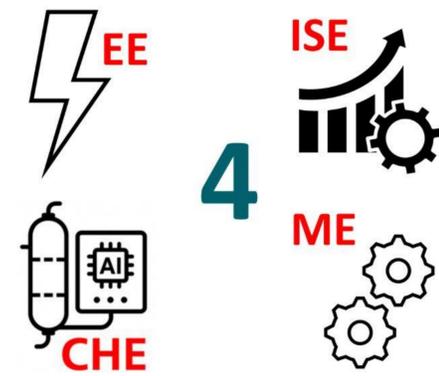


# Modular Vertical Farming System with Integrated AI, IoT-Based Automation, Algae Control, and Solar Energy Utilization

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## Introduction

In Saudi Arabia, only 1.5% of land is suitable for farming, yet agriculture consumes nearly 70% of the country's water resources, creating a major challenge for sustainable food production. Aligned with Vision 2030 goals for food security and resource efficiency, our project introduces a modular, scalable vertical farming system based on hydroponics—a solution known for conserving water and maximizing yield. However, hydroponic systems often require daily manual adjustments to parameters like pH, EC, and nutrient levels, and are vulnerable to issues like algae growth, which wastes water and nutrients. Our smart farming system solves these problems through automated monitoring and control, UV treatment, and solar-powered operation, all managed via a real-time web platform called Waraf.

## Constraints

- Total project cost  $\leq$  6000 SAR, Conduction of cost analysis.
- System must operate on 220V AC.
- Sensors must operate on 3.3-5V.
- Stacked Vertical farm towers must not exceed 4 meters.
- Tower vertical farm must not exceed 2 meters
- Hydrogen peroxide should not exceed 0.6ml per liter.
- Steady water flow that not exceeds 1 L per minute.
- The water must be between 300-400 ppm for early stages.

## Specifications

- Nutrient solution pH should be between 5.5 and 6.5.
- Nutrient solution electrical conductivity should be between 1200 and 2500  $\mu$ S/cm, for early stages electrical conductivity should be between 500 and 800  $\mu$ S/cm .
- Closed-loop hydroponic system with 90% water recycling efficiency
- Develop an optimization framework to manage 80% of variations.

- Optimize layout for 24 leafy greens per floor in the stacked system.
- The system can be powered by the 12V battery.
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- Stacked vertical farms, each has dimensions of (length 1.8 m, Width 0.6 m, Hight 2m) 2.16 m<sup>3</sup>.
- The pipes used in the stacked vertical farm are 10cm and 2.54 cm in diameter.
- Tower vertical farms, each with height of 2 meter.
- The pipes are used in the tower vertical farm are of diameter of 20cm.
- Solar panels that tracks the sun light, 60 degrees rotation.
- Automatically shut down if pH is larger than 6.5, or lower than 4.5.
- Automatically shut down if temperature larger than 27C, or lower than 18C.
- Payback period < 5 years.
- Grow over 15 types of leafy greens and herbs in the stacked vertical farm.
- Grow over 50 crops, including deep-rooted plants like tomatoes, peppers, and cucumbers, in a tower vertical farm.

## Testing / Validation



Figure 1: Prototype Testing

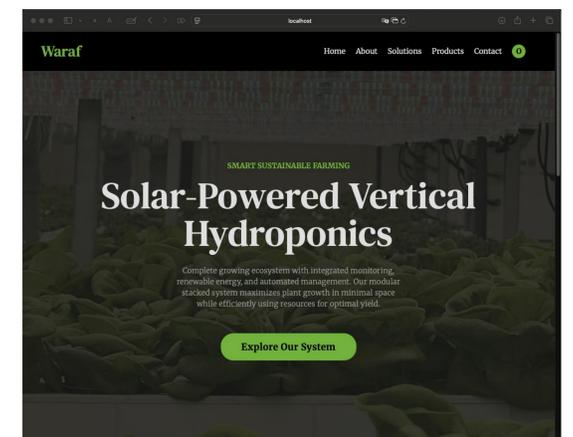


Figure 2: Website Testing

## Conclusion

This project enhances hydroponic farming by automating key processes, reducing water waste, and preventing algae growth. It offers a sustainable, easy-to-manage solution aligned with Saudi Arabia's Vision 2030 goals.