# Initial plan: Modular Smart Flowerpot System

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## Description:

Urbanisation continues at an unprecedented rate. According to the CIA's World Factbook, 65 countries and territories now have over 90% of their people living in urban areas (CIA, 2018). In these densely populated environments, local food production is increasingly challenging, creating a pressing need for improved food security. Singapore, for instance, with its 5.5 million residents, currently imports more than 90% of its food (BBC, 2022). This dependency highlights the potential and difficulties of urban farming, where limited space and high costs can impede widespread adoption.

In response to these challenges, this project aims to develop a data-driven dashboard for a modular smart plant monitoring system. The motivation is to empower urban dwellers to engage in small-scale farming by providing a user-friendly platform that aggregates real-time sensor data from individual plant modules. Each module, designed to be simple, reliable and easily configurable, will measure soil moisture, light levels, temperature and water reserves. In addition, the modules will automate plant care by regulating watering schedules based on sensor feedback.

The specific problem addressed by this project is the lack of accessible, real-time monitoring tools in affordable urban farming solutions. Although various self-watering planters and vertical farming systems exist, many are either too expensive, overly complex or fail to offer detailed, plant-specific data. By focussing on a modular design that integrates a centralised dashboard, the project aims to bridge this gap. This solution is both a technical and practical challenge, as it requires seamless integration of hardware and software under constraints such as limited time and resources. The approach is informed by discussions with my supervisor and builds on existing IoT and urban farming research, ensuring that the problem tackled is both significant and manageable within the scope of the project.

# Aims and Objectives:

## Aim:

To create a user-friendly, data-driven dashboard that seamlessly integrates modular smart plant monitoring units, allowing real-time visualisation and automated control of plant care. This system is designed to empower urban dwellers by simplifying the management of small-scale farming, making urban agriculture more accessible, efficient and cost-effective.

## Objectives:

1. Develop Modular Smart Plant Modules:

   The first objective is to design and build robust sensor-equipped modules that monitor key plant parameters such as soil moisture, light levels, temperature, and water reserves. These modules will be simple to assemble and reliable enough for various urban farming setups. To address risks like hardware component delays and sensor calibration inaccuracies, alternative components will be secured early and rigorous calibration tests conducted to ensure data accuracy.

2. Implement a Centralised Data-Driven Dashboard:

   The next objective is to develop a web-based or mobile dashboard that aggregates sensor data from all modules and displays real-time plant health metrics. This interface will also allow users to adjust watering schedules and other controls. Recognising the risk of communication challenges between modules and the dashboard, the project will utilise established protocols and conduct incremental integration tests to ensure seamless data flow and responsiveness.

3. Ensure Ease of Configuration and Scalability:

   A further objective is to design the system so that each module can be easily added and configured, making it suitable for both small-scale and expanded urban farming setups. The standardisation of the configuration process will help prevent compatibility issues when integrating multiple modules. Each module will be thoroughly tested before full-scale deployment, ensuring the system remains flexible and user-friendly.

4. Evaluate System Performance in an Urban Environment:

   A further objective is to design the system so that each module can be easily added and configured, making it suitable for both small-scale and expanded urban farming setups. The standardisation of the configuration process will help prevent compatibility issues when integrating multiple modules. Each module will be thoroughly tested before full-scale deployment, ensuring the system remains flexible and user-friendly.

# Feasibility:

The project is feasible within the given constraints, as it leverages affordable, readily available sensors, microcontrollers and open-source software. The modular design minimises hardware complexity, allowing individual components to be developed and tested incrementally. No significant ethical or legal issues are anticipated, as the project does not involve sensitive personal data, and all software will adhere to open-source licences. Potential feasibility challenges include shipping delays for hardware components and possible integration issues between the smart modules and the dashboard. These risks are mitigated by maintaining alternative suppliers for key components and employing well-documented communication protocols. The reliance on established IoT platforms further reduces the likelihood of unforeseen technical complications. Overall, the project's scope is well defined and manageable within the available timeframe, and the strategy for addressing potential setbacks has been discussed with my supervisor.

# Work Plan:

| Week (Date – Title) | Tasks | Milestone | Deliverables |
|---|---|---|---|
| **Week 1 (03.02.25 – Project Setup and Initial Research)** | Finalise project scope and dual focus (hardware & dashboard). | Overview of project goals and high-level design. | Design document<br><br>Literature review summary<br><br>Preliminary components list |
| | Review literature on IoT planters, urban farming, sensor tech, & data visualisation. | | |
| | List preliminary hardware components and software tools. | | |
| | Sketch initial design ideas for hardware modules and dashboard. | | |
| **Week 2 (10.02.25 – Finalising Specs and Ordering Components)** | Finalise hardware specs (sensors, microcontrollers, basics) and software stack. | Final specs document with confirmed orders. | Complete specs document<br><br>Ordering confirmations |
| | Refine wiring schematics and data flow diagrams. | | |
| | Order components and secure required resources. | | |
| **Week 3 (17.02.25 – Early Prototyping: Hardware & Software)** | Test key sensors on a breadboard. Select communication protocols. | Basic hardware tests and software framework ready. | Sensor test logs<br><br>Back-end code repository<br><br>Dashboard UI sketches |
| | Develop initial back-end framework (simulate data if needed). | | |
| | Create initial dashboard mock-ups. | | |
| **Week 4 (24.02.25 – Hardware Assembly: First Module)** | Assemble first sensor module (install sensors for soil moisture, light, temperature, water reserves). | First module operational with live sensor data. | Build photos<br><br>Test logs<br><br>Initial firmware code |
| | Develop firmware to read and transmit sensor data. | | |
| | Conduct basic hardware tests. | | |
| **Week 5 (03.03.25 – Integration and Calibration)** | Integrate sensor module with back-end (replace simulated data with live readings). | Single module with calibrated data and basic automation. | Revised firmware<br><br>Updated back-end code |
| | Implement sensor calibration routines. | | |

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| | Add basic control features (e.g. automated watering)<br>Order extra components for scalability. | | Calibration reports |
| **Week 6 (10.03.25 – Expanding the Hardware Network)** | Assemble and integrate a second sensor module.<br>Update back-end to handle multiple modules.<br>Test configuration and expansion. | Multi-module setup with reliable data aggregation. | Multi-module demo<br>Updated integration code<br>Scalability documentation |
| **Week 7 (17.03.25 – Advanced Dashboard Development)** | Develop an enhanced dashboard with live data, trend analysis, and controls.<br>Refine UI for clear data display and alerts.<br>Integrate dashboard with multi-module back-end. | Functional dashboard prototype with real-time data. | Dashboard prototype<br>Source code<br>UI documentation |
| **Week 8 (24.03.25 – Stress Testing & Evaluation)** | Deploy system in a trial urban environment (e.g. indoor flat with plants).<br>Monitor sensor accuracy and dashboard responsiveness.<br>Record environmental data and system performance. | Evaluation of system performance under real conditions. | Test logs<br>Observation notes<br>Performance report |
| **Week 9 (31.03.25 – Refinement and Iteration)** | Implement improvements (sensor recalibration, wiring/enclosure tweaks, UI updates).<br>Update firmware, back-end, and dashboard.<br>Document changes and feedback. | Enhanced, robust prototype. | Updated hardware docs<br>Revised code<br>Change logs |
| **Week 10 (07.04.25 – Consolidated Testing & Freeze)** | Conduct final integrated testing of hardware and dashboard.<br>Freeze major changes.<br>Compile documentation of performance and feedback. | Stable, near-final prototype with clear metrics. | Testing summary<br>Performance data<br>Consolidated documentation |

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| **Week 11 (14.04.25 – Report Preparation)** | Consolidate all project documentation (design, schematics, calibration, iterations, feedback).<br><br>Draft final report with visuals. | First complete draft of the final report. | Draft report<br><br>Compiled project files<br><br>Visual aids |
| **Week 12 (21.04.25 – Report Preparation)** | Draft the final report. | Draft final report and documentation ready. | Revised report |
| **Week 13 (28.04.25 – Submission)** | Revise the final report based on feedback.<br><br>Finalise documentation on hardware builds, sensor calibration, and dashboard features. | Successful submission and demonstration. | Final report<br><br>Demo materials<br><br>Fully functional prototype |

# References:


- BBC (2022) How Singapore is turning multi-storey car parks into farms. BBC News Business [Online]. Available at: https://www.bbc.co.uk/news/business-61919430 [Accessed 29 January 2025]
- CIA (2018) Field Listing – Urbanization. The World Factbook [Online]. Available at: https://www.cia.gov/the-world-factbook/field/urbanization/ [Accessed 29 January 2025]