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# Smart Seed Germination Prediction Box

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**ABSTRACT:** The Smart Seed Germination Prediction Box is a compact system designed to evaluate seed viability at an early stage, focusing on tomato and chilli seeds. It creates a controlled environment where seeds are placed on a moist medium to initiate germination. The system uses temperature, humidity, and soil moisture sensors to continuously monitor environmental conditions. During germination, viable seeds produce slight increases in temperature and humidity due to metabolic activity. These variations are detected and processed by a microcontroller to predict seed viability based on threshold values. The system is portable, cost-effective, and powered by a rechargeable battery, making it suitable for farmers. It reduces seed wastage, improves germination accuracy, and supports efficient agricultural practices.

**KEYWORDS:** Seed Viability, Germination, Sensors, Microcontroller, Agriculture.

## I. INTRODUCTION

Vegetable seed quality plays a vital role in determining crop yield and overall agricultural productivity. Among commonly cultivated vegetable crops, tomato (Solanum lycopersicum) and chilli (Capsicum annuum) are highly sensitive to germination conditions such as temperature, humidity, and soil moisture. Tomato seeds typically require a temperature range of 20–30°C, while chilli seeds prefer slightly higher temperatures of 25–35°C for effective germination. Any variation in these environmental factors can significantly affect germination rate and seed viability.

Traditional methods of testing seed germination are time-consuming, labor-intensive, and often require laboratory setups, making them less accessible to farmers. To overcome these limitations, the Smart Seed Germination Prediction Box is developed as an efficient and low-cost solution. The system creates a controlled micro-environment where seeds are placed on a moist medium, and environmental parameters are continuously monitored using sensors.

During germination, viable seeds undergo metabolic activity and respiration, leading to slight changes in temperature and humidity. These variations are analyzed using a microcontroller to predict seed viability. This approach enables early detection of viable seeds, reduces wastage, and supports precision agriculture practices.

## II. LITERATURE REVIEW

1. Infrared-Based Seed Vigor Analysis (2020)
A study introduced infrared thermography to evaluate seed vigor by detecting temperature variations during germination. It showed that viable seeds produce measurable heat patterns due to metabolic activity, enabling non-invasive seed quality assessment.

2. Machine Learning-Based Germination Prediction (2020)
Research proposed a machine learning approach using image analysis to automatically detect germinated seeds. The system achieved high accuracy (above 90%) and reduced manual effort in seed evaluation, proving automation is effective for large-scale germination studies.

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3. Temperature and Water Requirement Study (2020)
A study analyzed how temperature and water potential influence seed germination. It concluded that optimal temperature and moisture conditions significantly improve germination rate, while extreme conditions reduce seed viability.

4. Environmental Factors on Germination (2019)
Research highlighted that temperature, light, and moisture are key factors controlling seed germination. Proper environmental control improves germination percentage and seed growth performance.

5. Mathematical Modeling of Germination (2019)
A study used mathematical models to predict seed germination based on environmental conditions. Results showed that combining temperature and moisture data helps accurately estimate germination behavior and seed performance.

## III. STEP-BY-STEP ALGORITHM

Step 1: Start System
Power ON the system.

Step 2: Initialize Sensors
Activate microcontroller and sensors.

Step 3: Place Seeds
Keep seeds on moist medium in box.

Step 4: Record Baseline
Store initial temperature and humidity.

Step 5: Collect Data
Read sensor values periodically.

Step 6: Process Data
Send data to microcontroller.

Step 7: Calculate Variation
Find change from baseline values.

Step 8: Compare Threshold
Check values with set limits.

Step 9: Decide Viability
Viable / Non-viable classification.

Step 10: Display Output
Show result on LCD.

Step 11: Repeat (Optional)
Continue monitoring if needed.

Step 12: Stop System

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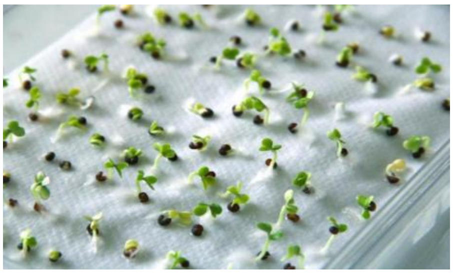
## IV. MATERIALS

1. Temperature & Humidity Sensor (DHT11)


Working:
Measures temperature and humidity inside the box
Detects slight environmental changes during germination
Helps identify viable seeds

2. Moisture Medium (Tissue Paper Method)



Working:
Tissue paper holds moisture for seeds
Seeds absorb water (imbibition process)
Simple and low-cost alternative to soil

3. Microcontroller (Arduino UNO)


Working:
Acts as system brain
Collects and processes sensor data
Controls output display

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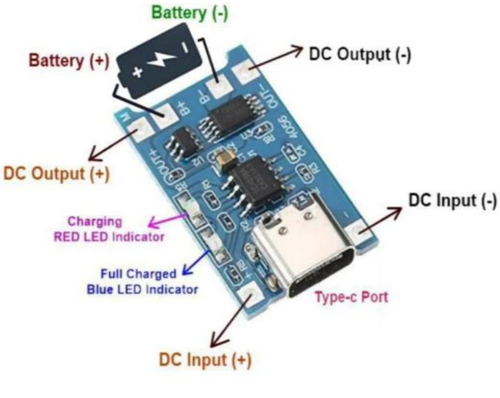
4. LCD Display (16x2)


Working:
Displays temperature and humidity values
Shows seed result (Viable / Non-viable)

5. Rechargeable Battery (Li-ion 18650)

Working:
Supplies power to system
Portable usage possible
Provides 4–6 hours backup

6. Charging Module (TP4056)



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Working:
Charges battery safely
Prevents overcharging
Easy USB charging

7. Connecting Wires & Breadboard

Working:
Connects all components
Helps easy circuit setup
Ensures signal transmission

## V .COST ESTIMATION

| S.No | Component | Quantity | Cost (₹) | Total (₹) |
|---|---|---|---|---|
| 1 | Arduino UNO / ESP32 1 | 800 | 800 | |
| 2 | DHT22 Sensor (Advanced) | 1 | 400 | 400 |
| 3 | 16x2 LCD / OLED Display | 1 | 300 | 300 |
| 4 | Li-ion Battery (High Capacity) | 1 | 300 | 300 |
| 5 | TP4056 Charging Module | 1 | 100 | 100 |
| 6 | Breadboard + Jumper Wires | 1 set | 200 | 200 |
| 7 | Smart Box (Acrylic / Glass) | 1 | 500 | 500 |
| 8 | LED Indicators & Buzzer | 1 set | 150 | 150 |
| 9 | Cooling Fan / Ventilation 1 | 200 | 200 | |
| 10 | Tissue + Setup Materials | 1 | 100 | 100 |

Total Maximum Cost = ₹3050

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## VI. BLOCK DIAGRAM

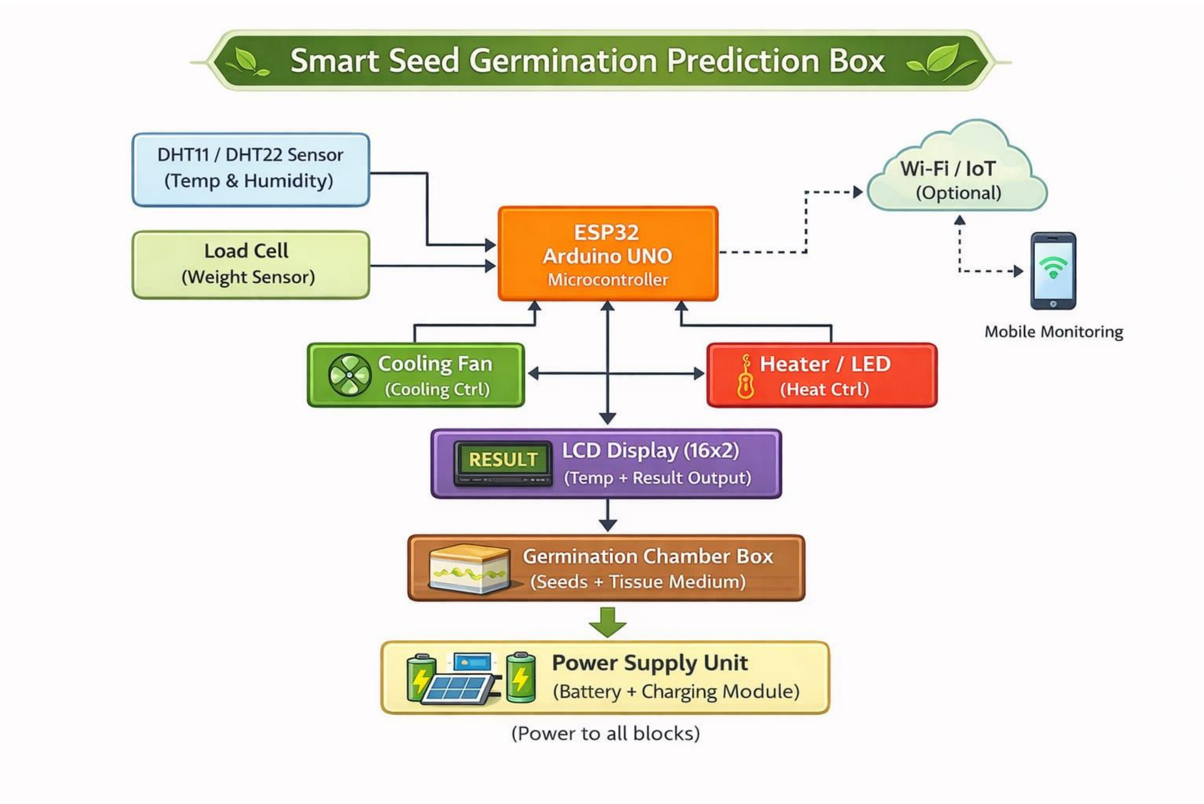


Fig.1 Block diagram of smart seed germination prediction box.

## VII.WORKING

The Smart Seed Germination Prediction Box operates by creating a controlled environment for seeds such as tomato and chilli. Seeds are placed on moist tissue paper inside a closed chamber, which helps initiate the imbibition process. The DHT11/DHT22 sensor continuously monitors temperature and humidity levels inside the box, which are key factors influencing germination.

During germination, viable seeds undergo metabolic activity and respiration, producing slight increases in temperature and humidity. These variations are sensed and transmitted to the microcontroller (Arduino/ESP32). The controller processes the data and compares it with predefined threshold values to determine whether the seed is viable or non-viable.

Based on the analysis, the system activates control components like a cooling fan or heater to maintain optimal conditions. The final result is displayed on the LCD screen, indicating germination status. The system ensures efficient, real-time monitoring and improves accuracy while reducing manual effort in seed testing.

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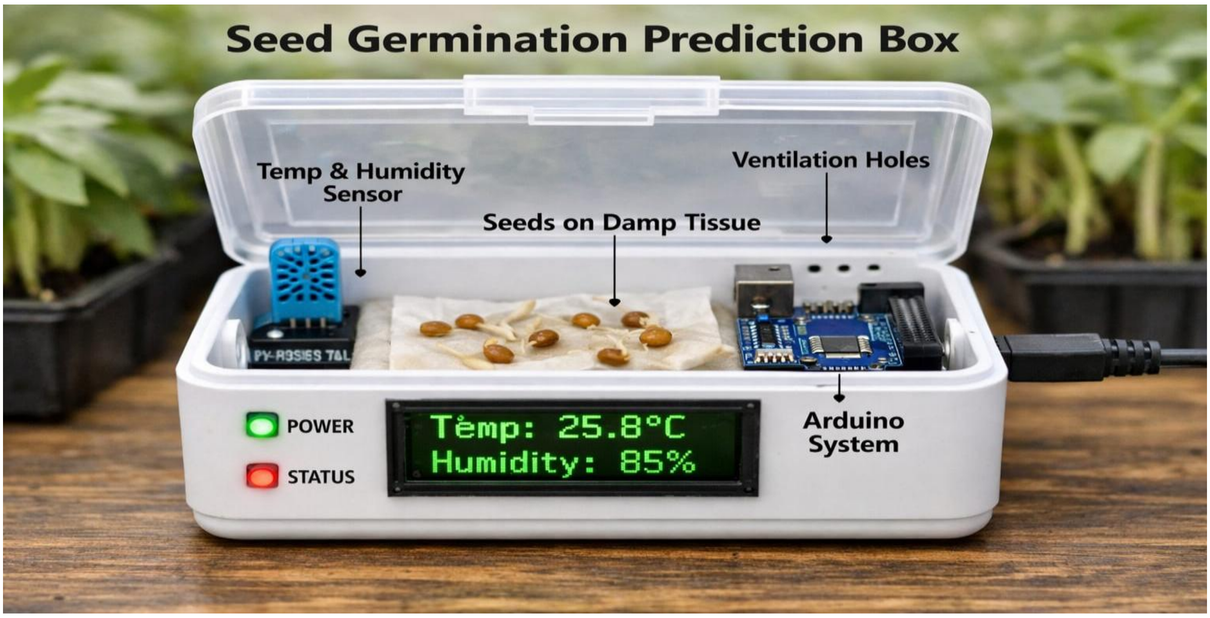
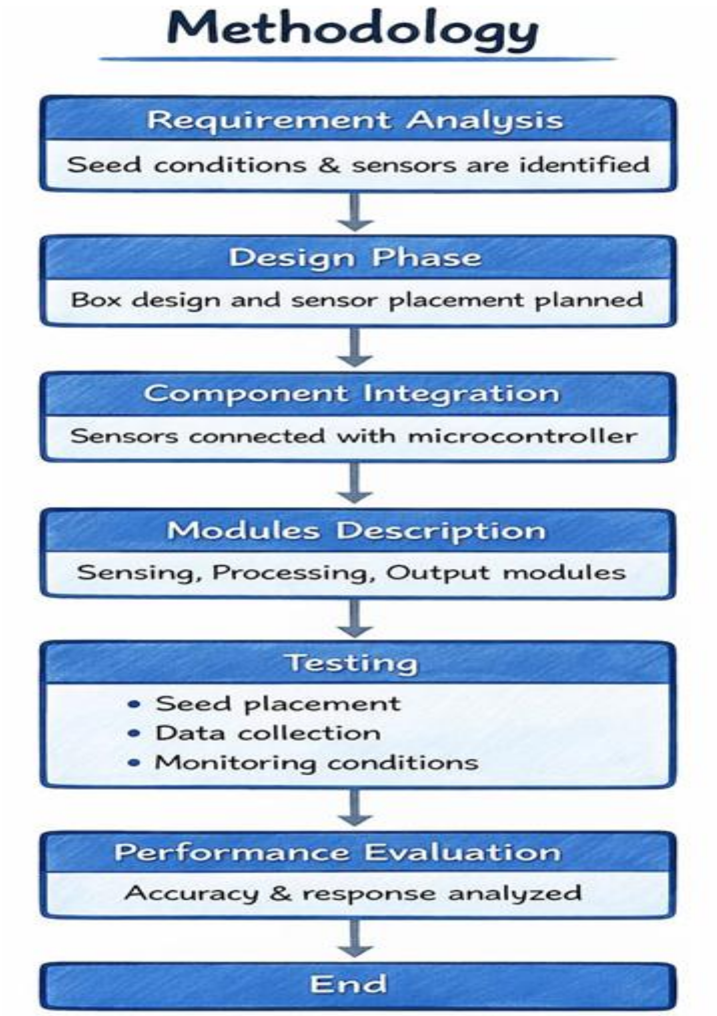
## VIII. METHODOLOGY



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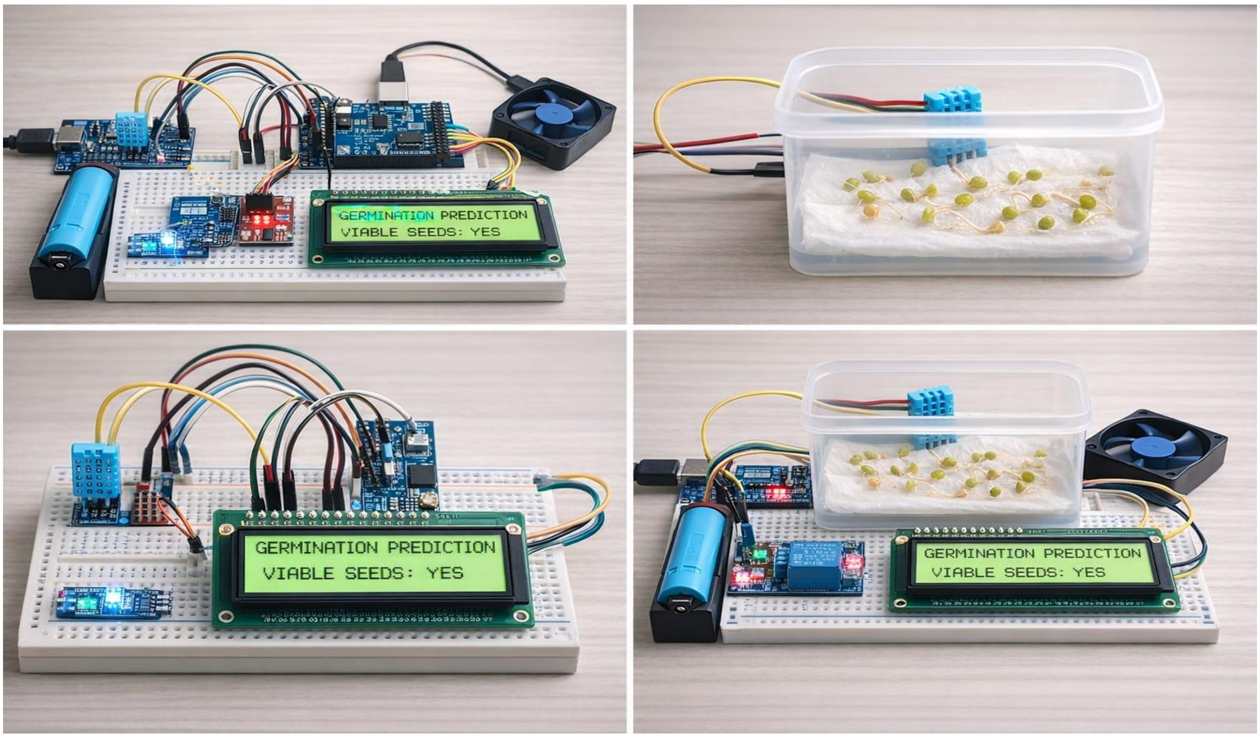
## IX. CIRCUIT DIAGRAM




## X. RESULTS AND DISCUSSION

The developed Smart Seed Germination Prediction Box successfully monitored temperature and humidity variations during seed germination. Tomato and chilli seeds showed noticeable changes in environmental parameters due to metabolic activity, confirming viability. The system accurately detected these variations using the DHT sensor and processed the data through the microcontroller. The results indicated that viable seeds produced a slight temperature rise and stable humidity levels compared to non-viable seeds. The integration of control components maintained optimal conditions, improving germination efficiency. Overall, the system provided reliable, real-time analysis with reduced manual effort, demonstrating its effectiveness as a low-cost and efficient seed testing solution.

## XI. ADVANTAGES

The Smart Seed Germination Prediction Box offers a cost-effective and efficient method for evaluating seed viability. It enables real-time monitoring of temperature and humidity using sensors, significantly reducing manual observation and errors. The controlled environment improves germination accuracy and consistency, especially for seeds like tomato and chilli. Its compact and portable design, along with a rechargeable battery, allows easy usage in both laboratory and field conditions. The use of tissue paper instead of soil simplifies maintenance and ensures clear observation. Additionally, the system provides quick results, helping farmers and researchers make timely decisions, ultimately improving agricultural productivity and seed quality assessment.

## XII. CONCLUSION

The Smart Seed Germination Prediction Box successfully demonstrates an efficient and low-cost approach for evaluating seed viability. By integrating temperature and humidity sensors with a microcontroller, the system accurately monitors environmental changes during germination. The use of tissue paper as a moisture medium simplifies the setup while ensuring effective results. The system reduces manual effort and provides real-time analysis, improving reliability and decision-making. It is suitable for both laboratory and field applications. Overall, the project proves to be a practical and innovative solution for enhancing seed quality assessment and supporting modern agricultural practices.

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