PEOJECT PLAN PROPOSAL

Smart Modular Indoor Farming Pods for Urban Homes

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1.COVER LETTER

To

Dr. Andrei Guschin
College of Engineering
Northeastern University
Boston, MA-02115

Date: December 5, 2025

Subject: Project Plan for Smart Modular Indoor Farming Pods for Urban Homes

Dear Dr. Guschin

We are pleased to submit our comprehensive project plan for the development of **Smart Modular Indoor Farming Pods** designed specifically for urban residents. Urban living spaces continue to shrink while the demand for fresh, sustainable food grows. In Boston, where snow can blanket the city for up to four months annually, our solution enables year-round indoor cultivation of herbs, leafy greens, and small vegetables.

The Smart Modular Indoor Farming Pods project addresses this critical need by offering compact, scalable farming solutions equipped with advanced sensors to monitor water levels, humidity, and light conditions. Paired with an intuitive companion mobile app that provides real-time guidance, our system makes home-grown produce accessible even to first-time growers in small apartment settings.

This document provides a detailed definition of the work involved, scheduling information, risk analysis, monitoring and control mechanisms, and comprehensive financial planning for all phases of the project. The vertically integrated system is designed with modularity at its core, allowing users to expand from a single pod to multiple pods based on their available space and growing ambitions. With an estimated cost of $4,648 it is expected to be completed in 12 weeks.

The project leverages environmentally friendly technology and user-centred design principles to promote sustainable living, reduce reliance on external produce sources, and provide long-term value to urban communities. Through our phased approach, covering research and planning, design and integration, testing and validation, and final reporting, we will deliver a tangible, user-friendly product that meets all specified success criteria.

We believe this project not only fulfils academic requirements for engineering project management but also addresses a genuine societal need in urban food sustainability. We look forward to your guidance throughout this development process.

Sincerely,

Danyelle Veillard
Ashwini Mahadevaswamy
Shamsheer Hussain
Madison Rogers
Mohit Athipedu

2.EXECUTIVE SUMMARY

Introduction:

Urban living spaces continue to shrink while interest in sustainable, home-grown food steadily rises. The Smart Modular Indoor Farming Pods project aims to address this growing need by providing a compact, scalable indoor farming solution suitable for apartments and small households. Living in regions such as Boston, where snow and harsh winters restrict outdoor gardening for nearly four months a year, highlights the importance of a year-round indoor cultivation system. This project uses modern sensor technology and guides mobile applications to enable residents to grow fresh produce sustainably within limited spaces.

Product:

The Smart Modular Indoor Farming Pod is a self-contained, expandable unit equipped with sensors that monitor water, humidity, and light levels to maintain ideal plant growing conditions. Each pod is designed to support herbs, leafy greens, and small vegetables such as peppers and tomatoes. The system includes adjustable LED grow lights, configurable plant trays, and stackable modular frames that allow users to increase vertical space as plants grow. A companion mobile application provides real time guidance such as watering reminders, nutrient alerts, and harvest suggestions, ensuring accessibility even for first time growers. Together, these features transform the pods into a practical and efficient home farming solution.

Field Evaluation:

The technologies incorporated in the system, such as humidity and light sensors, microcontrollers, and full spectrum LED grow lights, are widely used in commercial indoor farming environments. These components are known for their reliability and consistency, producing optimal conditions for healthy plant growth. The modular design of the pods, along with adjustable lighting and ventilation, supports a variety of plant types and prevents overcrowding as crops mature. Early evaluations suggest that the pods can maintain stable environmental conditions, enabling high quality produce even in settings with no natural sunlight. The integrated app further enhances usability by reducing user errors and improving care routines.

Production:

The development process includes several phases: market research, detailed design, hardware and software integration, and prototype testing. The pods will be assembled using lightweight materials, sensor modules, LED lighting panels, and microcontrollers. The farming compartments are designed to accommodate both soil based and hydroponic configurations. As the system evolves, the design can be expanded to support additional crop types and include more advanced environmental controls. During testing, plant trials will be conducted to validate growth performance, user experience, and overall system efficiency.

3.PROJECT OBJECTIVES

The objective of this project is to develop Smart Modular Indoor Farming Pods that enable urban residents to grow herbs, leafy greens, and small vegetables in a compact, sustainable, and convenient way. The project aims to create a modular system that can be expanded to fit different household spaces and incorporates sensors to monitor water, humidity, and light, ensuring optimal growing conditions. A companion mobile app will guide users with real time tips on watering, nutrients, and harvesting, making it accessible even for first-time growers. The project will progress through defined phases, including initial research and design, system development and integration, and pilot testing in urban households to gather feedback and refine the solution. By delivering a tangible, user-friendly product and tracking measurable outcomes such as adoption rates, usability, and customer satisfaction, the initiative seeks to promote sustainable living, reduce reliance on external produce, and provide long-term value to urban communities.

Project Phases and Duration:

This project will be completed in 12 weeks, including all phases: market research, design, risk analysis, conceptual testing, and final reporting with a post-market release strategy.

This project is dived into different phases. Each phase of this project was listed below with details of each phase.

Phase 1: Research & Planning (Weeks 1–3)
Phase 2: Design & Integration Planning (Weeks 4–6)
Phase 3: Testing & Validation (Weeks 7–9)
Phase 4: Integration, Evaluation, and Finalization (Weeks 10-12)

Critical Success Factors:

1. Should complete a functional prototype within 8 weeks, staying within the budget.
2. To achieve plant growth in the required test environment for at least 2 plant varieties (leafy green and small vegetable).
3. Maintain the app accurately up to a minimum of 95% command execution rate.

4. Get positive feedback of at least 80% from 15-20 beta users in Boston to purchase at that price point, and a minimum of 70% for a successful harvest for first-time growers.
5. Modular design supporting 1 – 5 pod configurations without underperforming.
6. Cost-effective materials and manufacturing for scalability and mass production while maintaining product quality.
7. Also having clear communication and discussion among software and design teams by maintaining a resolution response time of 4 hours for critical issues and 24hours for standard problems.

Assumptions:

1. Assuming that urban residents are willing to grow plants in their apartments or houses, where there is a lack of land availability for growing plants. Users will select plant varieties suitable for small-scale, indoor modular farming (under 14–16 inches in mature height). Plants such as basil, lettuce, or microgreens are compact by nature.
2. The modular design assumes a footprint no larger than 1 sq. ft. per pod, expandable vertically for users with more space.
3. Indoor environments in Boston may receive little to no sunlight during winter; therefore, artificial lighting will serve as the primary light source.
4. Electricity usage will be minimal due to the use of energy-efficient LED lights estimated at under 15W per pod.

4. PROJECT ORGANIZATION

The Smart Indoor Farming Pod project requires a multidisciplinary approach that integrates hardware engineering, software development, agricultural science, quality assurance, and business operations. Recognizing that this project presents complex challenges beyond a single domain, the team has been structured into five specialized functional areas.

Team Structure and Functional Roles

1. **Hardware Development Team:**
   The Hardware Development Team is responsible for the physical design and implementation of the indoor farming pod, including:
   - Enclosure design and structural engineering
   - Sensor selection and integration (moisture, light, humidity)
   - Electronics assembly and circuit design
   - Component mounting and spatial optimization

   Rationale: The physical infrastructure and sensor array form the foundation of the system. However, hardware components alone cannot deliver functional value without corresponding software interpretation, necessitating close coordination with the Software and App Development Team.
2. **Software and App Development Team**
   This team develops the digital interface and data processing systems that enable user interaction with the hardware, including:
   - Mobile application development
   - Sensor data interpretation and visualization
   - Alert and notification systems
   - User interface design

   Rationale: Sensors generate raw electrical signals that require software processing to become actionable information for users. This team translates technical sensor data into user-friendly insights such as watering reminders and environmental condition alerts.

3. **Agriculture and Environmental Systems Team**
   The Agriculture and Environmental Systems Team provides biological and horticultural expertise to ensure viable plant growth, including:
   - Optimal environmental condition specification (temperature, humidity, light spectrum)
   - Plant species selection and growth requirements
   - Growing medium and nutrient management
   - Biological validation and optimization

   Rationale: Technical sophistication alone does not guarantee successful plant cultivation. This team ensures that engineered environmental controls align with actual biological requirements for herbs, greens, and small vegetables. Without this expertise, the project risks creating a technologically advanced system that fails its fundamental purpose of sustaining plant life.

4. **Risk and Quality Management Team**
   This team proactively identifies, assesses, and mitigates project risks while ensuring quality standards, including:
   - Failure mode and effects analysis (FMEA)
   - Component reliability testing
   - Usability testing and user experience validation
   - Quality assurance protocols

   Rationale: IoT systems inherently face multiple failure modes including sensor malfunction, connectivity disruptions, and user interface confusion. Early identification and mitigation of these risks reduces both technical debt and project costs by addressing issues before they reach end users or require extensive rework.
5. **Business and Operations Team**
   The Business and Operations Team manages procurement, logistics, and market validation activities, including:
   - Component sourcing and procurement
   - Pilot testing coordination
   - User feedback collection and analysis
   - Scalability planning and cost analysis

Rationale: Successful transition from prototype to viable product requires operational planning beyond technical development. This team ensures resource availability, validates market assumptions, and establishes pathways for potential commercialization.

Collaboration and Communication Infrastructure:

To facilitate cross-functional coordination and maintain alignment across five specialized teams, the project utilizes the following project management tools:

- **MS Project:** Timeline management, dependency tracking, and critical path analysis
- **Trello:** Day-to-day task management and workflow visualization
- **OneDrive/Google Drive:** Centralized document repository for specifications, designs, and reports

Appendix 1, shows organization Structure tree diagram

5. IMPLEMENTATION PLAN

The project follows a 12-week implementation schedule divided into four phases. The timeline strategically sequences tasks based on technical dependencies while maximizing parallel workstreams where possible to compress overall duration without compromising quality or validation rigor.

Phase-by-Phase Implementation:

Phase 1: Research and Requirements Definition (Weeks 1-3)

Tasks:

- Project setup and planning (Week 1)
- Market research and feasibility analysis (Weeks 1-3)
- Technical requirements specification (Weeks 1-3)

Objectives:

- Validate market demand for indoor farming solutions in urban environments
- Assess technical feasibility of maintaining controlled growing environments in compact enclosures
- Define functional requirements, performance specifications, and budget constraints

Rationale: Empirical evidence from failed IoT product launches demonstrates that insufficient front-end validation leads to technically successful products that fail to meet market needs or exceed viable cost structures. This phase ensures that design and development efforts are grounded in validated user requirements and technical feasibility before significant capital expenditure occurs.

Phase 2: Design and Specification (Weeks 3-6)

Tasks:

- Mechanical and enclosure design (Weeks 3-6)
- Electronics and sensor selection (Weeks 5-8)
- Software and app prototype design (Weeks 6-10)

Strategic Task Sequencing:

The tasks in Phase 2 are deliberately staggered based on technical dependencies:

1. **Mechanical design begins in Week 3** as it requires only size constraints and budget parameters from Phase 1.
2. **Electronics and sensor selection begins in Week 5** because sensor specifications depend on physical space availability and mounting configurations determined during mechanical design. Premature sensor selection risks incompatibility with final enclosure design.
3. **Software development begins in Week 6** to allow hardware team completion of sensor selection in Week 5. Different sensors output data in varying formats and frequencies (e.g., DHT22 sensors report every 2 seconds while alternative

models may report every 10 seconds). Software architecture must align with actual hardware specifications to prevent rework.

Rationale: This sequential dependency management prevents wasted development effort. Starting all tasks simultaneously would require software developers to make assumptions about sensor specifications, necessitating substantial code refactoring when actual hardware selections are finalized. The staggered approach ensures each team builds correctly once rather than rebuilding after specification changes.

Phase 3: Prototyping and Initial Testing (Weeks 7-9)

Tasks:

- Electronics and sensor integration (Weeks 5-8)
- Software and app prototype development (Weeks 6-10)
- Prototype assembly and testing (Weeks 8-11)
- Plant trials and data collection (Weeks 8-11)

Parallel Development Strategy:

Phase 3 employs iterative, parallel development methodology rather than sequential waterfall approach. Multiple workstreams run concurrently:

- Electronics finalization overlaps with software development
- Prototype assembly begins while both electronics and software are in progress
- Plant trials commence immediately upon partial prototype completion

Rationale: Traditional waterfall methodology—completing hardware entirely before beginning software, then conducting integration—extends project timelines unnecessarily and delays problem discovery. Parallel development with continuous integration testing enables early identification of interface issues, communication protocol mismatches, or electromagnetic interference problems. Issues discovered in Week 8 are inexpensive to resolve; identical issues discovered in Week 11 create schedule and budget crises.

Critical Decision: Early Plant Trial Initiation

Plant trials begin in Week 8 despite incomplete prototype finalization. This represents the project's most strategically important scheduling decision.

Biological Constraint Analysis:

- Seed germination: 3-7 days (species dependent)
- Minimum observable growth period: 14-21 days
- Total biological validation time required: 3-4 weeks minimum

Implication: Delaying plant trials until Week 10 or 11 (when technical systems are fully complete) would provide insufficient time for biological validation. The project would conclude with a functioning IoT device displaying sensor readings but zero empirical evidence of actual plant survival or growth.

Strategic Advantage: By initiating plant trials in Week 8 with a partially operational prototype, the project obtains 3-4 weeks of real biological data. This enables:

- Validation of environmental control effectiveness
- Identification of growth issues (yellowing, mold, insufficient growth rate)
- Sensor threshold calibration based on actual plant response
- Evidence-based optimization of humidity, light, and irrigation parameters

This approach distinguishes a theoretical engineering exercise from a validated, functional product. The project prioritizes biological validation over technical completion, acknowledging that perfect sensor readings are meaningless if plants do not thrive.

Phase 4: Integration, Evaluation, and Finalization (Weeks 10-12)

Tasks:

- Evaluation and iteration (Weeks 10-12)
- Final report and presentation (Weeks 11-12)

Parallel Execution Rationale:

Final documentation occurs simultaneously with system optimization rather than sequentially afterward. This enables incorporation of empirical findings from plant trials into final system adjustments and documentation.

Data-Driven Iteration Process:

- Week 10 provides 2+ weeks of plant growth data
- Observations inform final calibration adjustments
- Final report documents evidence-based decisions rather than theoretical projections

Example: If plant trials reveal mold formation at 70% humidity, final system iteration reduces target humidity to 65% and updates app alert thresholds accordingly. The final report documents this evidence-based optimization rather than presenting original untested specifications.

5.1 WORK BREAK DOWN STRUCTURE (WBS):

This helps in breaking down the project into small parts and phases which can be easy and helpful for the Project Manager for monitoring the project and can predict the possibilities based on various circumstances of project phase.

Appendix 2, shows the WBS structure

5.2 RESPONSIBILITY CHART:

This simple matrix will shows the details about who is involved in each phase and task of the project with details about their specific role against each task.

Appendix 3, shows the Responsibility Chart

5.3 SCHEDULING

Project scheduling is prepared by using the Gantt Chart and PERT Analysis.

5.3.1 GANTT CHART

Prepared in Jupyter Notebook using Python code.

Appendix 4, shows the GANTT CHART of the project.

5.3.2 PERT Analysis

Appendix 5, shows the PERT Analysis of the project.

6.RISK ANALYSIS

Effective risk management is essential for project success in today's dynamic development environment. For the Smart Modular Indoor Farming Pods project, risks span hardware failures, software integration challenges, agricultural variability, budget constraints, and timeline pressures. This section presents both qualitative and quantitative risk analyses to prioritize mitigation efforts and ensure project resilience.

The project team recognizes that compared to many industries, engineering development projects are subject to elevated risks due to features such as prototype uncertainty, technology integration complexity, interdisciplinary coordination requirements, aggressive timelines, and constrained budgets. Rather than eliminating all risks (which would be impractical), our approach focuses on:

- Early identification of potential risk events
- Systematic assessment of likelihood and impact
- Proactive mitigation for high-priority risks
- Contingency planning for risks that materialize
- Continuous monitoring and reassessment throughout the project lifecycle

Top 10 Risks:

1. **Sensor supply delays or faulty sensors**: If parts arrive late or maybe if they don't work properly, it could delay the prototype or cause wrong readings.
   Mitigation: Order from at least two suppliers, keep some backup parts, and design the setup so sensors can be easily replaced.
2. **Electronics / Microcontroller Issues:** Wiring errors or incompatible modules could slow down the development.
   Mitigation*:* Use reliable components like Arduino or ESP32 and test everything on a breadboard before final assembly.

3. **Prototype Design Rework / Failures**: Parts might not fit, align properly, or work as intended, which could lead to wasted time in redesigning the prototype and reordering parts, delaying project timelines.
   Mitigation: Create quick 3D print mockups to test fit and alignment, design the prototype with flexibility for adjustments, and allow time for iterative improvements during development.
4. **Plant Growth Performance / Variation**: Plants may not grow as expected due to environmental conditions, nutrient availability, or lighting, giving inconsistent or unreliable results that affect data collection and analysis.
   Mitigation*:* Use multiple plants of each type, plant in batches to reduce variability, carefully record environmental conditions for comparison, and repeat trials when necessary to ensure data reliability.
5. **App Integration & CAD / Software Compatibility Issues**: The mobile or desktop app may not display sensor data correctly, could crash, or fail to communicate with hardware. CAD software or file compatibility issues could slow down mechanical or electronics design and create delays in production.
   Mitigation*:* Build and test a simple version of the app using sample data before connecting it to the actual sensors, ensure CAD files are compatible with the chosen 3D printers and fabrication tools, and validate workflows early in the development cycle.
6. **IoT / Connectivity Issues** - Sensors or pods may fail to transmit data to the app due to Wi-Fi or IoT connectivity issues, causing gaps in monitoring, delayed feedback, or incorrect automation.
   Mitigation*:* Test network reliability under different conditions, implement fallback local data storage, monitor connections continuously, and optimize firmware to handle intermittent connectivity.
7. **User Testing / UX Problems**: The app interface or pod setup may be confusing, leading to errors or frustration among users, which could reduce adoption, satisfaction, or effectiveness of the prototype. ***Mitigation****:* Conduct early and frequent testing with classmates, friends, or target users, gather detailed feedback, and iteratively improve both the physical pod and the app interface based on real-world testing.

8. **Budget Overrun:** Expenses could exceed the planned budget due to unforeseen costs for sensors, electronics, fabrication, or plant materials, which may compromise the project scope or quality.
   ***Mitigation**:* Track all spending carefully, prioritize essential components, establish contingency funds for unexpected costs, and make cost-effective decisions while maintaining project goals.

9. **Data loss or sensor logging issues**: If the system crashes or data isn't saved properly, it could affect analysis.
   ***Mitigation**:* Enable local backups on the device and export data regularly (like CSV files).

10. **Team member unavailability**: Illness or scheduling conflicts might cause delays.
    ***Mitigation**:* Keep shared documentation, cross-train teammates, and leave buffer time in the project schedule.

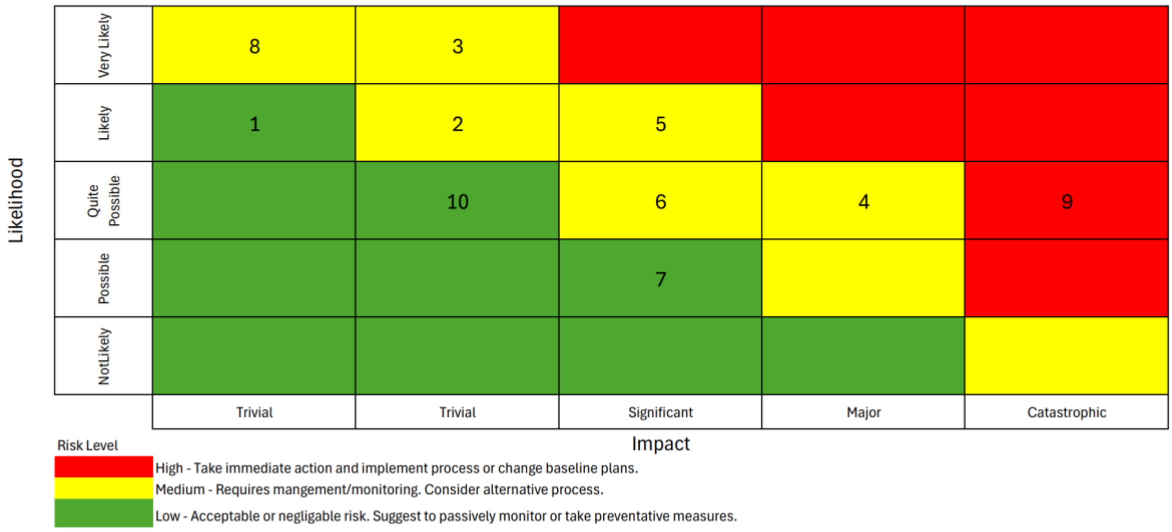
Will conduct the two different types of Risk Analysis to identify the Risks.

1. Qualitative Risk Analysis
2. Quantitative Risk Analysis

6.1 QUALITATIVE RISK ANALYSIS (INCLUDE A RISK MATRIX):

The objective of conducting qualitative risk analysis in our project is to ensure that all project members are prepared and aware of the potential risks that could impact our design, testing, and delivery schedule. This analysis allows the team to evaluate each identified risk based on its likelihood and impact, helping prioritize which ones need the most attention or mitigation planning.

We are using a 5x5 risk matrix to evaluate and visualize the qualitative risk levels for our top ten project risks. This matrix helps the team understand and contextualize the likelihood and consequences of each risk throughout the 12-week project timeline. Each risk was assessed collaboratively based on project scope, available resources, and technical complexity.



6.2 QUANTITATIVE RISK ANALYSIS (FMEA)

FEMA (Failure modes and Effects Analysis) is used generally to quantitatively analyze the project risk by calculating the Risk Priority Number (RPN).

RPN = Severity * Occurrence * Detection

Where.,
Severity (S) = Impact of the risks on the project
Occurrence (O) = likelihood that the risk occurs
Detection (D) = likelihood that the detected risk is detected before causing an impact.

Following table shows the assigned scores and the calculated RPN values for the top risks that are identified in the project.

Risks	Severity	Occurrence	Detection	RPN
Sensor supply delays or faulty sensors	8	6	3	144
Electronics or microcontroller issue	7	5	4	140
Prototype design rework/failures	6	7	5	210
Plant growth performance/variation	7	6	4	168

App integration and CAD/Software compatibility	7	5	5	175
IoT connectivity issues	8	6	4	192
User experience (UX) problems	6	7	3	126
Budget Over-run	8	4	5	160
Data loss or sensor logging issues	7	4	6	168
Team member unavailability	5	5	6	150

The higher RPNs for the risks like prototype redesign/rework (210), Connectivity Issues (192), app integration failure (175) are the critical areas to focus on the mitigation efforts on. This combined analysis provides a comprehensive risk preparedness and informed allocation of resources to reduce the overall project risks.

Main Objective of conducting the Risk Analysis is to identify and access the risks those are associated with the Smart Modular indoor Pods.

7.MONITORING AND CONTROL PLAN

This framework helps in tracking, evaluating and controlling the quality and progress of the Smart Modular Indoor Farming pods project. This plan aims to ensure that the project is delivered on time within the specified budget alongside meeting the performance, quality and user satisfactions as main objectives. Active oversighting will enable the early detection of any deviations and prompt corrective actions, maximizing the success of project.

ROLES AND RESPONSIBILITIES:

1. **PROJECT MANAGER:** Maintains the up-to-date action plans, consolidates the project status reports of project, monitors the milestone and escalates the issues/risks related to project.
2. **HARDWARE LEAD:** Monitors the development and testing of the sensors, home pod designs, and electronic integration in pods.
3. **SOFTWARE LEAD:** Tracks the app development, integration testing and user feedback analysis to update the app interface and features.
4. **QA LEAD:** Ensures adherence to the functional and usability criteria, conducts the testing of products and documents the results of each test.
5. **FINANCE LEAD:** Overseas the budget tracking and cost reporting of the project.

MONITORING TOOLS:

PM Tools: MS Project ad Trello for the task assignment, progress tracking of project at each phase, and Gantt chart visualization.

Documentation Repositories: OneDrive/Google drive/Confluence for the centralized project documentation and data logging.

Spreadsheet based repository documenting the risks/issues and their status along with the mitigation plans for each of them.

ACTIVITIES:

REPORT	**DUE ON**	**RESPONSIBLE**	**DESCRIPTION**
Progress Report 1	Post completing the initial research and planning phase	Project Manager / Hardware manager	Gives overview of the completion of the phase and early findings of the project
Progress Report 2	Post completing prototype design and app development	Software Lead / QA Lead	Provides information on prototype integration and app functionality
Progress Report 3	Post completing the initial testing and risk mitigation	QA Lead / Finance Lead	Gives test results summary, budget updates and risk reviews
Interim Report	During the midpoint of project	Project Manager	Provides comprehensive status update of project along with critical analysis
Progress Report 4	Post completing pilot testing and collecting user feedback	Software Lead / QA Lead	App/Pod performance review and user feedback
Final Report	Project Completion	Project Manager	Final assessment of project with lessons learned

REPORT SCHEDULE (ACCORDING TO WBS)

Progress Report 1 – After completion of Initiation Phase (A1-A4) – Week 2

a. A1: Conduct Feasibility Study
b. A2: Identify Key Stakeholders
c. A3: Develop Project Charter
d. A4: Finalize Project Charter

Progress Report 2 – After completion of Planning Phase (B1-B4) – Week 4

e. B1: Define Project Scope
f. B2: Identify Resources & Team
g. B3: Develop Work Schedule
h. B4: Budget Estimation

Progress Report 3 – After completion of Design Activities (C1-C2) – Week 7

i. C1: Design Indoor Farming Pod
j. C2: Procure Materials and Components

Progress Report 4 – After completion of Assembly & Testing (C3-C4) – Week 9

k. C3: Assemble Pod Prototype
l. C4: Testing of LED Systems

Interim Report – Mid-project Review – Week 6

Progress Report 5 – After completion of Control Phase (D1-D4) – Week 10

m. D1: Project Monitoring & Evaluation
n. D2: Risk Assessment
o. D3: Quality Control Review
p. D4: Performance Reports

Progress Report 6 – After completion of Marketing Activities (E1-E4) – Week 11

q. E1: Develop Marketing Strategy
r. E2: Create Branding & Packaging
s. E3: Conduct Market Research
t. E4: Determine Pricing

Final Report – End of Week 12 – Final prototype demonstration and project closeout

To ensure effective monitoring, a strong control system will be established. The system will be flexible, cost-effective, and designed to meet the real operational needs of the project. The following documentation will be required for effective

PERFORMANCE CONTROL:

1. Maintenance logs for pods and sensor systems
2. Quality control checklists (environmental control, structural stability)
3. Test results of automation, irrigation, and energy systems
4. Engineering Change Orders related to pod structure, IoT systems.

PERFORMANCE MEASUREMENT:

KPIs:

1. SCHEDULE ADHERENCE: Adherence to the completion of each phase within a (+/-) 5% tolerance to the timeline.
2. PROTOTYPE FUNCTIONALITY:
    a. Sensor data accuracy > 95%
3. App command success rate > 95%
4. Plant Growth Success: More than 4-5 plants should sustain in the pod design during the pilot testing of pods.
5. User Satisfaction: >80% of positive feedback from users/customers post launching the pilot pod to the participants/customers.
6. Budget Compliance: Maintain the expenses within (+/-) 10% of the allocated budget for each phase/project.
7. Risk Responsive Effectiveness: Resolving/mitigating the risks identified within the designated timelines.

Earned Value Management:

Critical ratio is used to quantify the performance for comparing the actual progress against the planned values.

Critical Ratio (CR) = [(Actual Budget)/ (Budgeted Progress)] *[(Budgeted cost of work)/ (Actual Cost of work)] NOTE:

CR > 1, indicates over performance
CR<1, indicated the under performance
Tolerance threshold for CR deviation is (+/-) 5%

8.FINANCIAL PLAN AND RESOURCE ALLOCATION

FINANCIAL PLAN:

The following plan outlines the estimated expenses for the Smart Modular Indoor Farming Pods Project. The financial estimates are based on the resources required for the 12-week development cycle, including hardware, sensors, software tools, prototype fabrication, and personnel time.

Assumptions:

1. No overhead costs such as rent, utilities, or administrative fees are included.
2. Personnel expenses are represented as estimated labor value for engineering and design work, not full-time salaries.
3. Lab access, 3D printing tools, and basic fabrication equipment are assumed to be provided by the institution.
4. Personnel are compensated monthly.
5. Hardware costs reflect prototype-level quantities, not bulk manufacturing.

Budgeting Method:

The total budget ceiling for the project was determined first, which was originally estimated to be $185–$455 for hardware, sensors, and software tools. After this determination, the funding was allocated across project phases and functional departments.

This method is beneficial given the project's short duration and the need for rapid procurement and coordination amongst teams. This approach helps ensure resources remain aligned with the project's critical success factors, facilitates rapid decision-making, minimizes planning time, and supports efficient task allocation.

Table 1: Materials and Cost

Task/Material	*Estimated Cost, USD*
Microcontroller board [Arduino/ESP32]	$30
Humidity, temperature, and water sensors	$40
LED grow light strips	$45
Pod structural materials [acrylic, PVC, modular joints]	$60
Wiring, power adapters, fasteners	$25
Prototype fabrication supplies	$30
App mockup software [Adobe]	$20
CAD design tool access	$15
Project management platform [Trello premium, MS project]	$20
Contingency [10-15%]	$25
Total Cost	**$310**

Table 2: Estimated Personnel Cost

Role	*Approx. Hours*	*Rate per Hour*	*Total Estimated Cost*
Lead Hardware Engineer / Electrical Engineer	25	$20	$500
Electrical Engineer	20	$18	$360
Mechanical Engineer	20	$18	$360
Systems Integration Engineer	15	$20	$300
Prototype Manufacturing Engineer	15	$18	$270
Software Engineer	25	$20	$500
App Developer	20	$20	$400
Data Analyst	10	$18	$180
Agricultural Specialist	15	$18	$270
Environmental Engineer	10	$18	$180
UX/UI Researcher	10	$18	$180
Quality Engineer	10	$18	$180
Risk Analyst	10	$18	$180
Procurement Specialist	8	$18	$144
Pilot Test Coordinator	8	$18	$144
Field Technician	10	$18	$180
Operations Manager	8	$20	$160
Total Estimated Personnel Effort Cost			**$4,338**

TOTAL ESTIMATED PROJECT COST:
Material and Tools: $310
Personnel Effort Value: ~$4,338
Overall Total Estimated Cost: ~$4,648

Estimated Budget Summary:

Based on our earlier HWs and updated vendor checks, the expected budget for building functional prototypes and completing app mockups ranges from:

$260 – $520

This represents the direct material and incremental costs for prototype development. The personnel costs listed in Table 2 reflect estimated labor value rather than cash outlay, as team members are contributing time as part of academic project requirements.

Financial Risk Evaluation:

High-risk areas:

- Prototype redesign costs due to misalignment
- Sensor or module replacement due to failure
- Additional lighting costs if early growth trials underperform

Mitigation:

- Allocate the highest contingency buffer to hardware
- Run early small-scale tests to confirm environmental stability
- Avoid non-essential custom components during early weeks

This includes hardware, materials, app prototyping, plant trial consumables, and all final report/presentation materials.

Cost-Benefit Analysis:
This project is a prototype development effort, not full commercial manufacturing, so the cost-benefit analysis focuses on conceptual market feasibility.
Assumptions for Economic Evaluation:

- Estimated retail price per pod (P): $120–$150.
- Per-unit manufacturing cost (VC): $35–$45.
- Estimated early-adopter interest in the Boston urban market: moderate (n=15-20 beta users).

Break-Even Analysis:
The break-even quantity is calculated using the formula:

Break-even quantity = FC / (P - VC)

Where:
- FC = fixed development cost (project cost) = $4,648
- P = retail price (used for calculation) = $135
- VC = manufacturing cost (used for calculation) = $40
- P - VC = Margin = $95

The break-even units calculation is: **$4,648 / $95 = 49 pods**

2. Prototype ROI:
The Return on Investment (ROI) formula is:
ROI = (Net profit After Break-even / Initial Investment) × 100
- Revenue (at break-even): 49 × $135 = **$6,615**
- Manufacturing Cost (at break-even): 49 × $40 = **$1,960**
- Net profit After Break-even: $6,615 - $1,960 - $4,648 = **$7**
- Initial Investment: $4,648

ROI = ($7 / $4,648) × 100 ≈ 0.15%

With a retail price of $135 per pod and a manufacturing cost of $40, the project reaches break-even at 49 pods. At this point, the net profit is only $7, resulting in an ROI of approximately 0.15%, which means the initial investment of $4,648 is fully recovered. Sales beyond 49 pods will generate positive returns. While the project is primarily a 12-week development and research effort, this analysis demonstrates that the project is cost-effective and manageable within the allocated budget.

RESOURCE ALLOCATION:

Structured the team into five key leadership roles to ensure efficient project execution. Project Manager oversees milestone tracking and risk escalation. The Hardware Lead will manages all sensor development and pod design integration. Software Lead will focuses on app development and feature enhancements. QA Lead will ensures a rigorous testing and usability validation across the project phases. Finance Lead will maintains budget compliance throughout the project lifecycle.

9.CONCLUSION

Up to 75% of new gardeners experience issues that lead to the death of their plants in their first year. Overwatering or underwatering, light access, and moisture levels are all prime culprits of this. Despite the early loss of one's plant, over 70% of beginners improve and continue buying plants. And to note, homeowners save up to $600 annually by producing their own produce at home.

The Smart Modular Indoor Farming Pods project has been developed and mapped to enable a significant shift in the cultivation of one's garden. Concerns and reiterations of the pods may develop. Nonetheless, the project plan has been meticulously planned out and reviewed. Risk Analysis and monitoring tools were also defined to avoid these obstacles arising for the company.

Essential points to be followed throughout the course of the project are communication between team members, among all departments, and paying close attention to the pace and funds being used on this project.

The Smart Modular Indoor Farming Pods have the potential to considerably aid in the reduction of produce costs for homeowners, as keeping their plants alive has never been easier.

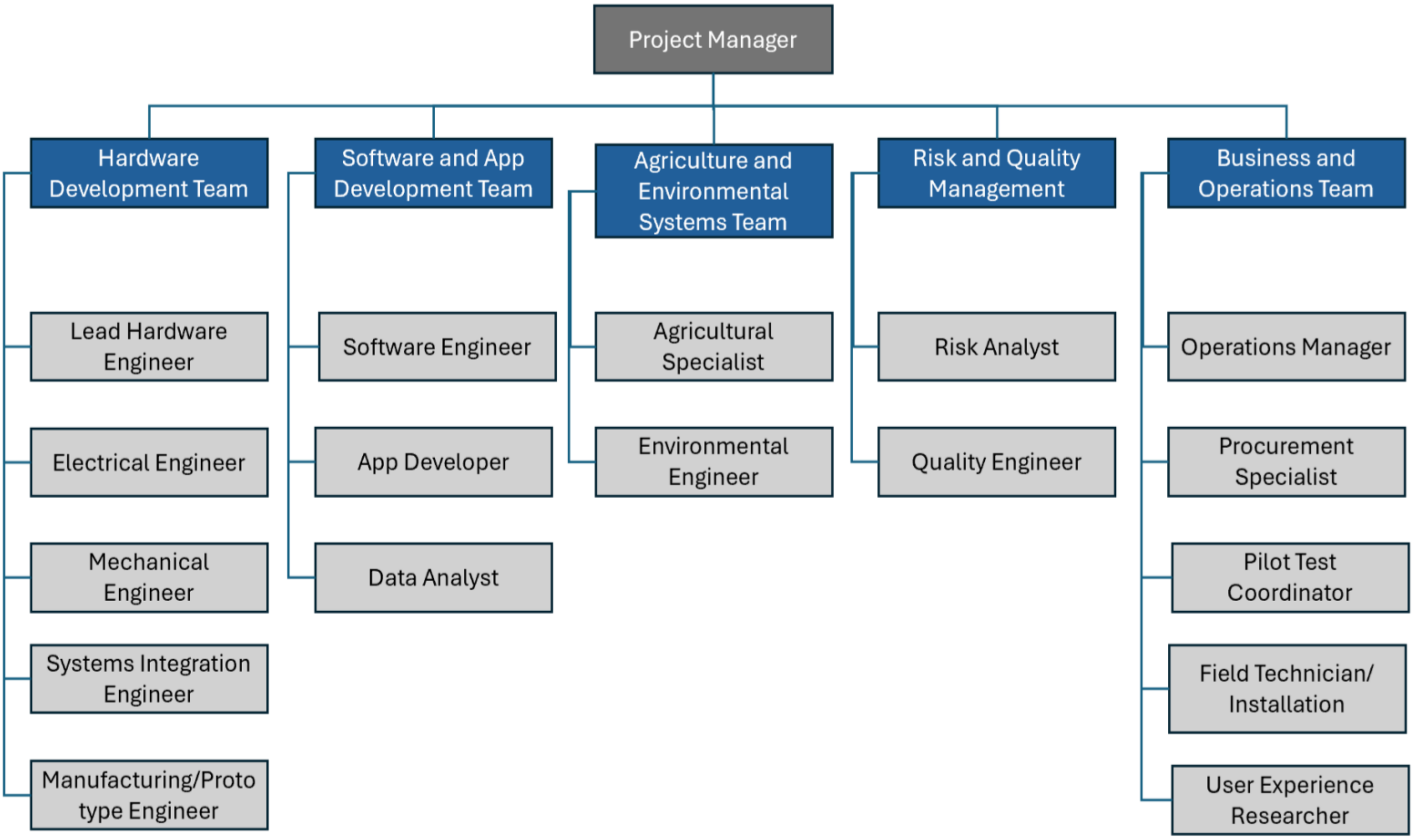
Sources:

https://terrariumtribe.com/houseplant-statistics/

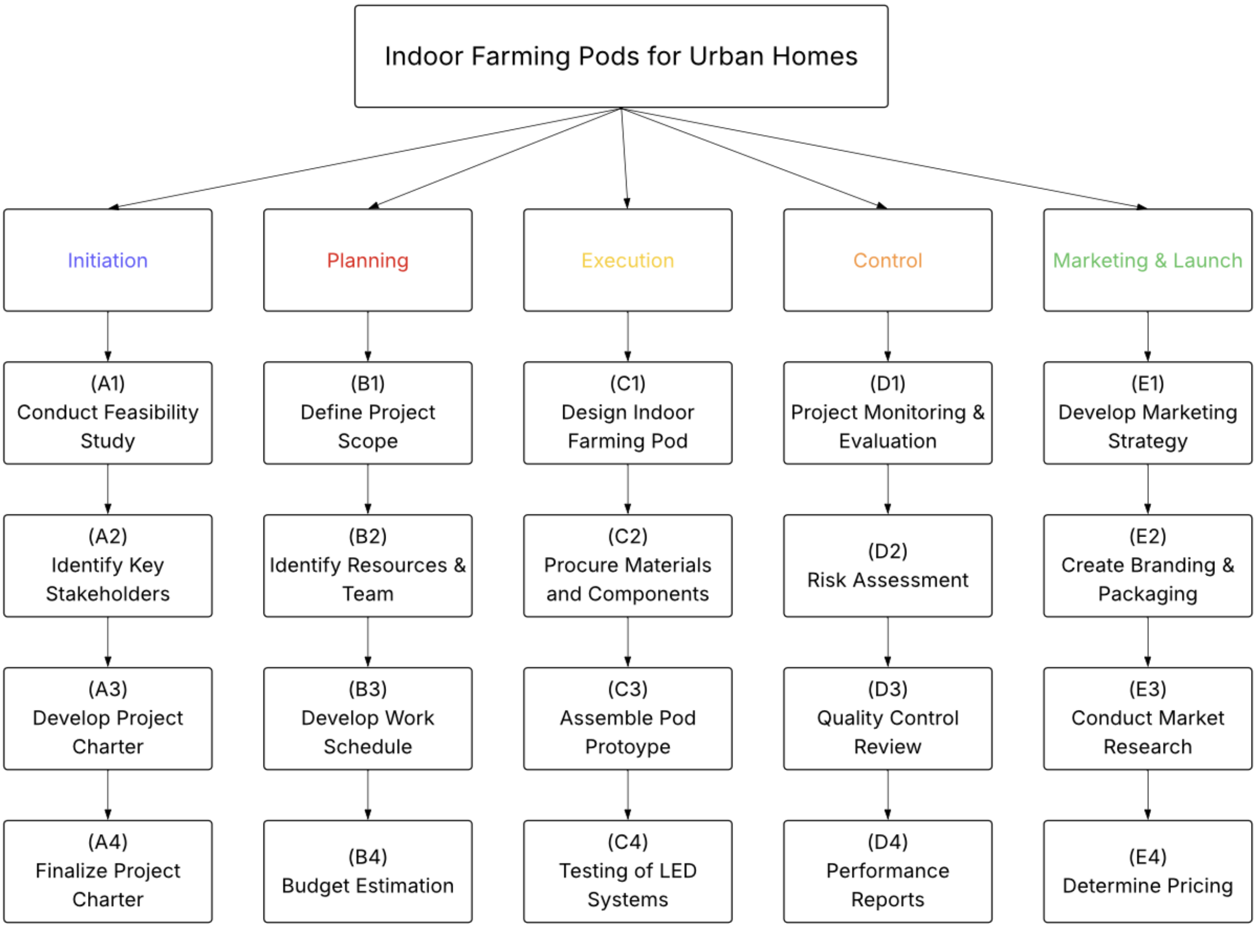
https://todayshomeowner.com/lawn-garden/guides/top-gardening-statistics/

APPENDIX

APPENDIX-1: *(Organization Structure)*



APPENDIX-2: *(WBS Structure)*



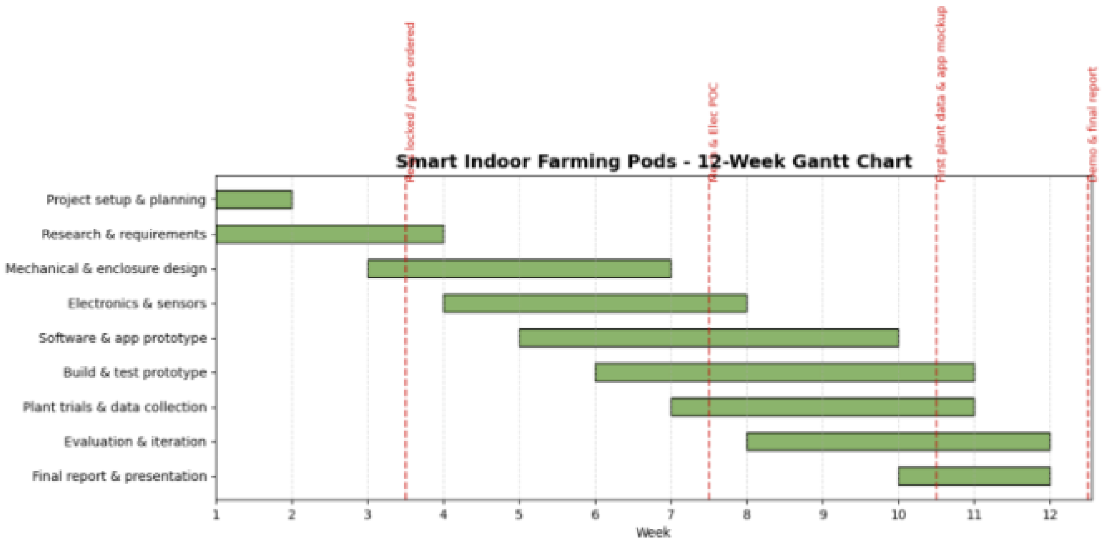
APPENDIX-3: *(Responsibility Chart)*

Responsibility Chart:

Subproject	Task	Proj. Mgr.	HardW. Dev Team	Software Dev. Team	Agri. & Envio. Team	Risk & Quality Mgr.	Buisness and Operations Team
Initiation	A1	$	^	^	^	!	^
	A2	*					$
	A3	*	^	^	^	^	$
	A4	*	^	^	^	^	$
Planning	B1	$	!	!	!	!	!
	B2	$	!	!	!	!	^
	B3	$	!	!	!	!	!
	B4	$	!	!	!	!	^
Execution	C1	!	$	$	$	^	
	C2	*	$	$	$	^	
	C3	!	$	$	$	^	
	C4	!	^	^	^	$	
Control	D1	$	*	*	*	*	*
	D2	^	!	!	!	$	
	D3	!	^	^	^	$	
	D4	*	$	$	$	$	
Marketing & Launch	E1	*	!	!	!	!	$
	E2	*	!	!	!	!	$
	E3	!					$
	E4	*	!	!	!	!	$
Legend:	$: Responsible; *: Report & Approve; ^: Support; !: Notify						

APPENDIX-4: *(GANTT Chart)*

Task / Week	1	2	3	4	5	6	7	8	9	10	11	12
Project setup & planning	X											
Research & requirements	X	X	X									
Mechanical & enclosure design			X	X	X	X						
Electronics & sensors				X	X	X	X					
Software & app prototype					X	X	X	X	X			
Build & test prototype							X	X	X	X	X	
Plant trials & data collection								X	X	X	X	
Evaluation & iteration									X	X	X	X
Final report & presentation										X	X	X



APPENDIX-5: *(PERT Analysis)*