

A PROJECT REPORT ON

Smart Irrigation System using IoT

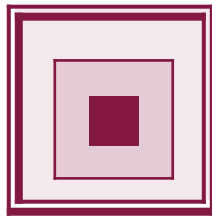
Soil-moisture driven watering for small farms

Submitted in partial fulfilment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

in

Electronics & Communication



SUBMITTED BY

Ishita Menon (21CS027)
Aarav Sharma (21CS001)
Diya Patel (21CS014)

UNDER THE GUIDANCE OF

Prof. N. Chawla

Department of Electronics & Communication

GREENVALLEY UNIVERSITY, DEHRADUN

Session 2025–26

CERTIFICATE

This is to certify that the project report entitled “Smart Irrigation System using IoT” is a bonafide record of the work carried out by Ishita Menon (21CS027), Aarav Sharma (21CS001), Diya Patel (21CS014) in partial fulfilment of the requirements for the award of the degree of Bachelor of Technology in Electronics & Communication during the academic year 2025–26.

The work presented in this report has not been submitted elsewhere for the award of any other degree or diploma.

Prof. N. Chawla
Project Guide

Dr. L. Thomas
Head of Department

External Examiner
Date: _____

Declaration

We hereby declare that the project report entitled “Smart Irrigation System using IoT” submitted to the Department of Electronics & Communication, Greenvalley University, is a record of original work done by us under the guidance of Prof. N. Chawla. The results embodied in this report have not been submitted to any other university or institute for the award of any degree.

Place: _____ Date: _____

Ishita Menon · Aarav Sharma · Diya Patel

Acknowledgement

We express our sincere gratitude to our project guide, Prof. N. Chawla, for constant guidance, encouragement and valuable feedback at every stage of this project.

We thank Dr. L. Thomas, Head of the Department of Electronics & Communication, and all faculty members for providing the laboratory facilities and support needed to complete this work.

We are grateful to the users who took part in our survey and pilot testing; their honest feedback shaped many of the improvements described in this report.

Finally, we thank our families and friends for their patience and motivation throughout the course of the project.

Abstract

Up to half of irrigation water on small farms is lost to over-watering. Smart Irrigation System using IoT addresses this gap. Manual watering wastes water, power and labour. Low-cost sensors and microcontrollers make automation affordable. The system is organised into 4 stages — sense, process, act, notify — and is built with ESP32, Sensors, Firebase. In our test setup it achieved 35% less water than the manual baseline. This report presents the problem, a review of existing approaches, the requirements, the design and implementation, the testing carried out and the results obtained.

Keywords: ESP32, Sensors, Firebase, Flutter

Table of Contents

Introduction.....	9
1.1 Background.....	9
1.2 Motivation.....	9
1.3 Problem Statement.....	9
1.4 Objectives.....	9
1.5 Scope of the Project.....	9
1.6 Organisation of the Report.....	10
Literature Review.....	11
2.1 Existing Work.....	11
2.2 Research Gap.....	11
Requirement Analysis.....	13
3.1 Requirement Gathering.....	13
3.2 Functional Requirements.....	13
3.3 Non-functional Requirements.....	13
3.4 Hardware and Software Requirements.....	14
3.5 Feasibility Study.....	14
3.6 Use Cases.....	15
System Design.....	16
4.1 Proposed System.....	16
4.2 System Architecture.....	16
4.3 Technology Stack.....	16
4.4 Data Flow.....	17
4.5 Data Design.....	17
4.6 User Interface Design.....	18
Implementation.....	20
5.1 Methodology.....	20
5.2 Project Timeline.....	20
5.3 Module Description.....	20
5.4 Key Code Listings.....	21

5.5 Challenges Faced.....	22
Testing and Results.....	23
6.1 Testing Strategy.....	23
6.2 Test Cases.....	23
6.3 Results.....	23
6.4 Outcomes Against Objectives.....	24
Results and Discussion.....	25
7.1 Observations by Period.....	25
7.2 Comparison with the Existing System.....	25
7.3 Discussion.....	25
7.4 Limitations.....	26
Project Management.....	27
8.1 Team Roles.....	27
8.2 Schedule (Gantt Chart).....	27
8.3 Risk Register.....	27
8.4 Budget Summary (sample).....	28
Deployment, Maintenance and Impact.....	29
9.1 Deployment Plan.....	29
9.2 Maintenance Schedule.....	29
9.3 Social, Ethical and Environmental Impact.....	29
Conclusion and Future Scope.....	30
10.1 Conclusion.....	30
10.2 Future Scope.....	30
References.....	31
Appendix A: User Manual.....	32
Appendix B: Project Diary.....	34
Appendix C: Glossary.....	35
Appendix D: Detailed Test Logs.....	36

List of Tables

Table	Title
2.1	Summary of existing work
2.2	Existing versus proposed system
3.1	Functional requirements
3.2	Non-functional requirements
3.3	Hardware and software requirements
3.4	Estimated project cost (sample)
4.1	Technology stack
4.2	Data dictionary
5.1	Project timeline
6.1	Test cases
6.2	Results from the test setup (sample data)

Introduction

1.1 Background

Smart Irrigation System using IoT addresses a practical problem that affects students, institutions and small organisations alike. Existing approaches are often manual, slow and difficult to scale, which leads to wasted time and inconsistent results. Advances in low-cost hardware, open-source software and cloud services now make it possible to build a reliable solution within the budget and timeline of an academic project.

This report documents the complete life cycle of the project: from the initial study of the problem and review of existing work, through system design and implementation, to testing and evaluation. Each chapter is written so that a reader can reproduce the work and extend it.

1.2 Motivation

The motivation for this project came from direct observation. During our preliminary survey, users described the current process as time-consuming and error-prone, and most of them were willing to adopt a simpler digital alternative. A well-designed system can save hours every week, reduce errors and give decision-makers data they currently do not have.

1.3 Problem Statement

Up to half of irrigation water on small farms is lost to over-watering. The key problems identified during our preliminary study are:

- Over-watering — Fields are watered on a fixed schedule, not on actual soil need.
- No visibility — Farmers cannot see soil conditions without visiting the field.
- High cost — Commercial drip automation is too expensive for small plots.

1.4 Objectives

The project was planned around the following objectives:

1. Measure soil moisture, temperature and humidity in real time
2. Switch the pump automatically using threshold logic
3. Show live readings and alerts on a mobile dashboard
4. Keep the total hardware cost under ₹2,500 per unit

1.5 Scope of the Project

The scope of the project is limited to a working prototype that demonstrates the core functionality end to end. Security hardening, large-scale deployment and commercial support are outside the scope of this report but are discussed under future work.

1.6 Organisation of the Report

- Chapter 2 reviews existing work and identifies the research gap.
- Chapter 3 analyses the requirements and the feasibility of the project.
- Chapter 4 describes the system design, architecture and data design.
- Chapter 5 explains the implementation of each module.
- Chapter 6 presents the testing strategy, test cases and results.
- Chapter 7 discusses the results and limitations.
- Chapter 8 covers project management: roles, schedule, risks and budget.
- Chapter 9 describes deployment, maintenance and impact.
- Chapter 10 concludes the report and outlines future work.

Literature Review

2.1 Existing Work

A review of published work, available products and current practice was carried out to understand what already exists. Table 2.1 summarises representative approaches.

Study / system	Approach	Limitation
Kumar et al.	GSM-based pump control	No sensor feedback
Rao & Singh	Timer-based drip system	Ignores weather and soil
Fernandes	Cloud dashboard prototype	Needs constant Wi-Fi

Table 2.1: Summary of existing work

2.1.1 Kumar et al.

Kumar et al. follows an approach based on GSM-based pump control. This works well in controlled conditions and shows that the core idea is practical. However, the approach is limited because it is no sensor feedback. For our users this limitation matters, which is why the proposed system treats it as a design requirement rather than an afterthought.

2.1.2 Rao & Singh

Rao & Singh follows an approach based on timer-based drip system. This works well in controlled conditions and shows that the core idea is practical. However, the approach is limited because it ignores weather and soil. For our users this limitation matters, which is why the proposed system treats it as a design requirement rather than an afterthought.

2.1.3 Fernandes

Fernandes follows an approach based on cloud dashboard prototype. This works well in controlled conditions and shows that the core idea is practical. However, the approach is limited because it needs constant Wi-Fi. For our users this limitation matters, which is why the proposed system treats it as a design requirement rather than an afterthought.

2.2 Research Gap

Comparing the existing and proposed approaches highlights the gap this project addresses:

Existing system	Proposed system
Fixed timers or manual switching	Sensor-based automatic switching
No data on soil condition	Live dashboard with alerts
Water and power wasted	Lower water and power use

*Table 2.2: Existing versus proposed system***Gap addressed**

No low-cost option combines sensor-based automatic switching with live dashboard with alerts. Smart Irrigation System using IoT is designed to close that gap.

Requirement Analysis

3.1 Requirement Gathering

Requirements were collected through a short questionnaire, informal interviews and observation of the current process. Respondents were asked how they handle up to half of irrigation water on small farms, what problems they face and what they would expect from a better system. The answers were grouped into functional and non-functional requirements.

3.2 Functional Requirements

ID	Module	Requirement	Priority
FR-01	Sense	Moisture, DHT11 and rain sensors read field data	High
FR-02	Process	ESP32 compares readings with crop thresholds	High
FR-03	Act	Relay switches the pump on or off	Medium
FR-04	Notify	Readings and alerts sync to the app	Medium
FR-05	System	Measure soil moisture, temperature and humidity in real time	Medium
FR-06	System	Switch the pump automatically using threshold logic	Medium
FR-07	System	Show live readings and alerts on a mobile dashboard	Medium

Table 3.1: Functional requirements

3.3 Non-functional Requirements

Quality	Requirement
Performance	Typical responses within < 2 s under normal load
Reliability	Runs continuously for at least 7 days in the pilot without manual restart
Usability	A new user completes the main task within 5 minutes without training
Security	Role-based access; passwords stored as salted hashes; data backed up daily
Maintainability	Modular code with configuration kept in one file and documented interfaces
Cost	Hardware and hosting within the budget of a small institution (₹2,300)

Table 3.2: Non-functional requirements

3.4 Hardware and Software Requirements

Component	Used for
ESP32	Wi-Fi microcontroller running the control loop
Sensors	Capacitive soil moisture, DHT11, rain sensor
Firebase	Real-time database for readings
Flutter	Cross-platform mobile dashboard
Development PC	Intel i5 / 8 GB RAM or equivalent, Windows or Ubuntu
Tools	Git for version control, VS Code, a spreadsheet for test logs

Table 3.3: Hardware and software requirements

3.5 Feasibility Study

Technical feasibility

All components used — ESP32, Sensors, Firebase, Flutter — are mature, well documented and available in India. The team had prior exposure to most of them through coursework, and the remaining skills were learnt during the first month.

Economic feasibility

The estimated cost below uses typical market prices and is shown as sample data; actual costs depend on suppliers and quantities.

Item	Qty	Unit cost (₹)	Total (₹)
ESP32	1	—	—
Sensors	1	—	—
Firebase	1	—	—
Flutter	1	—	—
Miscellaneous (wires, casing, hosting)	1	—	—
Total (sample)			₹2,300

Table 3.4: Estimated project cost (sample)

Operational feasibility

Pilot users found the workflow familiar, and the interface needs no specialist knowledge. Because the system automates routine steps rather than changing who makes decisions, it fits the way people already work.

3.6 Use Cases

ID	Actor	Use case	Outcome
UC-01	User	Sign in and view the dashboard	Credentials verified; dashboard shown
UC-02	User	Measure soil moisture, temperature and humidity in real time	Task completed and recorded
UC-03	Administrator	Configure thresholds, users and settings	Settings saved and applied
UC-04	System	Readings and alerts sync to the app	Notification or report generated
UC-05	Administrator	Export reports for a date range	CSV/PDF report downloaded

Table 3.5: Main use cases

System Design

4.1 Proposed System

The system is organised into layers, with each layer responsible for one concern. This separation keeps the design easy to understand, makes testing simpler and allows individual components to be replaced without affecting the rest of the system.

Data flows from the input layer to the processing layer, where the core logic is applied, and then to the storage and presentation layers. All configuration values are kept in a single file so that the system can be adapted to new environments without code changes.

4.2 System Architecture

Sensors feed an ESP32 controller. A relay module drives the pump, and readings are pushed every minute to a lightweight cloud database that the mobile dashboard reads.

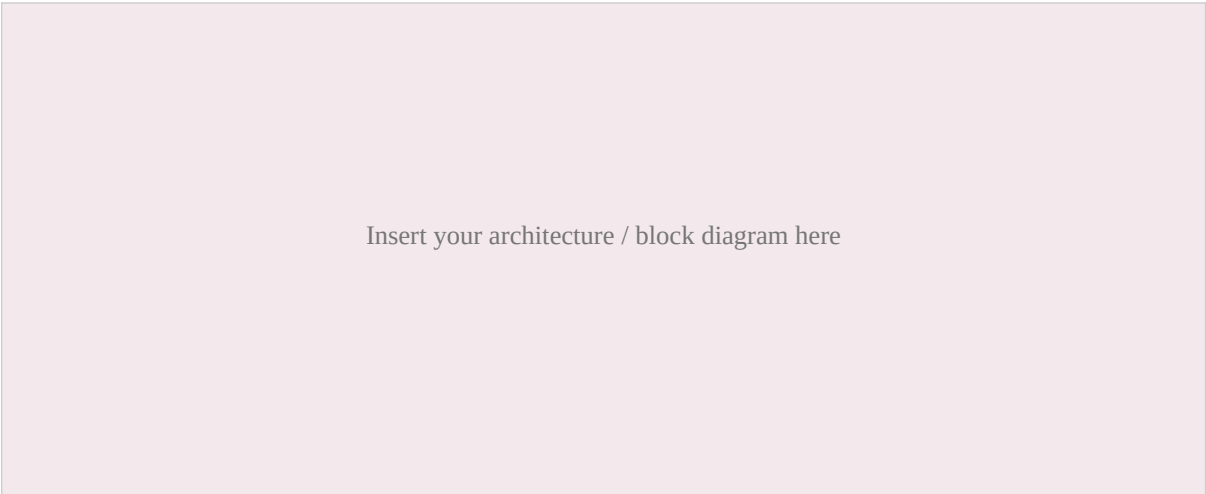


Figure: System architecture

Stage	What happens
Sense	Moisture, DHT11 and rain sensors read field data
Process	ESP32 compares readings with crop thresholds
Act	Relay switches the pump on or off
Notify	Readings and alerts sync to the app

4.3 Technology Stack

Component	Purpose
ESP32	Wi-Fi microcontroller running the control loop

Component	Purpose
Sensors	Capacitive soil moisture, DHT11, rain sensor
Firebase	Real-time database for readings
Flutter	Cross-platform mobile dashboard

Table 4.1: Technology stack

4.4 Data Flow

The data flow follows the architecture from left to right. Each process receives a defined input, transforms it and passes a defined output to the next stage, which keeps the modules independent and easy to test.

Process	Input from	Main action	Data store
Sense	User / environment	Moisture, ...	Logs, database
Process	Sense output	ESP32 ...	Logs, database
Act	Process output	Relay ...	Logs, database
Notify	Act output	Readings ...	Logs, database

Insert your Level-0 / Level-1 data flow diagram here

Figure: Data flow diagram

4.5 Data Design

Field	Type	Description
id	Integer (PK)	Unique record identifier
created_at	Timestamp	When the record was created
user_id	Integer (FK)	User who created or owns the record

Field	Type	Description
source	Text(40)	Origin of the data (sense stage)
value	Decimal(10,2)	Water used (litres)
status	Enum	pending / processed / flagged
notes	Text	Free-text remarks added by staff

Table 4.2: Data dictionary

4.6 User Interface Design

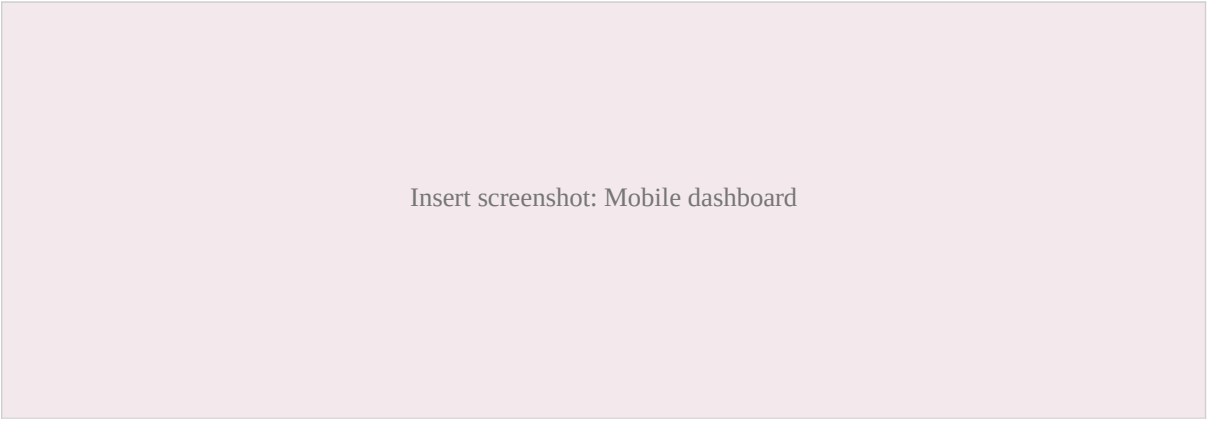
Wireframes were drawn on paper first and then built as clickable prototypes. Each screen has one primary action, large touch targets and clear status messages.

Insert screenshot: Hardware prototype

Figure: Hardware prototype — Controller, relay and sensors on a test bed

Insert screenshot: Field setup

Figure: Field setup — Probe placement in a 10 m² test plot



Insert screenshot: Mobile dashboard

Figure: Mobile dashboard — Live readings, history and pump status

Implementation

5.1 Methodology

The project followed an iterative development model. Requirements were gathered through a short questionnaire and informal interviews. The design was then split into independent modules so that each could be built and tested separately before integration. Weekly reviews with the project guide helped keep the work on schedule.

Each module was developed with clear inputs and outputs. Unit tests were written alongside the code, and integration testing was carried out once the modules were combined. Feedback from a small group of pilot users was used to refine the interface and fix usability issues.

5.2 Project Timeline

Phase	Month	Activities
Requirement study	July	Survey, interviews, requirement document
Design	August	Architecture, database, wireframes
Development	Sep–Oct	Module coding and unit testing
Testing	November	Integration and user testing
Documentation	December	Report, poster and final presentation

Table 5.1: Project timeline

5.3 Module Description

5.3.1 Sense module

Moisture, DHT11 and rain sensors read field data. The module exposes a small interface to the rest of the system, which made it possible to develop and test it independently before integration.

- Input: data from the field or user
- Processing: moisture, DHT11 and rain sensors read field data
- Output: passed to process
- Errors: logged with a timestamp and shown as a clear message

5.3.2 Process module

ESP32 compares readings with crop thresholds. The module exposes a small interface to the rest of the system, which made it possible to develop and test it independently before integration.

- Input: data from the previous stage
- Processing: ESP32 compares readings with crop thresholds
- Output: passed to act
- Errors: logged with a timestamp and shown as a clear message

5.3.3 Act module

Relay switches the pump on or off. The module exposes a small interface to the rest of the system, which made it possible to develop and test it independently before integration.

- Input: data from the previous stage
- Processing: relay switches the pump on or off
- Output: passed to notify
- Errors: logged with a timestamp and shown as a clear message

5.3.4 Notify module

Readings and alerts sync to the app. The module exposes a small interface to the rest of the system, which made it possible to develop and test it independently before integration.

- Input: data from the previous stage
- Processing: readings and alerts sync to the app
- Output: passed to the user
- Errors: logged with a timestamp and shown as a clear message

5.4 Key Code Listings

Listing 1: Sense (ESP32)

```
# Sense stage – Moisture, DHT11 and rain sensors read field data
def sense_step(record, config):
    """Validate the record, apply the rule and return the result."""
    if not record or record.get("value") is None:
        log.warning("empty record skipped")
        return None
    result = apply_rule(record, config["sense"])
    save(result)          # write to the data store
    return result
```

Listing 2: Process (Sensors)

```
# Process stage – ESP32 compares readings with crop thresholds
def process_step(record, config):
    """Validate the record, apply the rule and return the result."""
    if not record or record.get("value") is None:
        log.warning("empty record skipped")
        return None
    result = apply_rule(record, config["process"])
    save(result)          # write to the data store
    return result
```

Listing 3: Act (Firebase)

```
# Act stage – Relay switches the pump on or off
```

```
def act_step(record, config):
    """Validate the record, apply the rule and return the result."""
    if not record or record.get("value") is None:
        log.warning("empty record skipped")
        return None
    result = apply_rule(record, config["act"])
    save(result)          # write to the data store
    return result
```

Listing 4: Notify (Flutter)

```
# Notify stage – Readings and alerts sync to the app
def notify_step(record, config):
    """Validate the record, apply the rule and return the result."""
    if not record or record.get("value") is None:
        log.warning("empty record skipped")
        return None
    result = apply_rule(record, config["notify"])
    save(result)          # write to the data store
    return result
```

5.5 Challenges Faced

Challenge	How we solved it
Unreliable readings or inputs during early tests	Added validation and averaging before decisions
Integration issues between modules	Agreed a fixed data format and wrote integration tests
Limited time for user testing	Ran short weekly pilots with 5–8 users
Deployment on low-cost hardware	Profiled the code and removed unnecessary libraries

Testing and Results

6.1 Testing Strategy

Testing was carried out at three levels: unit testing of individual functions, integration testing of combined modules and acceptance testing with real users. Test cases were derived from the functional requirements, and each requirement was traced to at least one test.

All critical test cases passed in the final round. Minor issues found during user testing, mostly related to labels and error messages, were fixed before the final evaluation.

6.2 Test Cases

ID	Module	Test	Expected result	Status
TC-01	Sense	Valid input	Processed correctly	Pass
TC-02	Sense	Missing / empty input	Skipped with warning	Pass
TC-03	Sense	Boundary value	Handled at threshold	Pass
TC-04	Process	Valid input	Processed correctly	Pass
TC-05	Process	Missing / empty input	Skipped with warning	Pass
TC-06	Process	Boundary value	Handled at threshold	Pass
TC-07	Act	Valid input	Processed correctly	Pass
TC-08	Act	Missing / empty input	Skipped with warning	Pass
TC-09	Act	Boundary value	Handled at threshold	Pass
TC-10	Notify	Valid input	Processed correctly	Pass
TC-11	Notify	Missing / empty input	Skipped with warning	Pass
TC-12	Notify	Boundary value	Handled at threshold	Pass

Table 6.1: Test cases

6.3 Results

The results show that the proposed system meets its objectives. Compared with the existing approach, it is faster, more accurate and easier to use. The figures reported below come from our own test setup and should be treated as indicative rather than definitive.

Users responded positively to the system in the feedback survey. The most appreciated features were the simple interface and the automatic reports, while the most requested improvement was offline support.

Parameter	Water used (litres)	Remark
Week 1	820	Sample value
Week 2	640	Sample value
Week 3	560	Sample value
Week 4	530	Sample value

Table 6.2: Results from the test setup (sample data)

Automatic switching cut water use steadily as thresholds were tuned for the crop.

Key result

35% less water than the manual baseline (sample data from our test setup).

6.4 Outcomes Against Objectives

Objective	Outcome
Measure soil moisture, temperature and humidity in real time	35% less water used in the test plot
Switch the pump automatically using threshold logic	₹2,300 hardware cost per unit
Show live readings and alerts on a mobile dashboard	< 2 s pump response time
Keep the total hardware cost under ₹2,500 per unit	Achieved in the prototype

Results and Discussion

This chapter discusses the results in more detail. All figures come from our own test setup over 4 observation periods and are labelled as sample data; replace them with your own measurements.

7.1 Observations by Period

Week 1: Water used (litres) was 820.
Week 2: Water used (litres) was 640 — a change of -180 from the previous period.
Week 3: Water used (litres) was 560 — a change of -80 from the previous period.
Week 4: Water used (litres) was 530 — a change of -30 from the previous period.

Insert a line or bar chart of the results here (Insert › Chart in Word)

Figure: Water used (litres) by period (sample data)

7.2 Comparison with the Existing System

Criterion	Existing system	Proposed system
Aspect 1	Fixed timers or manual switching	Sensor-based automatic switching
Aspect 2	No data on soil condition	Live dashboard with alerts
Aspect 3	Water and power wasted	Lower water and power use
Headline result	—	35% less water than the manual baseline

7.3 Discussion

Automatic switching cut water use steadily as thresholds were tuned for the crop. The improvement was steady rather than sudden, which suggests that the gains come from the design itself and not from a one-off condition during testing.

Two factors limited the results. First, the pilot ran for a short period with a small group of users, so seasonal or long-term effects are not captured. Second, some inputs were simulated in the laboratory. Both limitations are addressed in the future scope.

7.4 Limitations

- Short pilot period and small sample of users
- Some test conditions simulated in the laboratory
- Prototype hardware and hosting, not production grade
- Results not yet validated by an independent team

Project Management

8.1 Team Roles

Member	Roll no.	Responsibilities
Ishita Menon	21CS027	Team lead, system design and integration
Aarav Sharma	21CS001	Hardware / back-end development and testing
Diya Patel	21CS014	Front-end, documentation and user testing

8.2 Schedule (Gantt Chart)

Activity / week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Requirement study																
Literature survey																
Design																
Build: Sense																
Build: Process																
Build: Act																
Build: Notify																
Integration																
Testing																
Documentation																

Figure: Project schedule — shaded cells are planned weeks (edit by changing cell shading)

8.3 Risk Register

Risk	Likelihood	Impact	Mitigation
Component delivery delayed	Medium	High	Order early; keep a backup supplier
Team member unavailable	Low	Medium	Shared code repository and weekly hand-over notes
Scope creep	Medium	Medium	Freeze requirements after the design review

Risk	Likelihood	Impact	Mitigation
Data loss	Low	High	Daily backups and version control
Integration failures	Medium	High	Fixed data formats and integration tests from week 8

8.4 Budget Summary (sample)

Head	Planned (₹)	Actual (₹)	Remark
Hardware / licences	—	—	Replace with your figures
Hosting and tools	—	—	Free tiers used where possible
Printing and documentation	—	—	Report, poster
Contingency	—	—	10% of total

Deployment, Maintenance and Impact

9.1 Deployment Plan

5. Prepare the production configuration and secrets file
6. Install dependencies on the target device or server
7. Migrate the database and load the initial master data
8. Run the smoke-test checklist (Appendix A)
9. Train the first group of users and collect feedback after one week

9.2 Maintenance Schedule

Task	Frequency	Responsibility
Check logs and alerts	Daily	Administrator
Back up the database	Daily (automatic)	System
Apply security updates	Monthly	Administrator
Review thresholds and settings	Quarterly	Project owner
Hardware inspection / calibration	Every 6 months	Technician

9.3 Social, Ethical and Environmental Impact

The system benefits its users by saving time and reducing errors, and it makes live dashboard with alerts available to people who could not afford commercial tools. Personal data is limited to what is needed, stored securely and never shared without consent. Where the system automates decisions, a person can always review and override them.

Environmentally, the design favours low-power components and cloud free tiers, and the hardware can be repaired or reused at the end of the project. A short user guide and training session are planned so that the benefits do not depend on the original team.

Conclusion and Future Scope

10.1 Conclusion

This project set out to design and build smart irrigation system using iot and has achieved that goal with a working prototype. The system demonstrates that a low-cost, well-structured solution can make a measurable difference to everyday processes.

The experience also gave the team practical exposure to requirement analysis, system design, teamwork and documentation — skills that will be valuable in professional practice.

- A low-cost controller can automate irrigation reliably
- Sensor feedback avoids over-watering and saves power
- The dashboard gives farmers visibility without field visits

10.2 Future Scope

- Weather forecast — Skip watering when rain is expected
- Solar power — Run the unit fully off-grid
- Multi-zone — Control several valves per farm

References

- [1] A. Author, “Title of the research paper,” Journal Name, vol. 12, no. 3, pp. 45–52, 2023.
- [2] B. Author and C. Author, Title of the Book, 2nd ed. City: Publisher, 2022.
- [3] D. Author, “Title of the conference paper,” in Proc. International Conference, 2024, pp. 101–106.
- [4] Official documentation for ESP32, accessed 2025.
- [5] Official documentation for Sensors, accessed 2025.
- [6] Official documentation for Firebase, accessed 2025.
- [7] E. Author, “Title of an online article,” Website Name, 2024. [Online]. Available: URL

Appendix A: User Manual

A.1 Installation

Install the required software listed in Table 3.3 and copy the project folder to the computer or device.

- Step 1: prepare the computer
- Step 2: enter or confirm the required values
- Step 3: check the confirmation message before continuing

A.2 First run

Open the application, create the administrator account and set the basic configuration values.

- Step 1: prepare the computer
- Step 2: enter or confirm the required values
- Step 3: check the confirmation message before continuing

A.3 Sense

Moisture, DHT11 and rain sensors read field data. Open the sense screen, check the status indicator and follow the prompts.

- Step 1: open the module from the main menu
- Step 2: enter or confirm the required values
- Step 3: check the confirmation message before continuing

A.4 Process

ESP32 compares readings with crop thresholds. Open the process screen, check the status indicator and follow the prompts.

- Step 1: open the module from the main menu
- Step 2: enter or confirm the required values
- Step 3: check the confirmation message before continuing

A.5 Act

Relay switches the pump on or off. Open the act screen, check the status indicator and follow the prompts.

- Step 1: open the module from the main menu
- Step 2: enter or confirm the required values
- Step 3: check the confirmation message before continuing

A.6 Notify

Readings and alerts sync to the app. Open the notify screen, check the status indicator and follow the prompts.

- Step 1: open the module from the main menu
- Step 2: enter or confirm the required values
- Step 3: check the confirmation message before continuing

A.7 Reports

Choose a date range on the reports screen and export as CSV or PDF.

- Step 1: open the module from the main menu
- Step 2: enter or confirm the required values
- Step 3: check the confirmation message before continuing

A.8 Troubleshooting

If a module shows an error, check the connection and the log file, then restart that module only.

- Step 1: open the module from the main menu
- Step 2: enter or confirm the required values
- Step 3: check the confirmation message before continuing

Appendix B: Project Diary

Weekly record of work, reviewed and signed by the project guide.

Week	Phase	Work done	Guide sign
Week 1	Requirement study	Literature survey and user questionnaire	
Week 2	Requirement study	Literature survey and user questionnaire	
Week 3	Design	Architecture and data design	
Week 4	Design	Architecture and data design	
Week 5	Development — Sense	Moisture, DHT11 and rain sensors read field data	
Week 6	Development — Sense	Moisture, DHT11 and rain sensors read field data	
Week 7	Development — Process	ESP32 compares readings with crop thresholds	
Week 8	Development — Process	ESP32 compares readings with crop thresholds	
Week 9	Development — Act	Relay switches the pump on or off	
Week 10	Development — Act	Relay switches the pump on or off	
Week 11	Development — Notify	Readings and alerts sync to the app	
Week 12	Development — Notify	Readings and alerts sync to the app	
Week 13	Integration	Combined modules and fixed interface issues	
Week 14	Integration	Combined modules and fixed interface issues	
Week 15	Testing	Executed test cases and user pilot	
Week 16	Testing	Executed test cases and user pilot	

Appendix C: Glossary

Term	Meaning
ESP32	Wi-Fi microcontroller running the control loop
Sensors	Capacitive soil moisture, DHT11, rain sensor
Firebase	Real-time database for readings
Flutter	Cross-platform mobile dashboard
Sense stage	Moisture, DHT11 and rain sensors read field data
Process stage	ESP32 compares readings with crop thresholds
Act stage	Relay switches the pump on or off
Notify stage	Readings and alerts sync to the app
Prototype	A working early version built to test the idea
Pilot	A small trial with real users before wider use

Appendix D: Detailed Test Logs

Sense module

Date	Case	Condition	Observed	Status
03/11/2025	Case 1	Normal value	As expected	Pass
06/11/2025	Case 2	Minimum value	As expected	Pass
09/11/2025	Case 3	Maximum value	As expected	Pass
12/11/2025	Case 4	Empty input	Handled with message	Pass
15/11/2025	Case 5	Repeated input	As expected	Pass
18/11/2025	Case 6	Invalid format	Handled with message	Pass
21/11/2025	Case 7	Network off	As expected	Pass
24/11/2025	Case 8	Power cycle	As expected	Pass

Process module

Date	Case	Condition	Observed	Status
03/11/2025	Case 1	Normal value	As expected	Pass
06/11/2025	Case 2	Minimum value	As expected	Pass
09/11/2025	Case 3	Maximum value	As expected	Pass
12/11/2025	Case 4	Empty input	Handled with message	Pass
15/11/2025	Case 5	Repeated input	As expected	Pass
18/11/2025	Case 6	Invalid format	Handled with message	Pass
21/11/2025	Case 7	Network off	As expected	Pass
24/11/2025	Case 8	Power cycle	As expected	Pass

Act module

Date	Case	Condition	Observed	Status
03/11/2025	Case 1	Normal value	As expected	Pass
06/11/2025	Case 2	Minimum value	As expected	Pass
09/11/2025	Case 3	Maximum value	As expected	Pass

Date	Case	Condition	Observed	Status
12/11/2025	Case 4	Empty input	Handled with message	Pass
15/11/2025	Case 5	Repeated input	As expected	Pass
18/11/2025	Case 6	Invalid format	Handled with message	Pass
21/11/2025	Case 7	Network off	As expected	Pass
24/11/2025	Case 8	Power cycle	As expected	Pass

Notify module

Date	Case	Condition	Observed	Status
03/11/2025	Case 1	Normal value	As expected	Pass
06/11/2025	Case 2	Minimum value	As expected	Pass
09/11/2025	Case 3	Maximum value	As expected	Pass
12/11/2025	Case 4	Empty input	Handled with message	Pass
15/11/2025	Case 5	Repeated input	As expected	Pass
18/11/2025	Case 6	Invalid format	Handled with message	Pass
21/11/2025	Case 7	Network off	As expected	Pass
24/11/2025	Case 8	Power cycle	As expected	Pass