Review of IOT-Enabled Small-Scale Hydroponic Systems for Indoor Farming of Leafy Vegetables.

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Abstract:-

Advances in hydroponics combined with Internet of Things (IoT) technology have paved the way for growing vegetables sustainably in controlled environments. This review examines the recent work by Nikolov et al. (2023), who built and tested a small-scale IoT-based hydroponic system for leafy vegetables. Their findings indicate that affordable automation can improve resource use, reduce reliance on soil, and supply urban communities with fresh produce year-round. This review places their study within the wider field of hydroponics research, highlighting its strengths, potential applications, and remaining challenges such as energy efficiency, scalability, and nutrient control.

Introduction:-

Urbanization is increasing worldwide, while climate variability and soil degradation continue to grow, creating a pressing need for farming methods beyond traditional soil- based agriculture. Hydroponics, which involves growing plants in nutrient-rich solutions rather than soil, offers benefits such as higher yields, reduced water use, and year-round production. When combined with IoT technology, hydroponic systems allow real-time monitoring and automated control. In this context, Nikolov et al. (2023) present a low- cost, IoT-based, small-scale hydroponic system designed for indoor lettuce production.

Key Contributions of the Study:-

System Architecture: The system design featured microclimate monitoring and control of the nutrient solution, ventilation, heating, and lighting. A NIDO ONE IoT controller enabled remote monitoring of pH, EC, temperature, and humidity.
Hardware Implementation: A metal rack system with nine trays, a 150 L nutrient tank, and full-spectrum LED grow lights was used, along with automated dosing of pH and nutrient solutions.

Experimental Findings:-

Tests with Lactuca sativa achieved a 75% germination rate, with pH and air temperature maintained within optimal ranges. Nutrient solution temperature and EC stability showed limitations.

Advantages:-

The system is simple to operate, remotely accessible, and suitable for small indoor and urban environments.

Critical Review:-

Strengths include affordability, ease of use, and demonstrated feasibility. Limitations involve suboptimal nutrient temperature, EC instability, untested scalability, and lack of economic analysis.

Comparison with Other Studies:-

Compared to other IoT-based systems offering better control at higher costs, and low- tech Kratky systems lacking automation, this approach offers a balanced solution.

Future Directions:-

Future work may include AI-based nutrient dosing, improved energy efficiency, enhanced **climate control, crop diversification, and detailed economic evaluation.**

Conclusion:-

The study shows that small-scale IoT-enabled hydroponics can support sustainable urban agriculture. Further improvements are needed to enhance nutrient control, scalability, and system efficiency.

References:-

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