Sustainable Greenhouse Farming

Team 53

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Introduction

Hydroponics is a soil-less farming method that uses a nutrient-rich water solution to grow plants, offering advantages such as increased crop yields, faster growth rates, and the ability to overcome poor soil conditions. It reduces the risk of soil-borne diseases and pests, allows for year-round cultivation in controlled environments, and promotes water efficiency by targeting water delivery to plant roots. Greenhouse farming also conserves water through reduced evaporation and controlled irrigation practices, but hydroponics tends to be the most water-efficient method overall.

Our project aims to construct a Sustainable Smart Farm that combines modern technology and eco-friendly practices to revolutionize urban agriculture. The centerpiece of the project is a vertical farm utilizing hydroponics, which eliminates the need for soil and conserves water while maximizing agricultural output in densely populated urban areas. The farm will be powered primarily by solar energy, stored in batteries for continuous operation and optimal growing conditions. A specialized water treatment system will ensure the use of clean water, particularly in areas with limited access. The project also incorporates a hybrid irrigation and nutrient system, tailored to individual plant needs for efficient resource management. Real-time monitoring and smart technologies will enable seamless adjustments and maximize yields. This scalable and replicable model addresses food security, water conservation, and clean energy in urban settings, serving as a beacon of hope for sustainable urban agriculture.

Problem statement

The Sustainable Smart Farming project addresses the challenges posed by urbanization and population growth to traditional agricultural practices. These practices rely on factors like soil quality, water supply, and weather conditions, which are becoming increasingly unsustainable. Greenhouse farming, while providing controlled environments, requires significant energy inputs and may not effectively conserve land and water resources. In contrast, hydroponics offers a groundbreaking solution by enabling soil-less agriculture, reducing water usage, and maximizing yield per unit area. The project integrates hydroponics with vertical farming, solar energy, and smart technologies to meet the global needs for food security, water and land conservation, and renewable energy utilization. It represents an innovative and sustainable approach to agriculture, promising improved resource efficiency, reduced environmental impact, and increased yields. This is crucial for meeting the growing demand for food and promoting ecological balance in urbanized areas.

Objectives

Reducing Water Consumption up to 85%

Totally powered by Renewable energy

Maximum Crops density

Lower plant crop cycle

Design

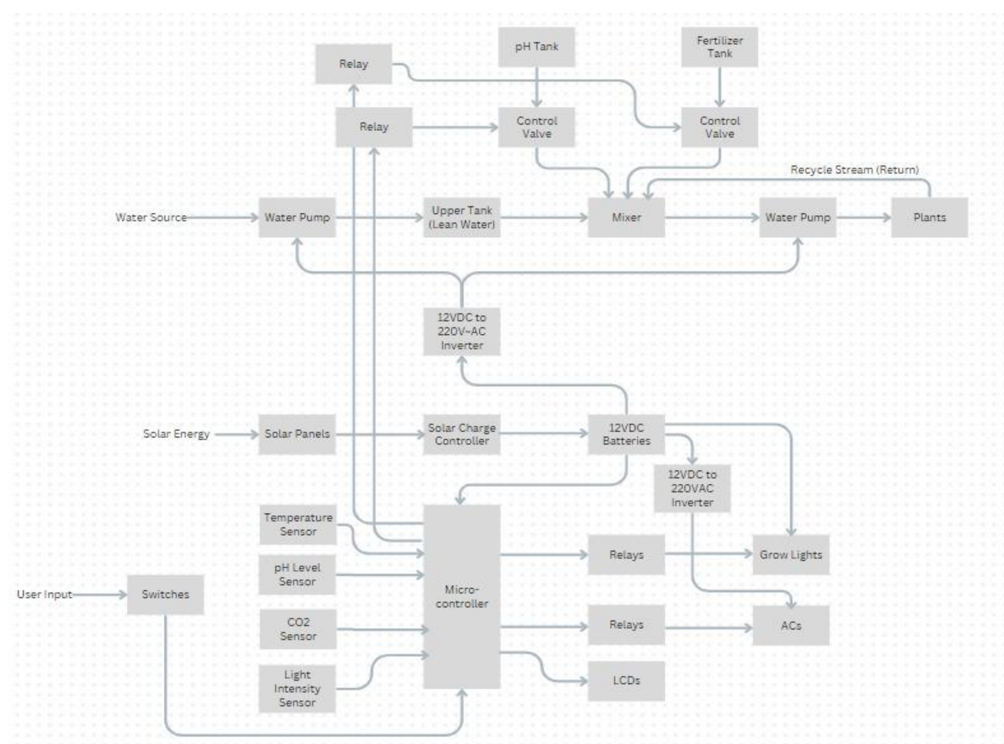

Figure 1: Process Block Diagram

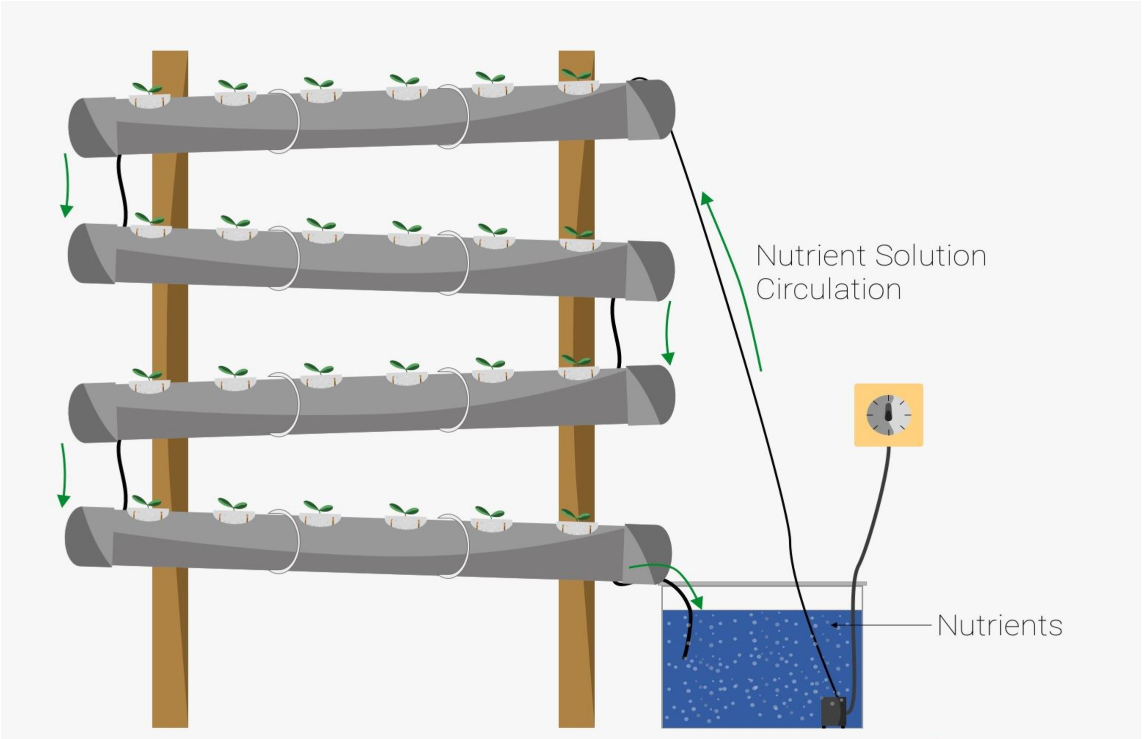

Figure 2: illustration of a single farming cell

Table 1: comprehensive schedule with rough estimates of improvements

Factor	Hydroponic Farming	Soil-Based Farming	Improvement (%)
Space Utilization (plants/m²)	6.14	3	104.67%
Water Usage (L/plant/day)	0.75	5	85%
Yield (times/year)	3	1	200%
Number of Harvests (times/year)	4	2	100%
Fertilizer Efficiency (L/Day)	98.9	118.68	16.67%
Waste (L/Day)	1647.8	16,477.9	+90%

Table 2: Mass balance calculations on large scale farming

	Value	Ratio with respect to water feed
Total number of plants	43,941	
Total water consumption by plants (L/Day)	32955.75	
Feed to plants (L/Day)	79093.8	2.4
Recycle stream	46138.05	
Waste (L/Day)	1601.348	0.05
Fertilizer (L/Day)	96.0809	0.003
pH feed (L/Day)	2434.05	0.076
Water Feed (L/Day)	32026.97	

Constrains

Weather: We will use solar energy system as our main power supply for the project and it can be inefficient in some weather conditions such as cloudy weather and dusty weather. Also, Frequent sandstorms and dust can accumulate on solar panels, and it will reduce their efficiency.

Limitation of water: Dry countries like Saudi Arabia have a lack of water resources and water is an essential resource for our project since we will use a hydroponics system for farming.

Authorization and permission of underground water usage: We will use underground water for our system to commercial customers and we need to get permission from the government to extract and treat the water.

Specification & Testing

- minimum required Irrigation flow level (5L/min*m^2): We have successfully met the required irrigation flow level by carefully selecting a water pump that matches this rated flow value.
- Greenhouse temperature range (15°C-26°C): We have met the specified greenhouse temperature range of 15°C to 26°C by implementing the cooling system designed.
- Battery storage (700Wh/m^2): We met this Specification by selecting the appropriate number of batteries to ensure that our total storage capacity meets or exceeds this specification.
- System accuracy (>90%): We integrated high-quality sensors known for their reliability and precision.
- pH level control range (5.5pH – 6.5pH): We have fulfilled this specification by developing the pH control system and calculating the amount of pH adjustor injection depending on each case.
- Product nutrient Content (> 90% compared to USDA Standards): we made sure that our product's nutrient content meets or exceeds 90% of the United States Department of Agriculture (USDA) standards, we will implement a rigorous testing and processing protocol.
- Plant Density (5-10 plants/m^2): We have met this specification by utilizing an optimization model to determine the optimal number of plants per square meter.

Conclusions

implementation of a sustainable Smart Farm that revolutionizes urban agriculture by combining hydroponics and solar energy. The vertical farm reduce the use of land, conserves water, and maximizes crop yields. Powered primarily by solar energy and equipped with a water treatment system, this scalable model promotes sustainable urban agriculture, addressing food security, water conservation, and clean energy