

Scientiarum: A Multidisciplinary Journal
Vol. 2 No. S1 (2026): Supplement Issue
DOI: 10.54646/SAPARS.2026.80

SAPAR SERVICES LLP
Scholarly Articles Publication And Repository Services

URBANGROW "EMPOWERING SMART CITIES WITH AUTOMATED, IOT-DRIVEN ROOFTOP HYDROPONICS AGRICULTURE."

Kalyan K S[1] Parnapalli Pushpanjali [2],

MCA 2nd year[1]

Assistant Professor[2]

Department of Computer Science and Applications

S.E.A. College of Science, Commerce and Arts

kk2534268@gmail.com[1]

pusharoyal777@gmail.com[2],

ABSTRACT

UrbanGrow is an intelligent hydroponic system designed to grow crops sustainably and effectively. It combines technologies from the Internet of Things, automation, data analysis, and web development to create an intelligent farm. The system continuously monitors parameters such as nutrients, pH, temperature, humidity, and water level. Sensor data is collected and sent to the system for monitoring and analysis. A web-based interface allows users to monitor the sensors and the overall state of the hydroponic farm. Automated processes can control water circulation and other agricultural activities based on specific conditions, reducing the need for constant monitoring and helping manage resources more effectively. The system also provides a crop management feature to maintain information about the crops grown and assist with decision-making. Notifications and system activity monitoring help

make the system more reliable and user-friendly. With the help of Krishi AI, users can receive useful recommendations about their crops and hydroponic farming. The platform uses a modular architecture that combines the frontend, backend, database, and IoT components.

Keywords: Urban Agriculture, Hydroponics, Internet of Things (IoT), Smart Farming, Automation, Sensor Monitoring, Artificial Intelligence, Sustainable Agriculture.

INTRODUCTION

Urbanization and population growth have resulted in a reduction in the availability of land for traditional agriculture but an increase in the demand for fresh and local produce. Traditional agriculture involves land, water, and constant human intervention, thus there arises a need for efficient cultivation practices that will be feasible in urban areas. Hydroponics is an advanced practice of cultivating plants in a controlled environment without using any soil where the plant receives water and required nutrients in a specific proportion. Maintaining the hydroponics system manually becomes difficult as

there are several parameters that need to be monitored constantly like pH level, nutrient level, temperature, humidity, and water level. With the help of Internet of Things (IoT) one can get constant monitoring and data collection through sensors. Automation will further decrease human involvement in the process of farming through setting pre-defined conditions. UrbanGrow is an intelligent rooftop hydroponic farm that integrates IoT, automation, software technologies, and data management technologies in urban agriculture. This system provides a web interface where real-time sensor monitoring, crop management, system control, notification services, reporting, and data analytics happen. An AI enabled module called Krishi AI helps in advising about crops and hydroponics agriculture.

RELATED WORK

Urban agriculture is gaining increasing significance because of rapid urbanization, population growth, and the scarcity of agricultural lands. Conventional farming is characterized by large land requirements, intensive use of water resources, and constant supervision, making it hard to use in highly concentrated cities. Hydroponics is another option which involves cultivation without soil but in nutrient-enriched water and optimal environmental conditions. Hydroponics is characterized by good space and water utilization, which makes it relevant in urban rooftop gardening. UrbanGrow is a system for smart farming in hydroponics on rooftops which combines IoT, automation, and software solutions. It utilizes sensors for collecting data about the pH level, nutrient content, temperature, humidity, and water level. All the information is collected and processed to provide real-time updates in a web-based dashboard. Automated mechanisms help to regulate various processes of farming, like water circulation under certain conditions. The platform also supports crop management, notifications, reports, historical data, monitoring of the system and others. Another module in the system is AI-assisted, and its name is Krishi AI which provides crop-related information and information on hydroponics farming..

RESEARCH GAP

Though various studies have looked into the concepts of hydroponics, IoT-based farming, and smart systems, there are still research gaps to fill concerning the creation of an integrated solution for urban rooftop farming. The majority of the previously made hydroponic systems do not offer a complete solution to urban rooftop farming. Most related works only address a specific area of concern in the whole smart farming field. Some works address nutrient sensing while others look into environmental sensing, irrigation systems, or growth analytics.

Additionally, most of the IoT-based agricultural solutions are reliant on manual management. This is a problem considering that urban dwellers are mostly not well versed in rooftop farming or do not have the time to manage such systems. Several works have addressed the application of sensors to monitor the required parameters in a farm. However, there is still a research gap concerning automated decision support systems for smart farming that can offer assisted recommendations. Though multiple parameters such as pH, TDS, temperature, and humidity have been monitored and reported in the previous works, none of the related works offer an intelligent system that can offer recommendations or take automated actions based on the acquired sensor data. Additionally, most of the previous solutions do not offer web-based monitoring, reporting, and control systems. There is a need for an affordable, scalable, and integrated system that can be used in small urban rooftops for farming. The inclusion of AI assistance, translation services, historical analytics, and automated notifications is also limited in most of the previous works. Thus, this project addresses these research gaps by developing an integrated system that includes sensors, actuators, database, web dashboard, AI assistance, and automation features to create a complete smart rooftop hydroponics system for urban farming.

PROPOSED METHODOLOGY

The proposed methodology of UrbanGrow is designed with the utilization of Internet of Things, web technologies, automation, database, analytics, and AI assistant to develop a proficient smart rooftop hydroponics management system. The process begins with the user's registration and authentication. Upon successful verification, farmers and administrators can access the platform in separate portals. Administrators can supervise the system, whereas farmers can utilize different services, including

managing the crops, accessing information regarding cultivation, purchasing hydroponic equipment, and analyzing the results. An ESP32 microcontroller is used to acquire data about Total Dissolved Solids, pH, temperature, humidity, and water level from various sensors. The collected information is then transferred to the web application backend, which is built using Flask, Python, and PostgreSQL. This data is stored in the database so that it can be used for monitoring and analytics. Additionally, an automation system is used to control and regulate water pumping and other mechanisms. This is done by setting threshold values and linking them with relays. The backend then relays the information to the microcontroller so that it can turn off and on the water pump. The system also has a notification system that sends out activity notifications, alarms, and analytics reports to the users. The web portal and the application offer comprehensive dashboards where users can review their farm activities. Moreover, Krishi AI assistant is available to respond to queries and provide farming recommendations. The system can also be switched between three languages, including English, Kannada, and Hindi. Besides monitoring and controlling farms, administrators can supervise notifications, analytics, automation, sensors, users, and the overall system performances. Overall, the proposed methodology presents an efficient and effective hydroponics system that is capable of meeting the demands of precision rooftop farming.

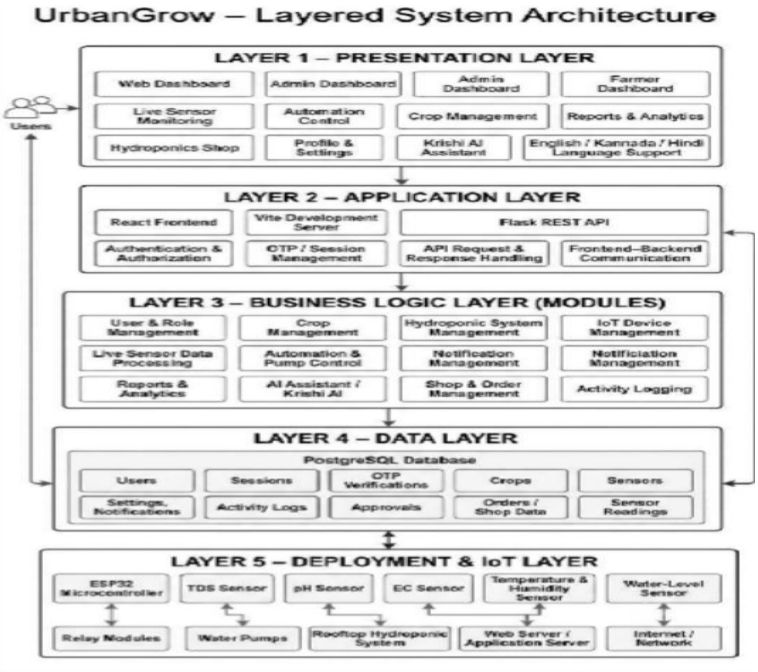
EXPERIMENTAL SETUP

The experimental setup of the proposed system comprises IoT hardware, hydroponic components, web application, and database to enable real-time monitoring and automation of a rooftop farm. The hardware prototype was designed using the ESP32 microcontroller connected to the sensors to monitor the desired water quality, pH, conductivity, temperature and humidity, and water

level. A water pump and relay module were also included in the prototype to regulate the ongoing process based on given conditions.

The ESP32 was also programmed to receive the sensor data and transmit the information through an internet connection to the server. The backend application was coded using the Python programming language and the Flask framework. It managed the requests from the sensor devices and the web application while also featuring REST API for prototype-web application communication. A PostgreSQL database was used to manage the web application's user data, sensor data, reports, crops, notifications, and system settings.

The front end was designed using the bootstrap framework to offer a responsive web application where users could monitor the farm's status, manage the crop, observe automation reports, and interact with the Krishi AI bot. Experiments were conducted using the prototype to record and evaluate the system's performance under varying water quality and environmental conditions. The observations were made on the system status, sensor data, automation control, database contents, and dashboard data to inform the experimental results.



URBANGROW Layered System Architecture

RESULT AND DISCUSSION

The Urban Grow system is a promising development in terms of utilizing IoT-based monitoring, automated hydroponic processes, web-based management, database-driven storage, and AI-assisted interactions. The proposed system was tested in the experiment, where the TDS, pH, temperature, and other metrics were collected and uploaded to the web dashboard. It was found that with the use of the ESP32, it is possible to send the required signals to the back-end via the internet.

The system automation feature is particularly useful, as it allows for the regulation of the water pump based on certain thresholds. It is evident that the creation of rules and the use of relays eliminate the need for constant user interference. Thus, the automation tool can be used extensively for rooftop hydroponic farming.

The web interface offers a variety of features for the user, varying from dashboard views to automation settings and reports. It also features a separate area for farmers, where the processes can be monitored in real-time and data reviewed.

The PostgreSQL database is particularly useful for the system, as it allows for the structured storage of information related to users, sensors, crops, and system settings.

Finally, the addition of the AI assistant, Krishi, is an excellent attribute to the system, as it allows for a more personalized experience and better support for the user. The multilingualism of the program also facilitates its easier use. To summarize, the system was found to offer a comprehensive view and control over the rooftop farming system while utilizing IoT features, databases, and an AI assistant. The project can be expanded in the future to include more intricate analytics and models, as well as more sensors and a wider application base.

CONCLUSION

UrbanGrow was an integrated smart rooftop hydroponics system that utilized the concepts of IoT, automation, web, database management, and AI assistant to enable efficient urban farming. The developed system was capable of monitoring essential hydroponic parameters such as TDS, pH, temperature, humidity, and water-level using an IoT-based ESP32 framework. In addition, automation was achieved using a water-pump actuator that minimized the need for manual intervention in the process. The web portal offered a complete solution for monitoring and controlling the farm, including sensors, automation processes, reports, announcements, user management, and system settings. PostgreSQL open-source database was utilized to store and manage the system and sensor data in a structured manner. The database enabled easy query of specific information from the system, including historical sensor data useful in decision-making. The Krishi AI assistant was also integrated into the system to offer natural language assistance and enhance the ease of use of the system. Additionally, the system's interface was available in multiple languages to meet the

needs of different users.

The developed prototype demonstrated how IoT-based sensing, automation, web-based monitoring and control, and AI-assisted natural dialogue could be integrated into a smart rooftop hydroponics system. However, there are still several opportunities for improvement, including integration into existing systems, utilizing machine learning algorithms to recommend different types of crops based on sensor data, adding more environmental sensors, implementing more advanced automation techniques, and testing at scale.

FUTURE SCOPE

The project can be further developed by introducing more advanced technologies and decision-making systems such as machine learning to study the collected data from sensors and the growth patterns of various crops and make predictions about future plant growth and nutritional demands, irrigation process, environmental factors, and other features. It can be achieved due to the prediction capabilities of machine learning algorithms. These algorithms can also prevent irregular sensor readings and malfunctions of the system that may interfere with crop growth.

More sensors can be introduced to the system, including those that measure dissolved oxygen, light, electrical conductivity, CO2, ions, and other factors. The system's automation processes can be improved by introducing modern technologies that allow the creation of self-regulating systems. These processes can include regulating the water flow and fertilization based on the needs of the plant, controlling the light, and adjusting the environment. The application can also gain new functions allowing users to operate the platform from different devices via the internet.

Advanced statistical and data analysis utilities can be applied to study the crop growth processes and present the information in informative graphs or reports. The functionality of the Krishi AI assistant can be expanded by introducing more features, such as consulting services for individual crops, technical support, and multilingual support. The application can be equipped with functions allowing it to work in different languages and provide agricultural recommendations in real-time.

Finally, field tests can be conducted on larger scales to examine the performance of the system in different environments and conditions with various crops and structures. These trials will ensure the efficiency and sustainability of the system while also securing a good level of automation and utilizing resources. All the aforementioned improvements can make the platform a more competitive and attractive solution for those who want to engage in technology-driven rooftop farming.

REFERENCES

Arduino. (n.d.). Arduino documentation. https://docs.arduino.cc/

Espressif Systems. (n.d.). ESP32 series datasheet. https://www.espressif.com/en/products/socs/esp32

Food and Agriculture Organization of the United Nations. (n.d.). The future of food and agriculture: Trends and challenges. https://www.fao.org/

Jensen, M. H. (1985). Hydroponics. Horticultural Reviews, 7, 483–559.

Mozilla Developer Network. (n.d.). MDN Web Docs. https://developer.mozilla.org/

OWASP Foundation. (n.d.). OWASP Web Security Testing Guide. https://owasp.org/www-project-web-security-testing-guide/

Pallets Projects. (n.d.). Flask documentation. https://flask.palletsprojects.com/

PostgreSQL Global Development Group. (n.d.). PostgreSQL documentation. https://www.postgresql.org/docs/

Python Software Foundation. (n.d.). Python documentation. https://docs.python.org/3/

React. (n.d.). React documentation. https://react.dev/

Resh, R. (2013). Hydroponic food production: A definitive guidebook for the advanced home gardener and the commercial hydroponic grower (7th ed.). CRC Press.

SQLAlchemy. (n.d.). SQLAlchemy documentation. https://docs.sqlalchemy.org/

Vite. (n.d.). Vite documentation. https://vite.dev/guide/

World Health Organization. (n.d.). Urban agriculture and food security. https://www.who.int/