to urban farming.

### PROTOTYPE



### CONCLUSION

The establishment of a hydroponic system for urban agriculture, augmented by environmental sensors and regulated lighting, can greatly improve both sustainability and productivity. By employing humidity and temperature sensors, cultivators can meticulously monitor and sustain ideal conditions, thereby minimizing water consumption and ensuring that plants receive the precise moisture and temperature necessary for optimal growth. This level of precision not only conserves resources but also boosts both the yield and quality of crops.

Moreover, the integration of artificial lighting through luminous bulbs as a controlled light source facilitates an extended growing season and enables indoor farming opportunities. Such lighting ensures consistent photosynthesis, independent of external weather conditions, thereby decreasing reliance on natural sunlight and allowing for food production in various urban environments, including those with limited access to natural light.

Collectively, these technologies render hydroponic urban farming more efficient, sustainable, and adaptable to urban landscapes. The system promotes year-round cultivation, diminishes the carbon footprint associated with conventional agriculture, and can enhance local food security. In summary, the incorporation of sensors and controlled lighting within hydroponic systems presents a viable approach to sustainable and resource-efficient urban farming.

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