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WATER METRIC STEPS

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COMPUTER INFORMATION SYSTEMS

KING ABDULLAH II SCHOOL OF INFORMATION TECHNOLOGY
THE UNIVERSITY OF JORDAN

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ABSTRACT

Water plays an essential and important role in social and economic development all over the world. Water is a gift from God to all creatures on our planet and its conservation is a responsibility for all civilized human beings and it is possible to face a shortage of its existence someday in the future if it is consumed in an ill-considered manner. There are different ways to save water and one of these ways is by rationalizing water consumption. In this project, A water meter was created to update each person with their water readings every 10 minutes, in addition, a prediction algorithm was built to show the user their predicted consumption in the next three months with a user-friendly graphical user interface.

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LIST of ABBREVIATIONS

PHP	Hypertext Preprocessor
IDE	integrated development environment
UML	Unified Modeling Language
UMS	Universal Measurement System
RE	Requirements Engineering
HTML	Hypertext Markup Language
CSS	Cascading Style Sheets
SQL	Standardized Query Language
GUI	Graphical User Interface
USB	Universal Serial Bus
DBMS	Database Management System
ID	Identification
DFD	Data Flow Diagram
ERD	Entity Relationship Diagram
PERT	Program Evaluation Review Technique
SVR	Supported Vector Regression

CHAPTER ONE

1.0 INTRODUCTION

1.1 Preamble

The need for water now is becoming an essential problem due to the population density, Lack of water resources, misuse of water, illegal use of water, damage in the pipes, and assaulting the water. Therefore, rationalizing water consumption is becoming more important nowadays.

1.2 Project Motivation

There were many reasons why we chose to build a website rather than an application, some of these reasons are:

1. Accessibility, websites provide access to users on a wide range of devices, regardless of the operating system, through the browser.
2. Cost-Effective Development, it is less costly to develop websites than mobile apps due to the smaller amount of development time required.
3. Faster Speed to Market, websites do not need to be approved by app stores and marketplaces, so it is faster to get them to market.
4. Ease of Updates, developers make changes to a common code base, so updates are simple. And developers can push updates to a server quickly for instant visibility across all devices.

And the main reason for building a website that is connected to a sensor that provides water readings and alert users to rationalize water consumption was because our country Jordan suffer from water scarcity, and we should be aware of using water.

This website will allow users to have the ability to know the value of the water consumption synchronously, also have an idea of how much they will consume based on using prediction algorithms.

1.3 Problem Statement

There are many aspects to the problem statement of our project:

1. The water is becoming more and more scarce and expensive, so this project will help our country by reducing water consumption and save money.
2. Knowing the water bill value after a complete cycle can lead to high wasting compared to the utilization if they are directly aware of their consumption.
3. Having an easy way to know water consumption and get alerts, is now a very essential need.

1.4 Project Aim and Objectives

This project aims to understand current household water use behavior and water use patterns in Jordan city, to improve the efficiency of household water use, to encourage sustainable use and conservation of water resources, and to rationalize water consumption.

objectives:

1. Enabling users to know the value of their water consumption synchronously.

2. Alerting the user to rationalize water consumption, by sending notifications.
3. Reading users' water meters to give them awareness of how much water they consume and to motivate them to reduce unnecessary waste.
4. Predicting the users consumption based on their past consumption.

1.5 Project Scope

In this project, we built a water meter system that consists of a website and a sensor. We added the sensor next to the water meter which will deliver the water readings to the website to calculate the water bill for each user depending on their consumption in meters and will alert the user of how much water they consume and motivate them to reduce wasting water. We built our system from scratch using PHP, PHP Framework (Laravel), Python, and Arduino.

1.6 Project Software and Hardware Requirements

1.6.1 Software Requirements

1.6.2 Hardware Requirements

Table 1.1: Software Requirements

Software Requirements	Description
Arduino IDE	Arduino Software (IDE)- contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions, and a series of menus. It connects to the Arduino and Genuine hardware to upload programs and communicate with them.
Visual Studio Code	Visual Studio Code is a streamlined code editor with support for development operations like debugging, task running, and version control.
PyCharm	PyCharm is an integrated development environment (IDE) used in computer programming, specifically for the Python language. It makes it easier for programmers to write various web applications in Python supporting widely used web technologies like HTML, CSS, JavaScript, etc...
Draw io	draw.io is a free diagramming application that allows users to create and share diagrams within a web browser. The online tool works with G Suite/Google Drive and Dropbox and is deeply integrated and audit friendly in Atlassian's Confluence and Jira products.
Adobe XD	Adobe XD is the Adobe prototyping tool for user experience and interaction designers.

Table 1.2: Hardware Requirements

Hardware Requirements	Description	Cost	Quantity
Laptop	Intel® Core™ i7 processor. Operating systems: Windows* 10.	600$	1
Solar Charger 20000mAh	Portable Outdoor Mobile Power Bank, Camping External Backup Battery	23$	1
Arduino UNO Wi-Fi REV2 [ABX00021]	Works for Wi-Fi and Bluetooth Low Energy applications.	40$	1
Elegoo EL-CP-004	Multicolored Jumper Wire.	2$	20
water flow sensor	Water Flow Hall Sensor, Switch Flow Meter, Flowmeter Counter	9$	1
USB Cable A-Male to B-Male	One 16-foot-long high-speed multi-shielded USB 2.0 A-Male to B-Male cable	9$	1

1.7 Project Limitations

This project has many limitations, some of them are time constraints, money, and limited access to data, as I mentioned before we are required to deliver this project in a specific amount of time and this means that we will work only on the main objects, making sure to spend money as less as possible. And by only using the data that is legal to access.

1.8 Project Excepted Output

The expected output of this project is a user-friendly website that is free of bugs and errors, connected to a sensor that can read water meters accurately along with well-written documentation. This website is supposed to provide users with the following services:

1. The ability to monitor your water meter.
2. Calculating your water bill based on your consumptions.
3. Get alerts and notifications to rationalize consuming water.
4. Get predictions on how much the user will consume based on their past consumptions.

1.9 Project Schedule

Table 1.3: Activity Table

Task	Description	Team Member (Responsible)	Duration Time(day)	Predecessor
T1	Project Planning	All Team	5	-
T2	Feasibility Study	All Team	3	-
T3	Requirements Elicitation Techniques	All Team	5	T2
T4	Targeted Users	All Team	1	T3
T5	Functional Requirements	All Team	5	T3
T6	Non-Functional Requirements	All Team	5	T3
T7	Context Diagram	All Team	3	T5
T8	Entity Relationship Diagram	All Team	3	T3
T9	UML Use Case Diagram	All Team	3	T5
T10	UML Sequence Diagram	All Team	5	T5
T11	UML Class Diagram	All Team	3	T10
T12	Graphical User Interface Design	All Team	20	T5
T13	Implementation and Testing	All Team	101	T12

1.9.1 Gantt Chart

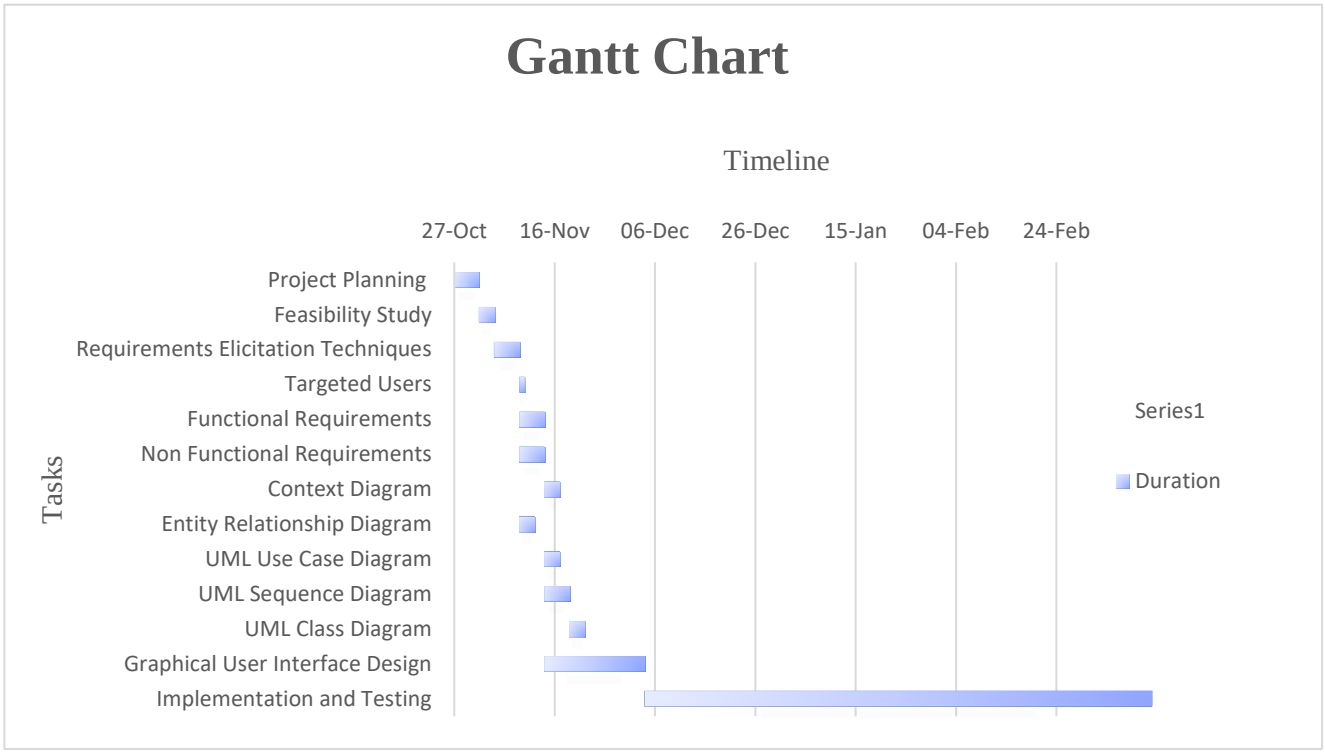


Figure 1.1: Gantt Chart

1.9.2 Pert Chart

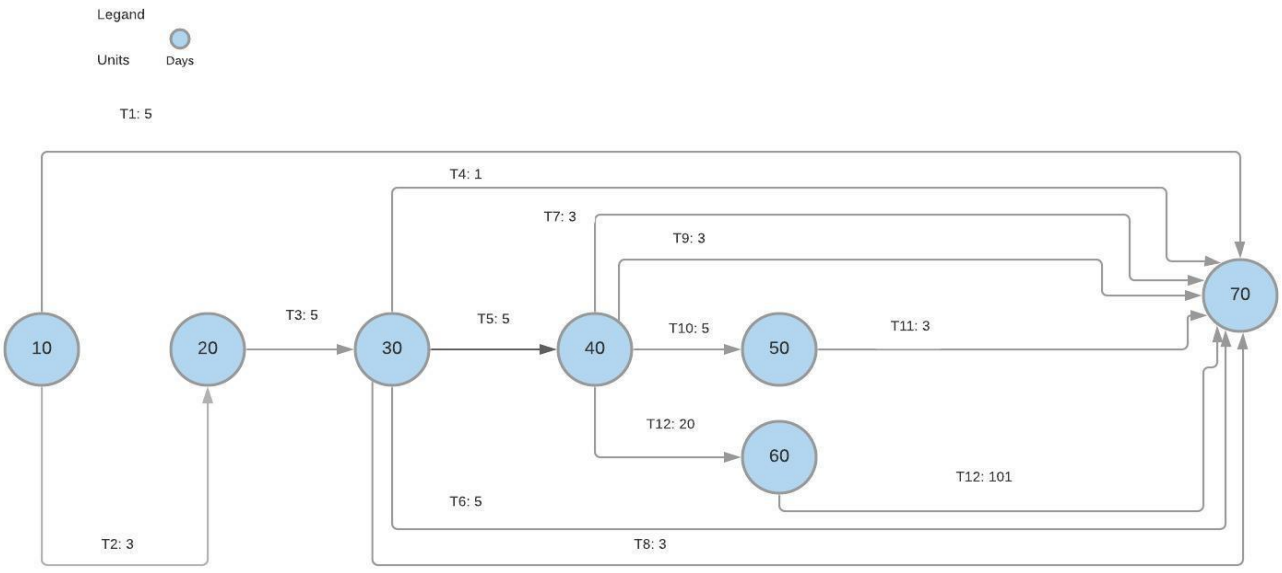


Figure 1.2: Pert Chart

1.10 Report Outline

In the following chapter, some related existed systems will be presented with determining its overall problems, continued with applicable solutions in our project.

In chapter 3, the requirements analysis will focus on the tasks that determine the needs and conditions of our project, starting with the feasibility study followed by elicitation techniques, targeted users, functional requirements definitions and specifications, UML use case diagram, and non-functional requirements.

Chapter 4 specifies the activities of the system design phase and transforms the previously defined requirements into a complete and detailed set of specifications that will be used during the next phase.

Chapter 5 defines how the information system should be built, ensuring that the information system is operational, used, and meets the quality standard.

Ensuring that the software has been correctly installed with all the inherent features and that the product is working as per expectations will be explained in chapter 6.

Chapter 7, an overall review will be presented including the strengths and weaknesses of our project.

CHAPTER TWO

2.0 RELATED EXISTING SYSTEMS

2.1 Introduction

If you want to develop a new system, it is essential to look at relevant existing systems and understand their weaknesses and strengths to develop your system to be more professional. Today you can find plenty of water meter systems that can give you a brief description of your water consumption and many more features.

In this chapter, an overview of some related existing systems will be mentioned in section 2.2. Overall problems and the solution approach will be further described in sections 2.3 and 2.4. Finally, a summary is presented in section 2.5.

2.2 Existing Systems

Mentioning relevant existing systems is considered one of the elicitation technique steps, which will help us in writing the requirements. Although, for now, we will just mention the similar existing systems that will help us see what features already exist and what features are missing and need to be added to this type of system.

2.2.1 Flume

The Flume water-saving system displays real-time water usage data directly, through which you can know the amount of water consumption and detect pipeline leaks by sending alerts about water squandering, Flume is only licensed for use in the United States.

Figure 2.1: Flume

2.2.2 Cloud UMS

Cloud Water Utility Management System, which is charged annually for 1 year, there are two ways to use it either semi-auto or full auto, it sends data via internal Bluetooth low energy radio channel technology to the mobile app within 10 meters of the radius or directly to cloud server via data logger and displays Realtime data on mobile app anywhere over the globe.

Figure 2.2: Cloud UMS

2.3 Overall Problems of Existing Systems

- Designed according to the specifications of the USA, where water is always available, so there is no need to use water tanks.
- The cost of the system is large and is outside the range of a large percentage of the Jordanian population.
- The main goal of these existing systems is metering not rationalizing.
- These systems need a high cost.
- All these systems are using applications, which may be hard to access from any device.

2.4 Overall Solution Approach

- Design according to the specifications of Jordan.
- The cost will be as less as possible, depending on using alternatives.
- Sending notifications to notify the user to rationalize water consumption.
- Building a website rather than an application to easily access the system from any device.
- Create the website to be user friendly and any user can understand how to use it simply.

2.5 Summary

In this chapter, we introduced some existing systems that are related to our project, this helped us to make a good decision on what features should we add and what weak points should we avoid, so we are currently developing a solution for these problems to improve the performance and user experience of this type of systems.

CHAPTER THREE

3.0 SYSTEM REQUIREMENTS ENGINEERING AND ANALYSIS

3.1 Introduction

Requirements Analysis involves reviewing the requirements to ensure that they all are useful for building the website. In this chapter, you will be introduced to the details of the Requirements Engineering (RE) phase starting with the Feasibility Study followed by Elicitation Techniques, Targeted Users, Functional Requirements Definitions and Specifications, Non-Functional Requirements, UML Use Case Diagram, and a section to summarize a comprehensive conclusion.

3.2 Feasibility Study

A feasibility study might uncover new ideas that could completely change a project's scope. It is best to make these determinations in advance, rather than to jump in and to learn that the project will not work. Conducting a feasibility study is always beneficial to the project as it gives you and other stakeholders a clear picture of the proposed project.

3.2.1 Operational Feasibility

Operational feasibility is the measure of how well a proposed system solves the problems and takes advantage of the opportunities identified during scope definition and how it satisfies the requirements identified in the requirements analysis phase of system development.

As web applications are familiar to wide users, we will not need much training to use them, but we will need to train users on how to deal with the sensor and how to put it on.

3.2.2 Technical Feasibility

The system is now being developed as an online website it can be opened through internet browsers supported by Web 2.0 features, it also consists of a sensor that should be added next to the water meter to deliver the readings of water consumptions, the user should buy the sensor to get the information provided by the website.

To construct the system, we must have the needed technical resources and requirements which are:

- Design Language: HTML, CSS.
- Programming Language: JavaScript, PHP, Python, and MySQL for database implementation.
- Hardware: A sensor that will be added next to the water meter and any technical device with internet access with a browser.

3.2.3 Economic Feasibility

- Development cost
  - Personal cost

Table 3.1: Personal Cost

Employee	Cost per hour	Hours	Total cost per hour
1 System Administrator	10 JD	30 hr	300 JD
1 Database Specialist	10 JD	15 hr	150 JD
1 System Analyst	20 JD	20 hr	400 JD
1 Data Analyst	10 JD	15 hr	150 JD
2 Programmers	30 JD	120 hr	3600 JD
1 GUI Designer	15 JD	25 hr	375 JD
Total	4975 JD		

- New Hardware's and Software's:

Table 3.2: New Hardware's and Software's

Name	Cost per unit	Description
1 Computer	650 JD	Computers will be used to develop and test the application.
1 DBMS Software	72 JD	software designed to store, retrieve, define, and manage data in a database.
1 Development Server	650 JD	server designed to facilitate the development and testing of programs, and websites.
1 Domain website	15	A domain is the name of a website, a URL

1 solar charger 20A	25 JD	solar charger is a charger that employs solar energy to supply electricity to devices or batteries
1 water flow sensor	10 JD	Measure the rate of flow of water and calculate the amount of water flowed through the pipe
1 USB cable A-male to B-male	3 JD	Transported data and power
1 Arduino UNO Wi-Fi REV2 [ABX00021]	40 JD	Arduino is an open-source electronics platform based on easy-to-use hardware and software.
1 Elegoo EL-CP-004	3 JD	cables
Total	1468	

- Development Cost = 4975 + 1468 = 6443 JD – (For development year)

➢ Operating Cost

- Employees

  2 Programmers (120 hr each 30 JD/hr) = 3600 JD.

  1 System Administrator (30 hr each 10 JD/hr) = 300 JD.

  Total= 3900 JD.

- Expenses

  1 Maintenance agreement for the server (450 JD).

  1 Maintenance agreement for DBMS Software (150 JD).

  Total= 600 JD.

- Operating cost = 3900 + 600 = 4500 JD - (For First Operating Year).

➢ Benefits

- Tangible Benefits: benefits that can be measured directly; they are like quality, profitability, and performance of the derived products.

Table 3.3: Tangible Benefits

TANGIBLE BENEFITS: Year 1 – 5
Cost reduction or avoidance communication gap in the old process 1,750 JD
Error reduction 1,900 JD
Increased flexibility 2,220 JD
Increased speed of activity 2,100 JD
Improvement in management planning or control 1,850 JD
Total Tangible Benefits = 9820 JD

- Intangible Benefits: benefits cannot be measured in terms of product metrics; these benefits include customer satisfaction and professional satisfaction.

3.2.4 Schedule Feasibility

Schedule Feasibility helps us to understand whether the project can be completed within a proper time frame or not. That is why we strictly selected the requirements of our system to be able to implement it in the acceptable time frame given to us.

3.3 Requirements Elicitation Techniques

Requirement's elicitation is the process of gathering requirements of a system before analyzing, modeling, or specifying them through elicitation techniques which include practices like interviews, questionnaires, user observation, workshops, brainstorming, use cases, role-playing, and prototyping. In our system, this process has been done by using many techniques such as Interviews, Exploring Existing Systems, and Questionnaires.

3.3.1 Exploring Existing Systems

This technique is considered one of the elicitation techniques that help us in gathering the requirements, knowing the existing and missing features, considering the important features, common activities, and problems that we should pay attention to in our system. The related existing systems were described in detail in chapter 2.

3.3.2 Interviews

We conducted interviews with some people from the public; the interviews generally lasted for about 20-30 minutes. The interviews were great help with writing our requirements, and we could cover some main topics including:

- Satisfaction with the current water meter.
- Some problems facing the users.
- Receptiveness to the new water meter.

Table 3.4: Interview Agenda

Duration in Minutes	TASK
2	INTRODUCTION
1	Introducing ourselves
2	Explaining our idea and goals.
1	Explaining the interview process.
6	INTERVIEW QUESTIONS
2	Satisfaction with the current water meter.
2	Some problems facing the users.
2	Features Requested from the users.
TOTAL TIME IN MINUTES	
18	

We started the interviews by introducing ourselves and explaining the project idea and what we are aiming for. Bellow, you can see the questions we have asked in the interviews and the summary of the answers we have got.

1. **Are there any problems you are facing with the current water meter?**

   Most of the answers were yes.

2. **Have you ever used a smart meter that shows your water-consuming in money?**

   As the interviews were conducted in Jordan, all the answers were ‘No’.

3. **Would you like to have a smart meter that alerts you and give you information about your water-consuming?**

   Most of the answers were ‘Yes’.

4. **Are there any ideas you would like to add for the new smart meter?**

   One of the suggestions was to add a meter which shows the pumping power to find out the reasons why the water is not reaching the tanks, other suggestion was to have the ability to know daily water consuming.

3.3.3 Questionnaire

We created a questionnaire to assist us in gathering requirements. Then, we asked a random group of people to answer it. Bellow, you can see the questions and their results.

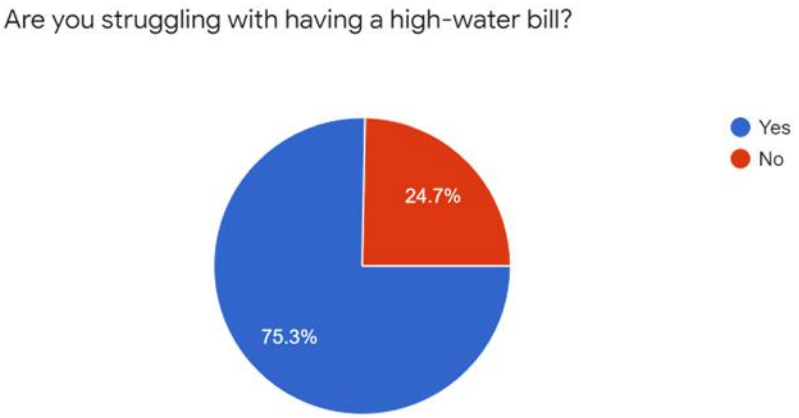


Figure 3.1: Question 1

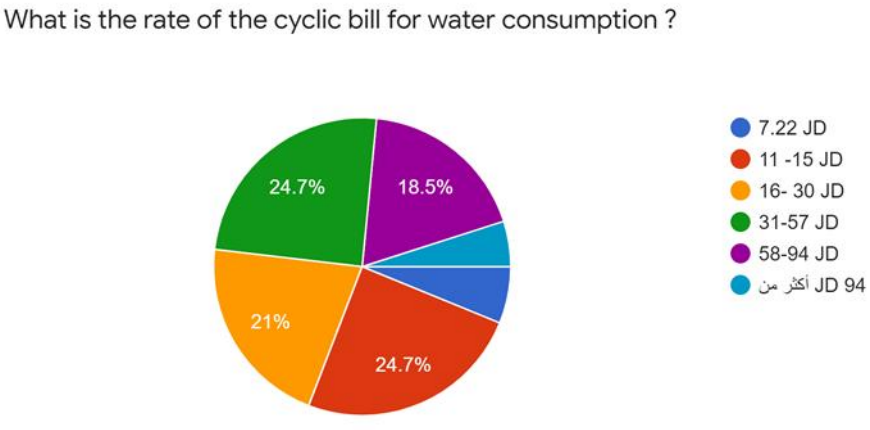


Figure 3.2: Question 2

Are you satisfied with having the water bill every 3 months?

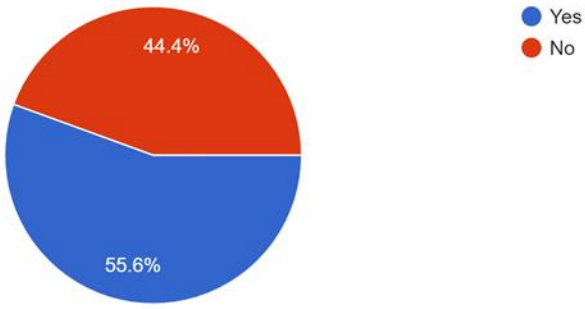


Figure 3.3: Question 3

Are there any problems you are facing with the currently water meter reading ?

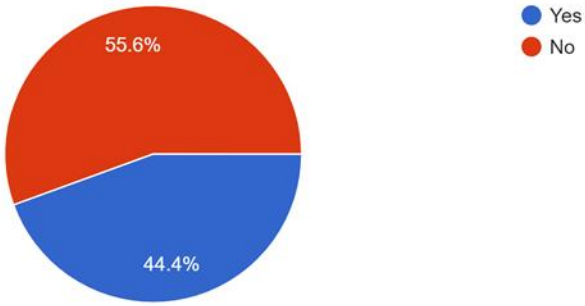


Figure 3.4: Question 4

If there will be a smart meter that helps you to rationalize water-consuming with a percent higher than 30, would like to use it ?

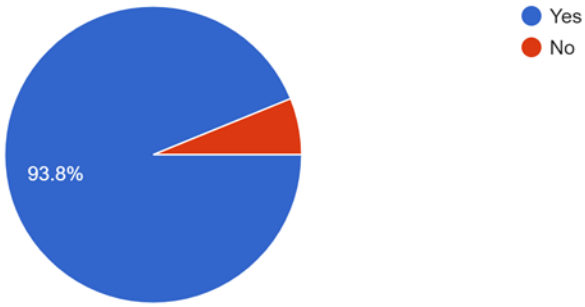


Figure 3.5: Question 5

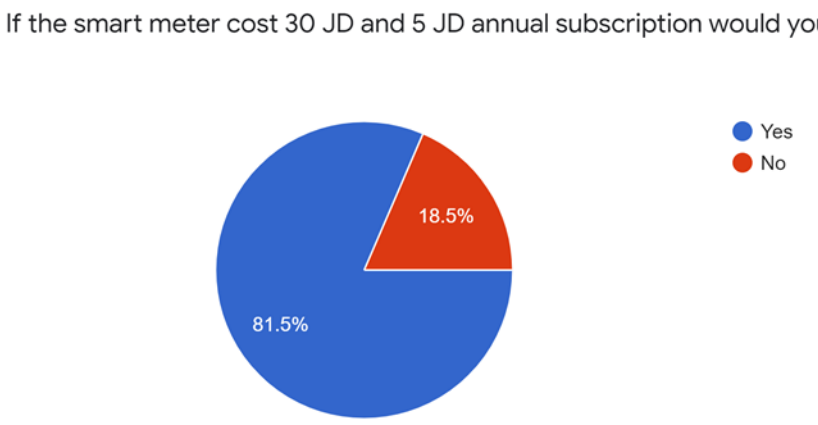


Figure 3.6: Question 6

3.4 Targeted Users

Targeted users are a specific group of people who are united by some common characteristics, and whom the system is designed and implemented for:

1) Users who have a water bill.

2) Ministry of Water and Irrigation.

3.5 Functional Requirements Definition

3.5.1 User

- **Purchasing the smart meter:**

  Users can purchase the smart meter from the selling points.

- **Login**:

  Users enter their national number and the sensor id to log in to the website.

- **Remember Me:**

  Clicking the “Remember Me” box tells the browser to save a cookie so that if the user closes out the window for the site without signing out, the next time the user goes back, it will be signed back in automatically.

- **Read About:**

  On the main screen, when selecting “About” the users will be directed to another screen that has further details about us.

- **Manage Account:**

- **View water readings:**

  Users can view their water readings at a specific time.

- **Exclusive Tips:**

  Tips will appear after the user register, so it helps him to understand the application.

- **Date and Time Selection:**

  Users can know how much water is consumed at a specific time and date.

- **Turn on Notification:**

  Users can turn on notifications to receive alerts if their consuming water overseas.

- **Contact us:**

  The users can contact us through the communication information provided on the website or through the contact form.

- **Logout:**

  Exiting the website.

3.5.2 Admin

- **Login**:

  Admin enters their username and password to log in to the website.

- **Answer Questions:**

  Admin can answer the user's questions.

- **Have a summary:**
  Admin can have a summary of the user's consumption.

- **Logout:**

  Exiting the system.

3.6 Functional Requirements Specifications

3.6.1 User

- **Purchasing the smart meter:**
  - Users can know where the selling points are by accessing the Water Metric Steps website at the bottom of the main page.
  - Then they can go to the selling points and purchase the smart meter.

- **Login**:
  - Access Water Metric Steps website homepage.
  - Press the "Login" button in the navigation bar.
  - The login page will appear.
  - Type in your national number and the sensor id.
  - Press the" Login" button.

- **Remember Me:**
  - Check the “Remember Me” checkbox on the login page.

- **Read About:**
  - Access Water Metric Steps website homepage.
  - Press the “About” button in the navigation bar.
  - The About Us page will appear for the user to read.

- **Manage Account:**
  - Access Water Metric Steps website.
  - Press the Profile icon next to your name in the navigation bar.
  - Your profile page will appear.
  - Click on the "manage my account" button.

- **View water readings:**
  - Login successfully.
  - Press the Profile icon next to your name in the navigation bar.
  - Your profile page will appear.
  - Enter your subscription number.
  - Choose a specific time and date.
  - Click on the "calculate" button.
  - Your water consumption in money will be displayed on your screen.

- **Exclusive Tips:**
  - Access Water Metric Steps website.
  - Tips will appear automatically to introduce you to the application.

- Click on each tip to continue.

- **Date and Time Selection:**
  - Access Water Metric Steps website.
  - Click on the "my water meter" button.
  - Choose the date and time to know your consumption.

- **Turn on Notification:**
  - Access Water Metric Steps website.
  - Press the Profile icon next to your name in the navigation bar.
  - Click on notifications.
  - Click on the “on/off” button.

- **Contact Us:**
  - Login successfully.
  - Press the Contact menu in the navigation bar.
  - A new page with a contact form will appear.
  - Fill in your information and the message you want to deliver.
  - Press the “Send Message” button.

- **Logout:**
  - Press the “Logout” button in the navigation bar.
  - You will be redirected to the homepage.

3.6.2 **Admin**

- **Login**
  - Access Water Metric Steps website.
  - Press the “Login” button in the navigation bar.
  - The login page will appear.
  - Type in your username and password.
  - Press the” Login” button.

- **Answer Questions:**
  - Access Water Metric Steps website.
  - Click on the questions bot.
  - Click on usernames so you can answer their questions.

- **Have a summary:**
  - Access Water Metric Steps website.
  - Click on the summary icon.
  - Click on usernames so you can have a summary of the user's consumption.

- **Logout**:
  - Press the “Logout” button in the navigation bar.
  - You will be redirected to the homepage.

3.7 Non-Functional Requirements

- **Availability**:
  - The users of the system should be able to connect to the system whenever they need it.

- **Software Quality:**
  - The system will have a high software quality so it will not be down easily, therefore, as a result, the system will have user confidence.

- **Privacy:**
  - Users' information is confidential and can be accessible and usable only by authorized people.

- **Usability:**
  - Usability is the appearance of the user interface and how people interact with it. In our system, the interface will be easy and understandable to all users and organized in a way errors are minimized.

- **Maintainability:**
  - Maintainability is about how easily the software system can be modified to correct faults, improve performance, or other attributes, or adapt to a changing environment. Our system can be updated to meet the changes in user requirements.

- **Performance:**
  - The system should be responsive and fast. We used modern hardware to build our system so it should be fast.

3.8 Summary

In this chapter, we began by introducing the details of the requirements engineering starting with the Feasibility Study including the four measures that are used in assessing the overall feasibility which are Operational Feasibility, Technical Feasibility, Economic Feasibility, and Scheduling Feasibility. After that, we applied some techniques in gathering requirements like interviews and questionnaires, followed by mentioning the functional and non-functional requirements.

CHAPTER FOUR

4.0 SYSTEM DESIGN

4.1 Introduction

This chapter outlines the System Design stage. The purpose of this chapter is to provide sufficient detailed data and information about the system and its system elements. It includes a Context Diagram, Data Flow Diagram (DFD) continued by two UML diagrams which are the UML Sequence Diagram and UML Class Diagram. These modeling diagrams help understanding, recognizing, and describing user requirements. Moreover, they describe the structure of the software to be implemented and expand the logical thinking or the idea about the system.

4.2 Context Diagram

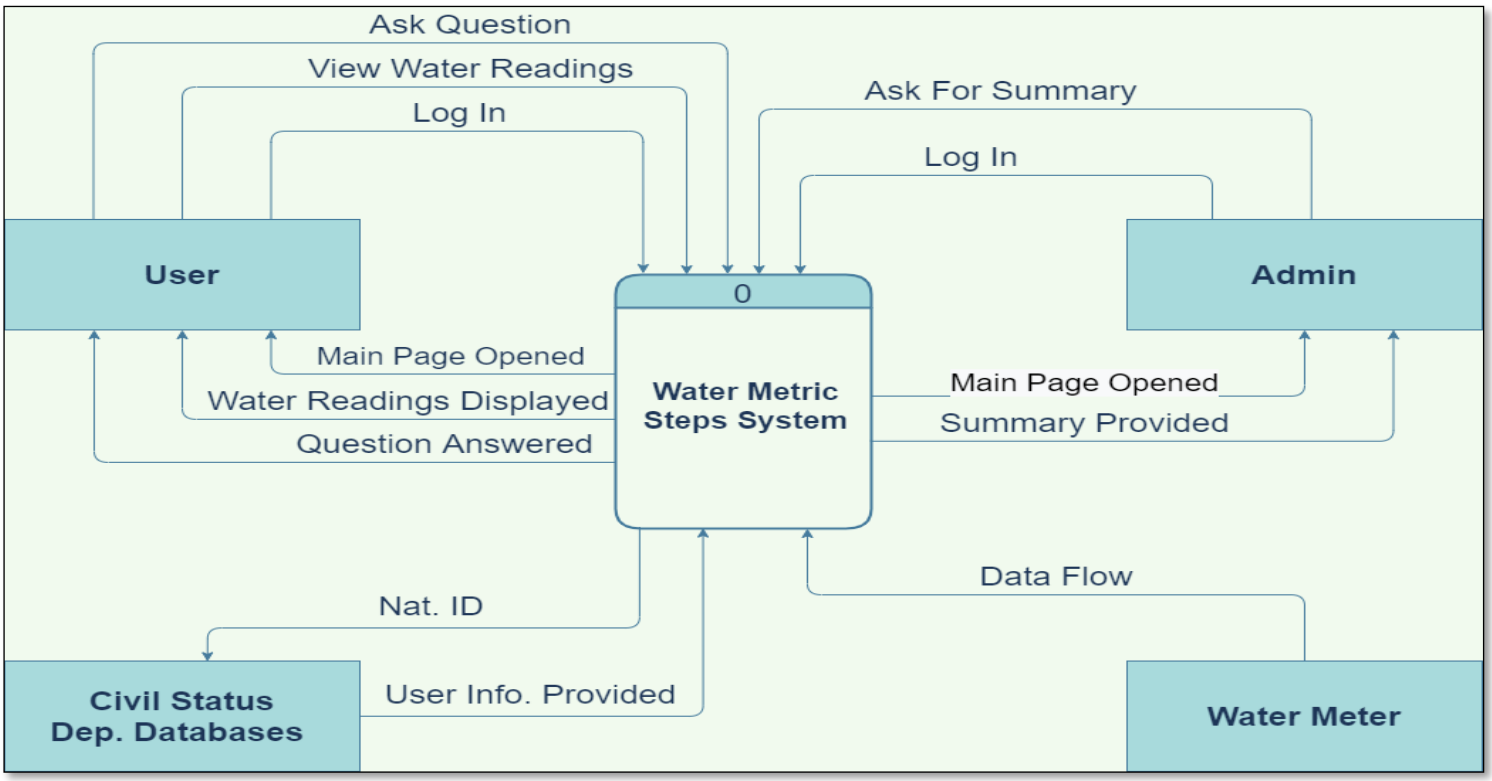


Figure 4.1: Context Diagram

4.3 Data Flow Diagram (DFD)

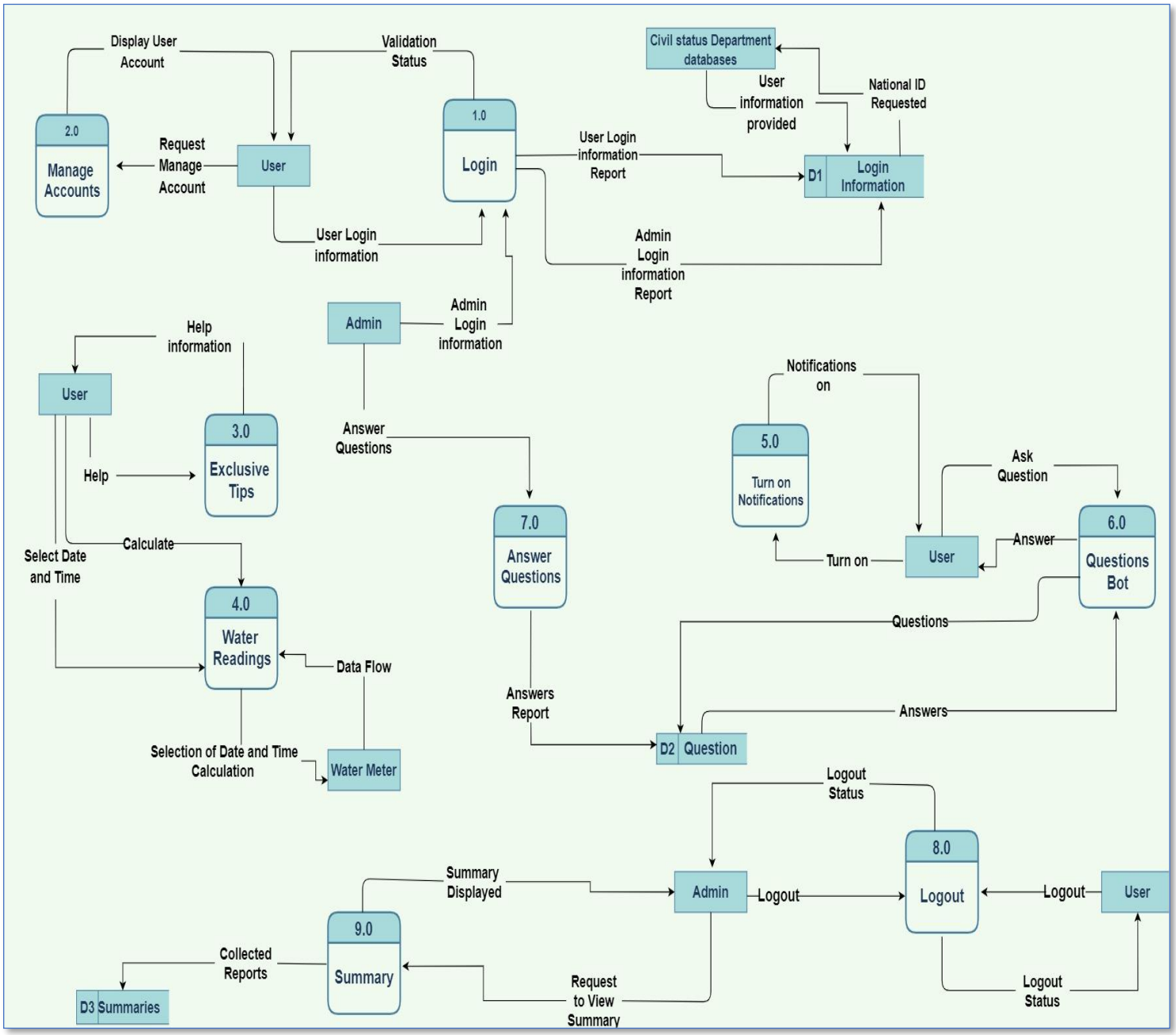


Figure 4.2: Data Flow Diagram

4.4 Entity Relationship Diagram (ERD)

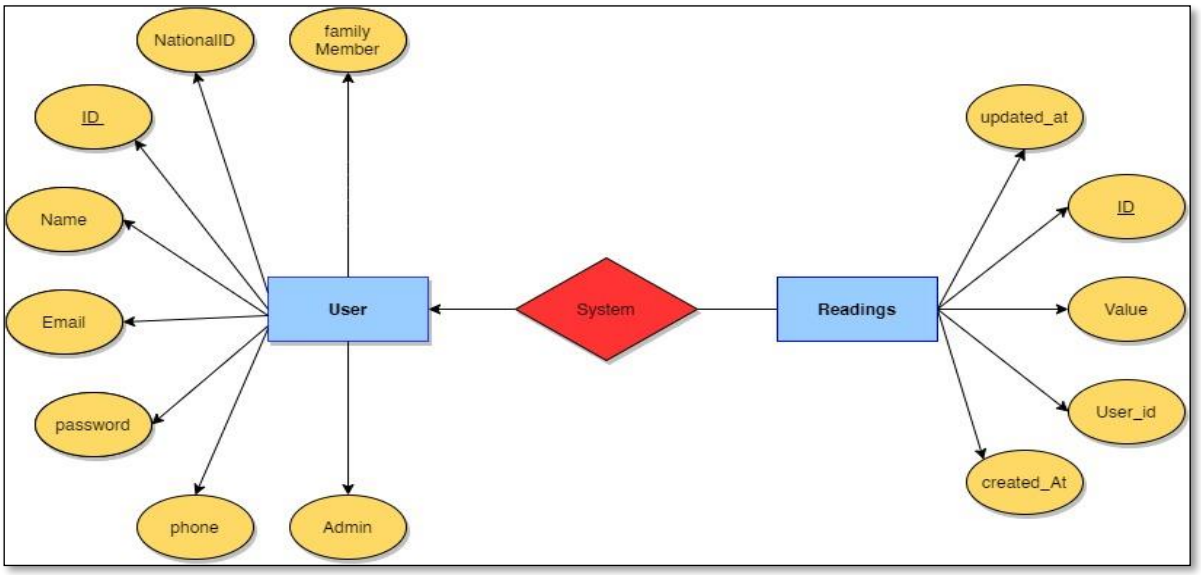


Figure 4.3: Entity Relationship Diagram

4.5 UML Use Case Diagram

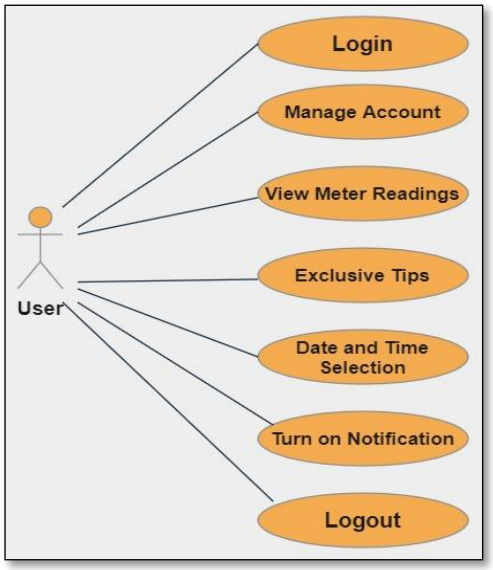


Figure 4.4: User- Use case

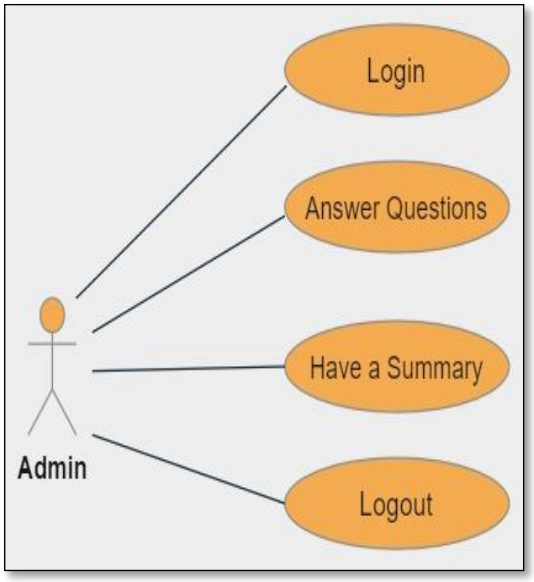


Figure 4.5: Admin-Use case

4.6 UML Sequence Diagram

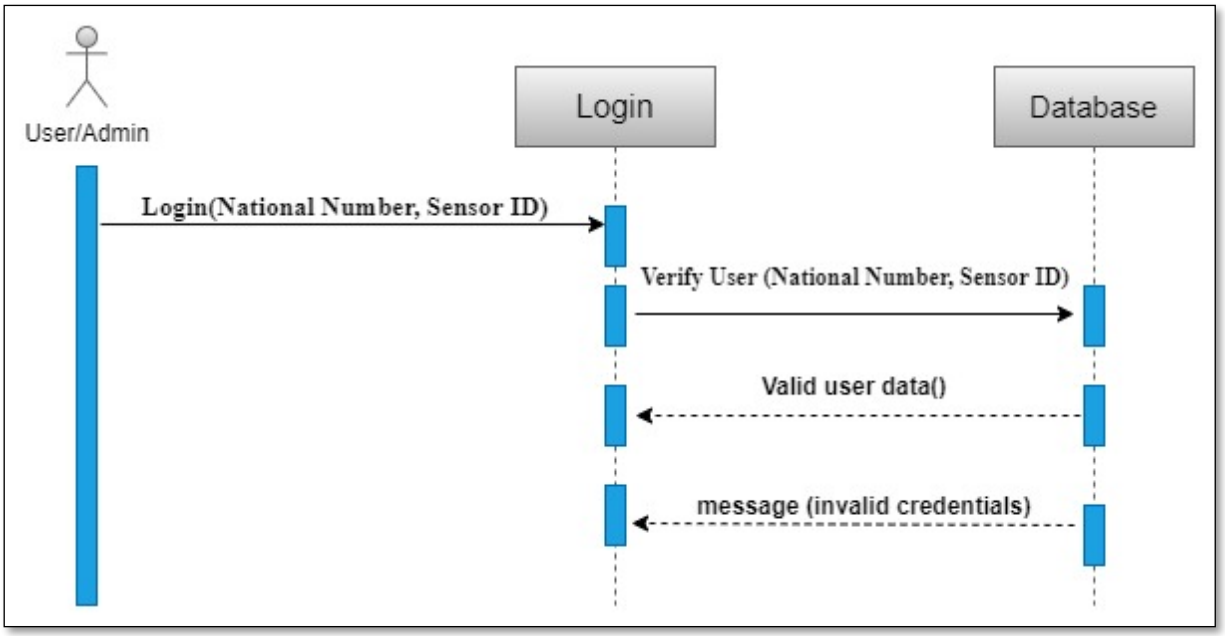


Figure 4.6: Login Sequence

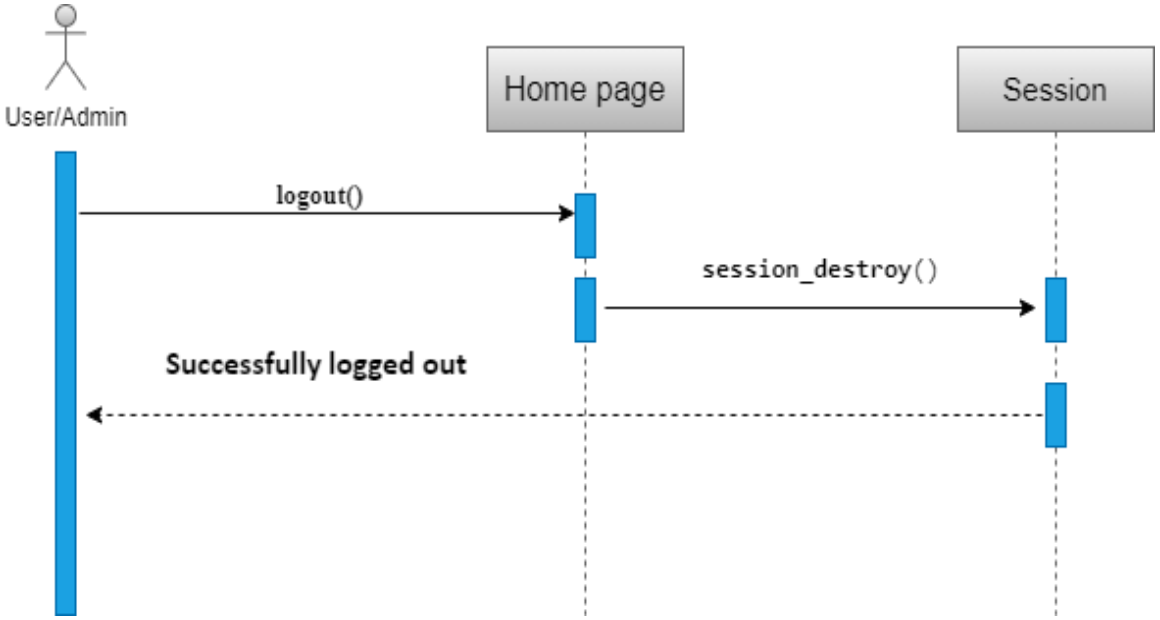


Figure 4.7: Logout Sequence

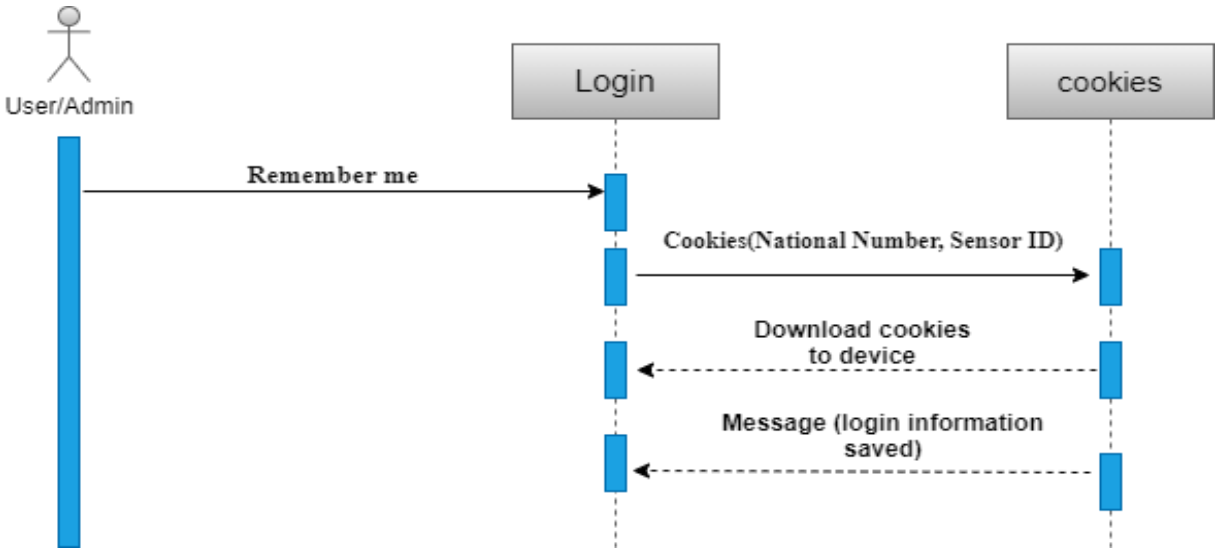


Figure 4.8: Remember Me Sequence

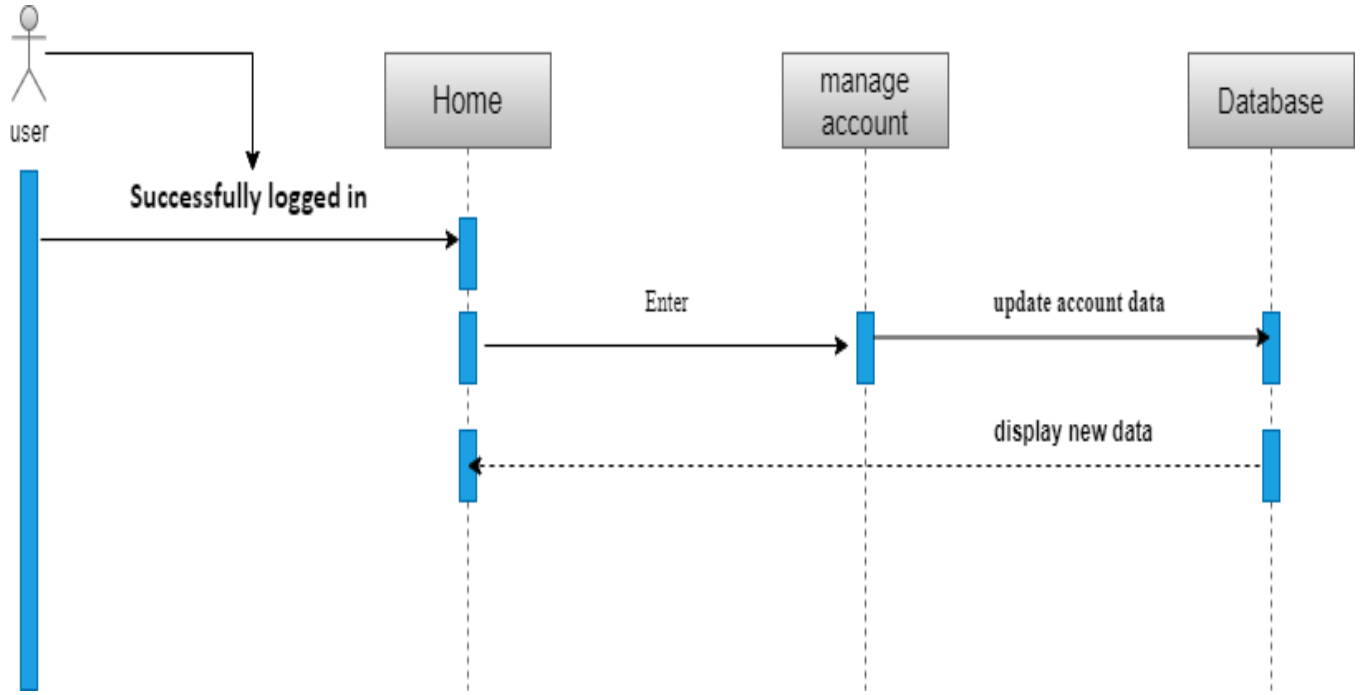


Figure 4.9: Manage Account Sequence

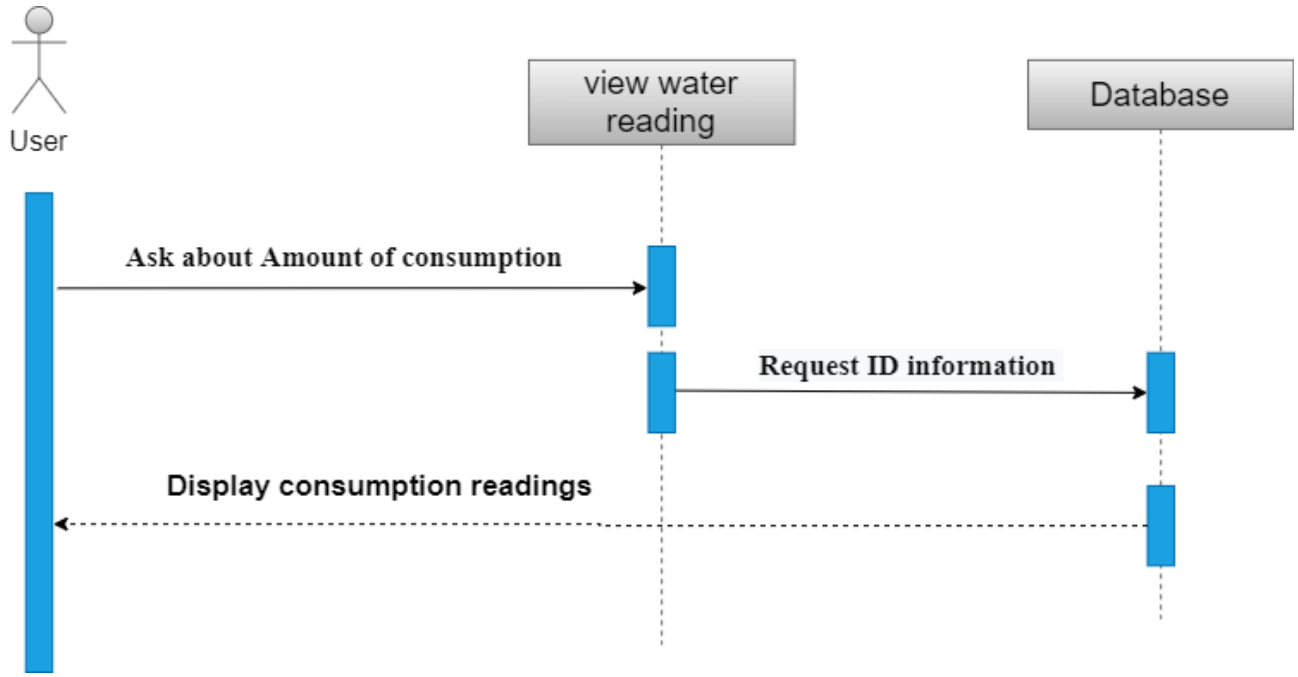


Figure 4.10: View Water Readings Sequence

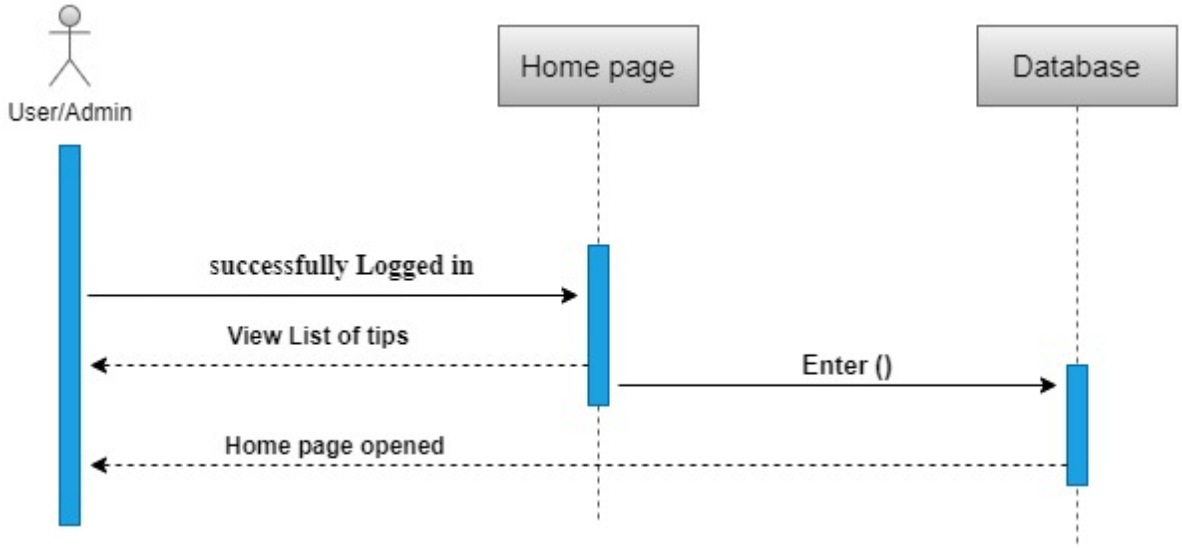


Figure 4.11: Exclusive Tips Sequence

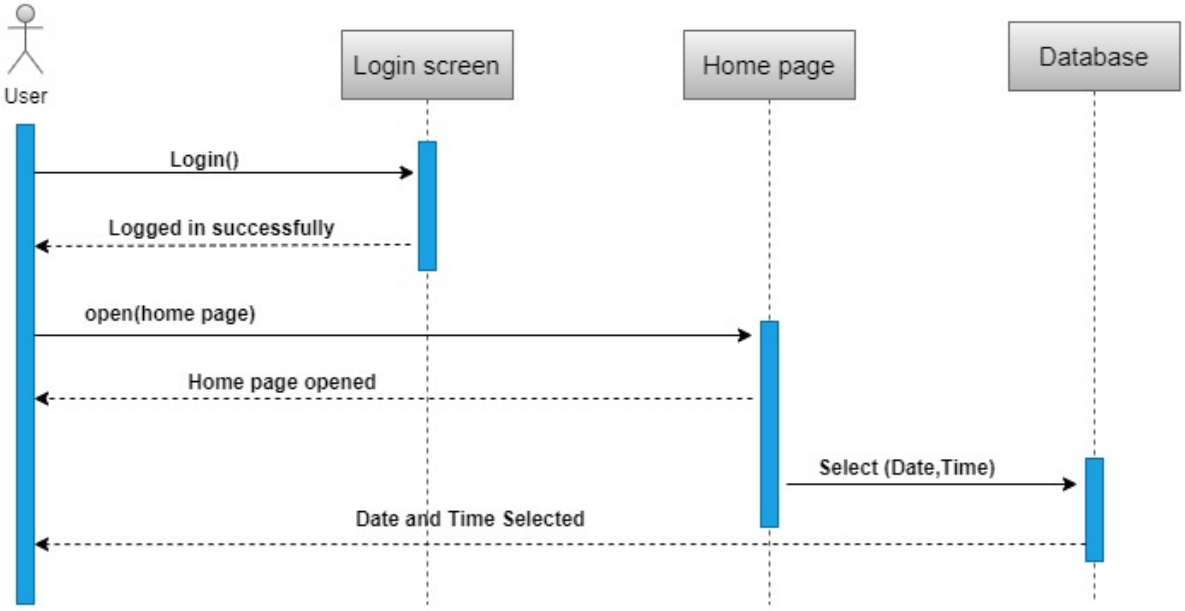


Figure 4.12: Date and Time Selection Sequence

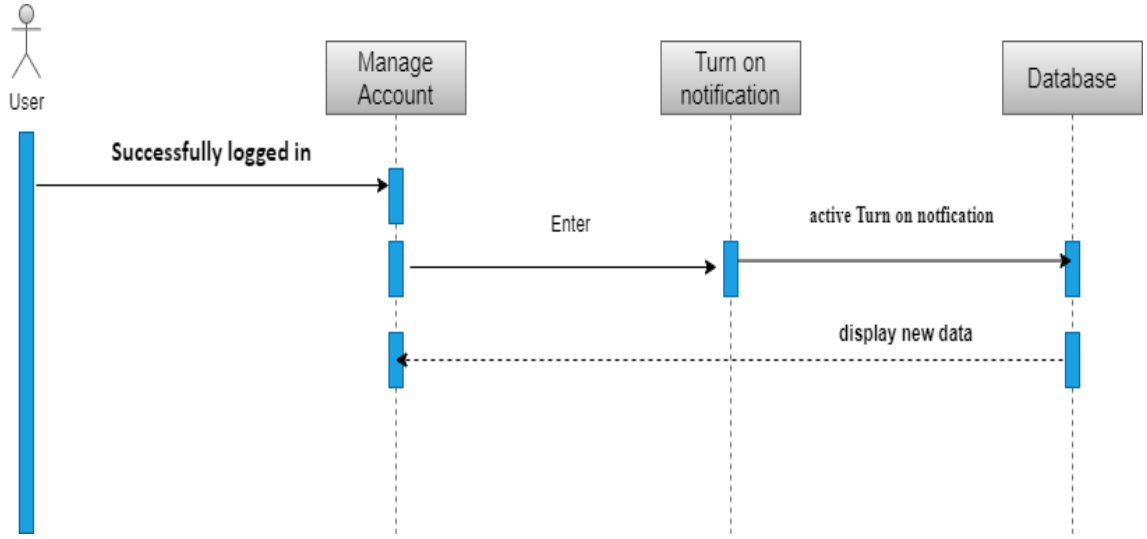


Figure 4.13: Turn on Notification Sequence

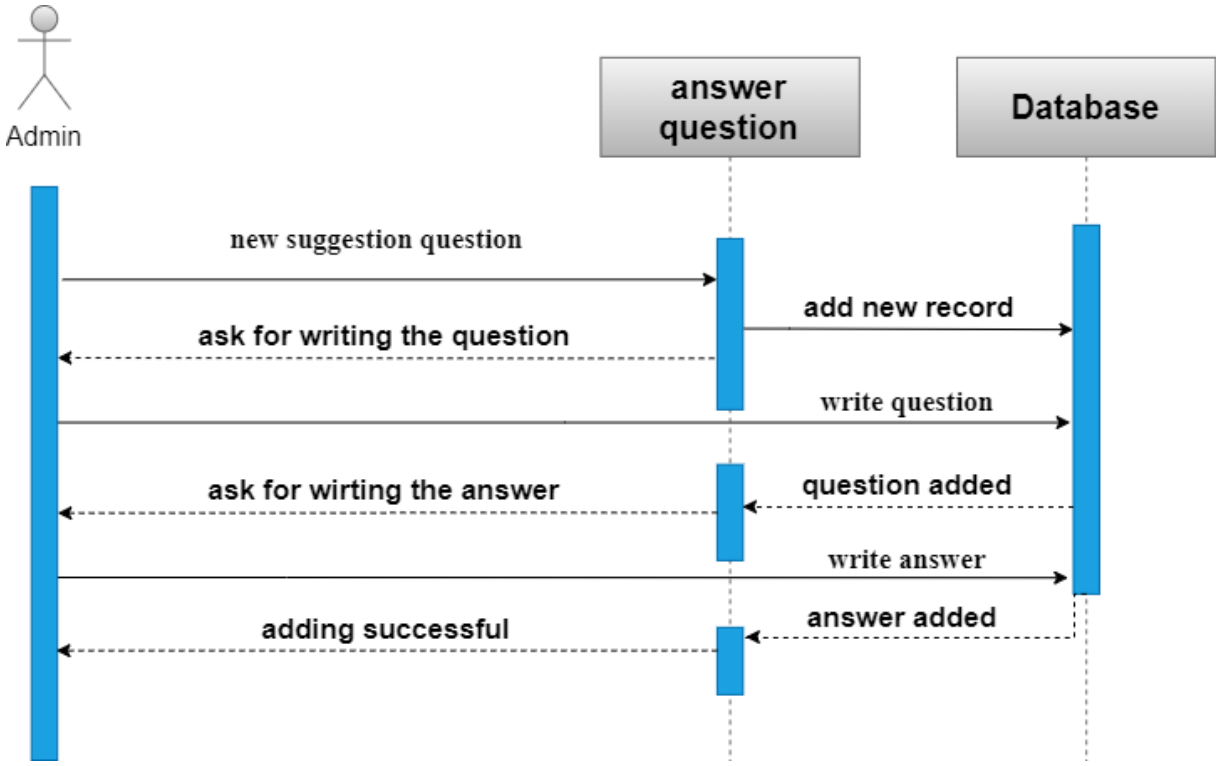


Figure 4.14: Answer Questions Sequence

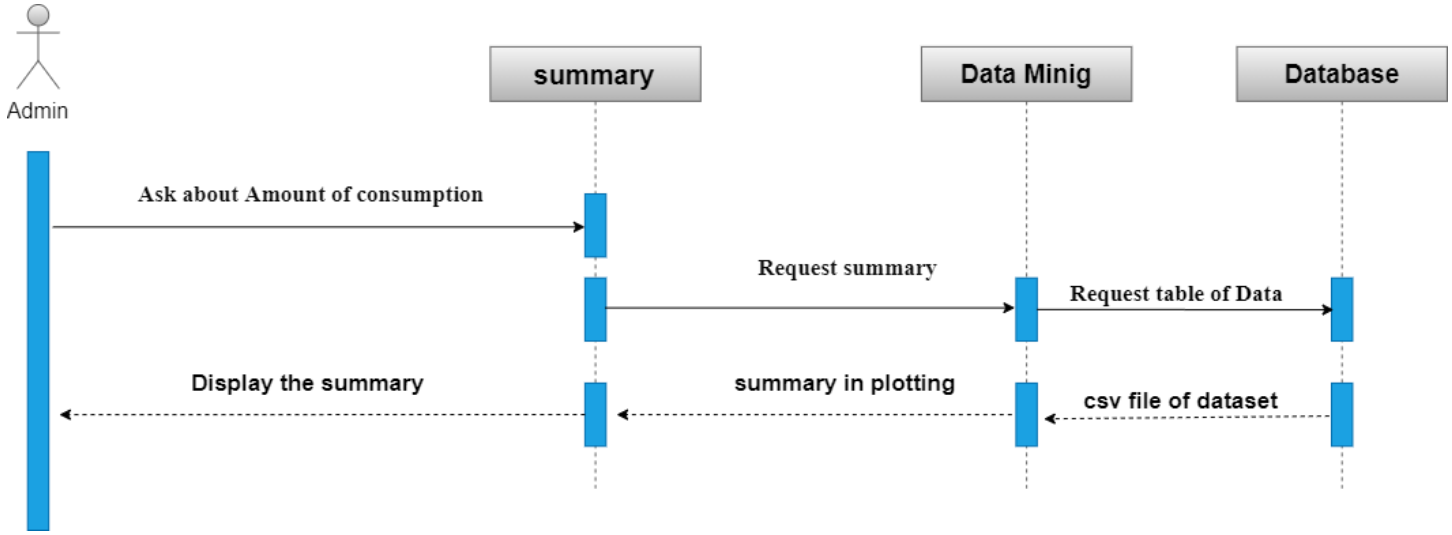


Figure 4.15: Have a Summary Sequence

4.7 UML Class Diagram

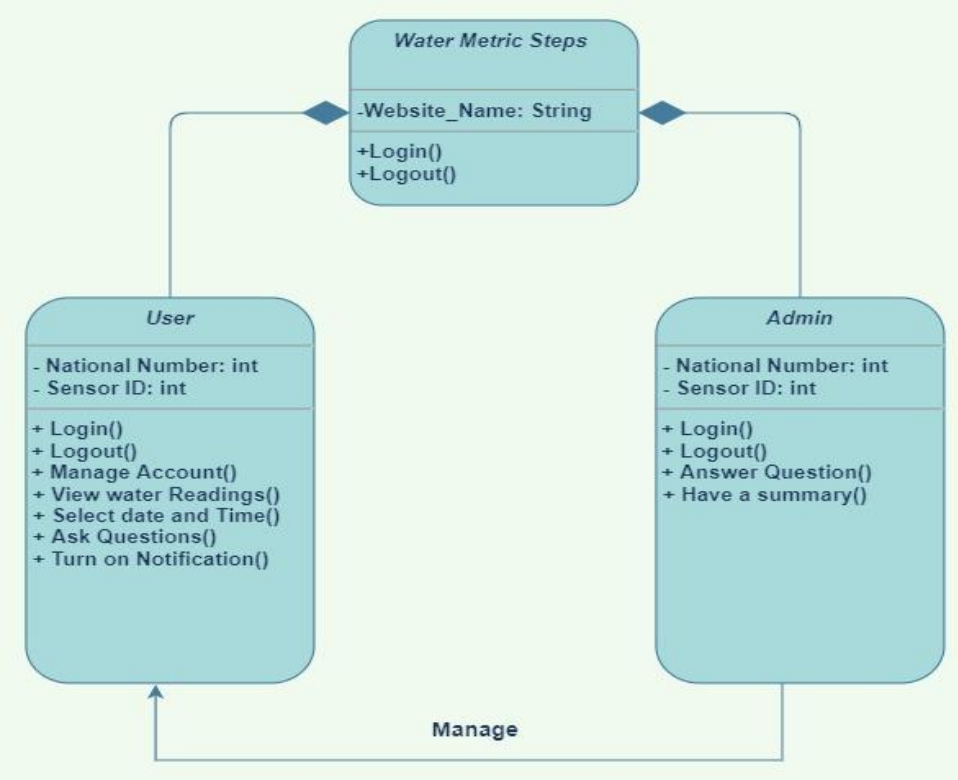


Figure 4.16: Class Diagram

4.8 Graphical User Interface (GUI) Design

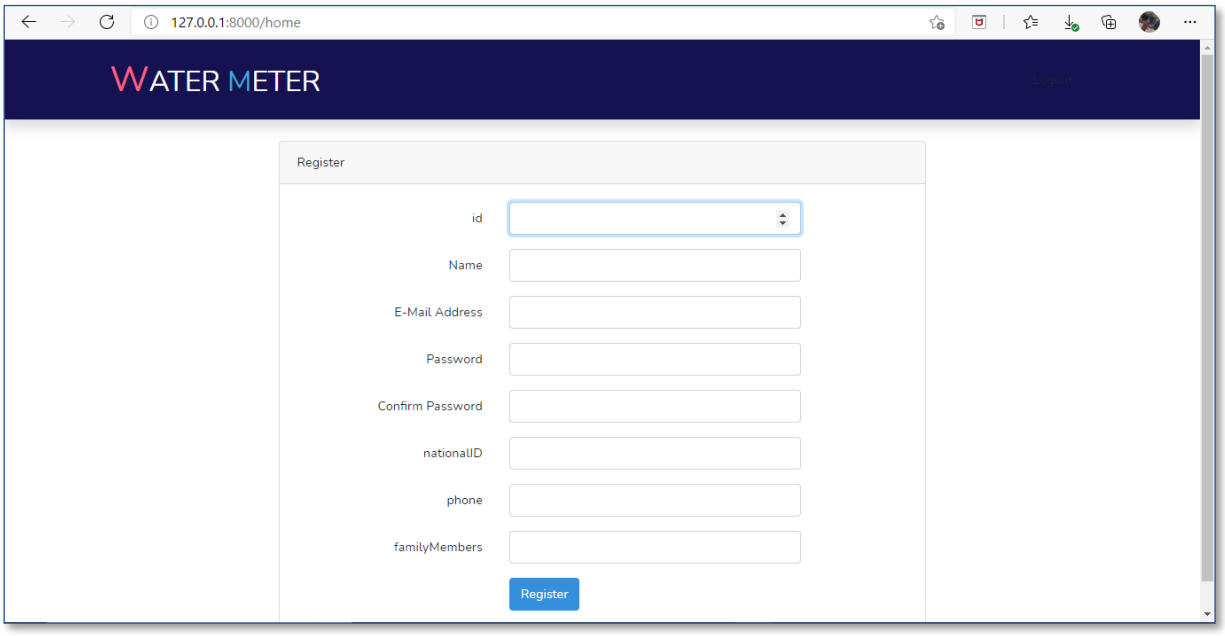


Figure 4.17: Register

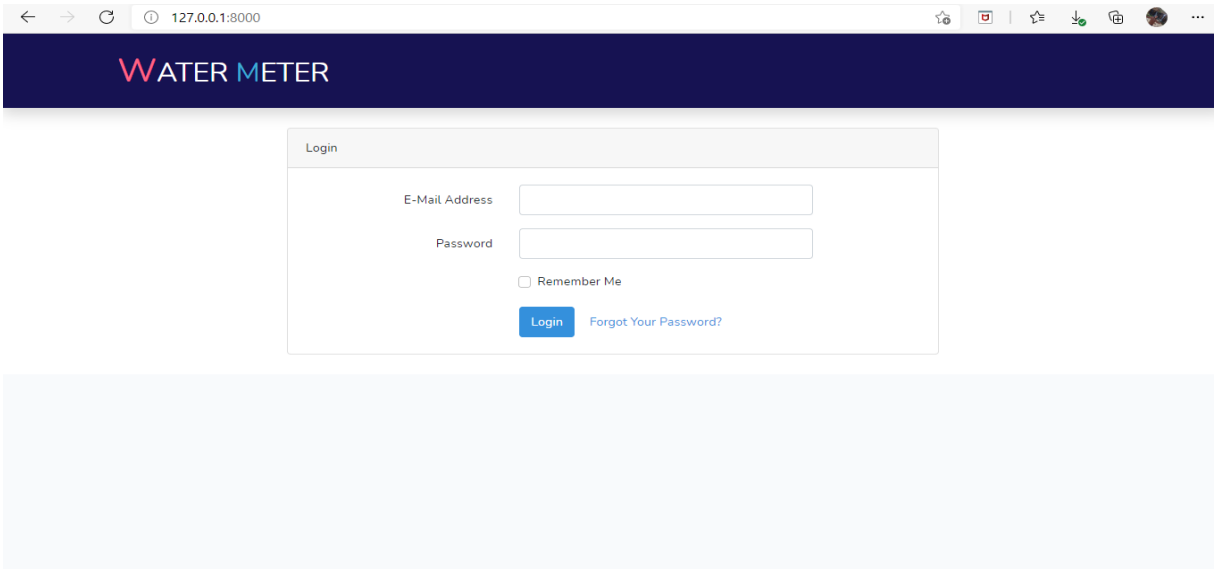


Figure 4.18: Login

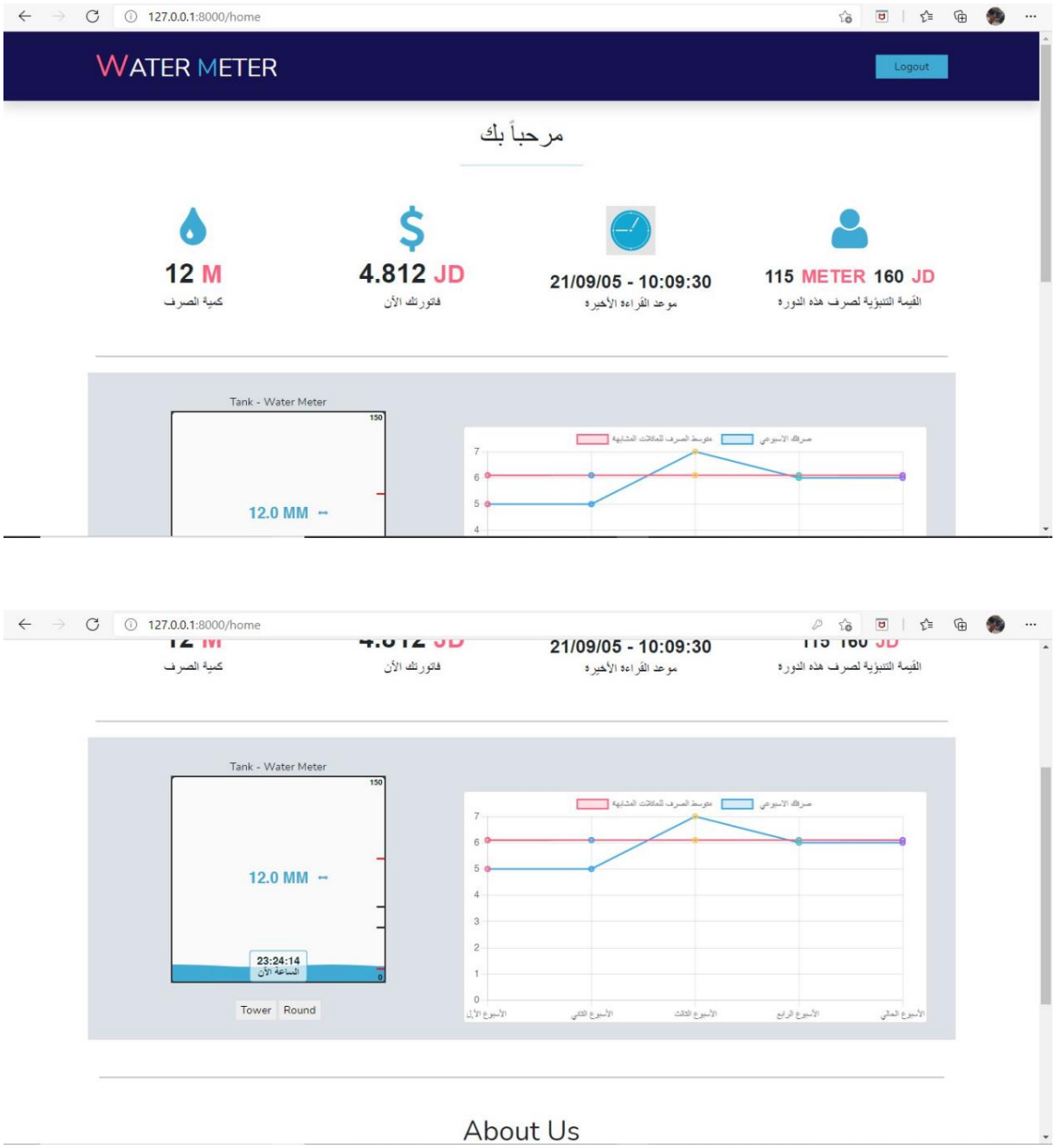


Figure 4.19,19: Home

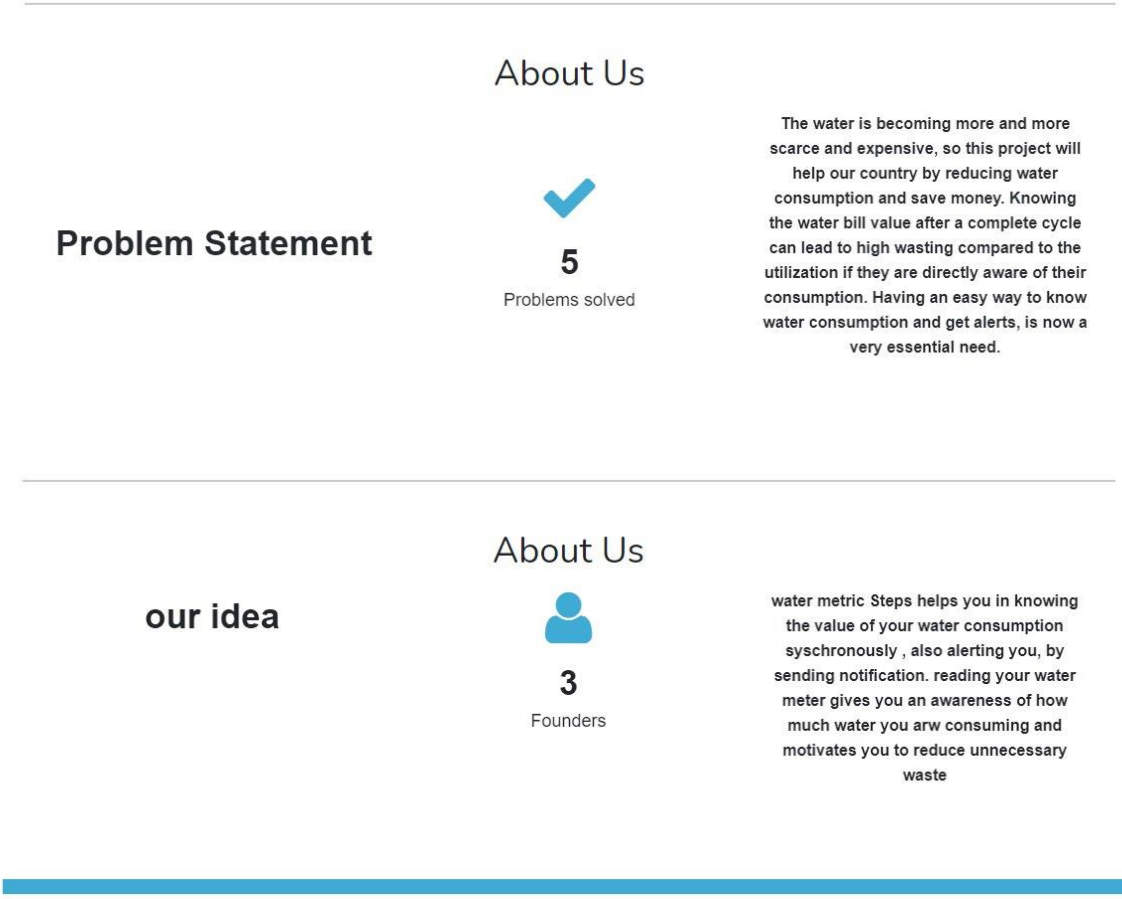


Figure 4.20,21: About Us

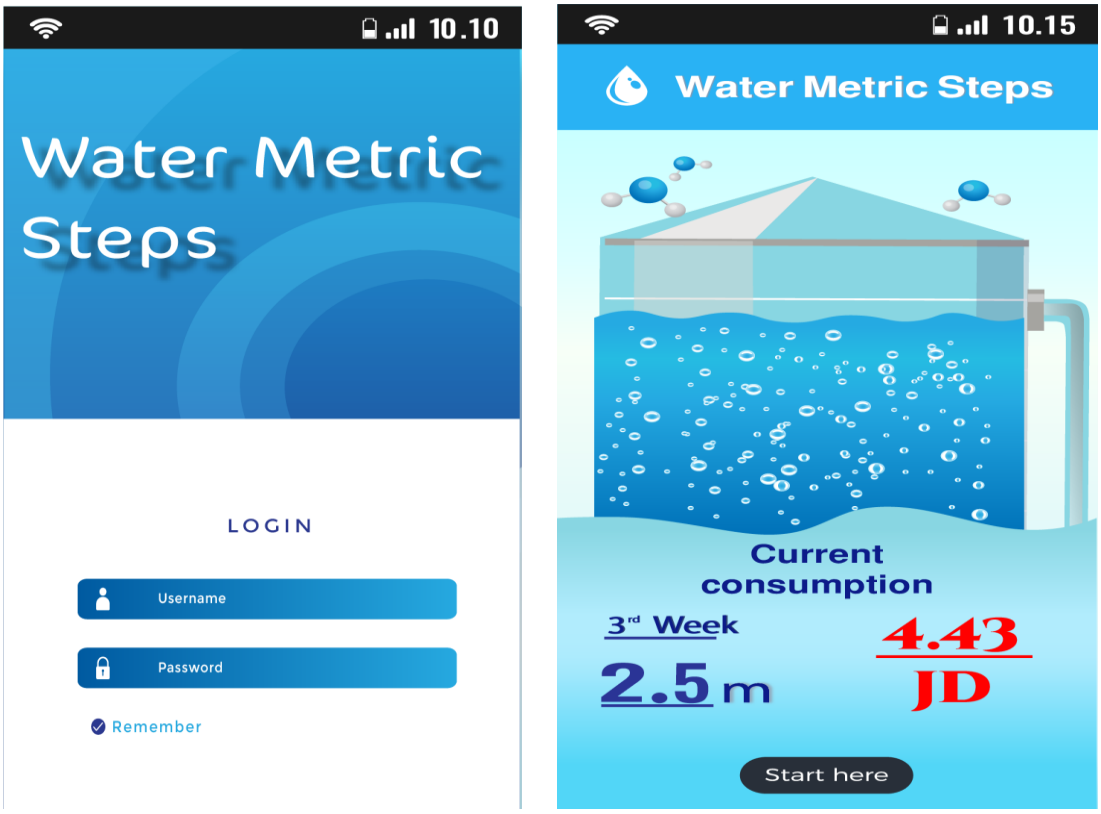


Figure 4.20: First-User Interface

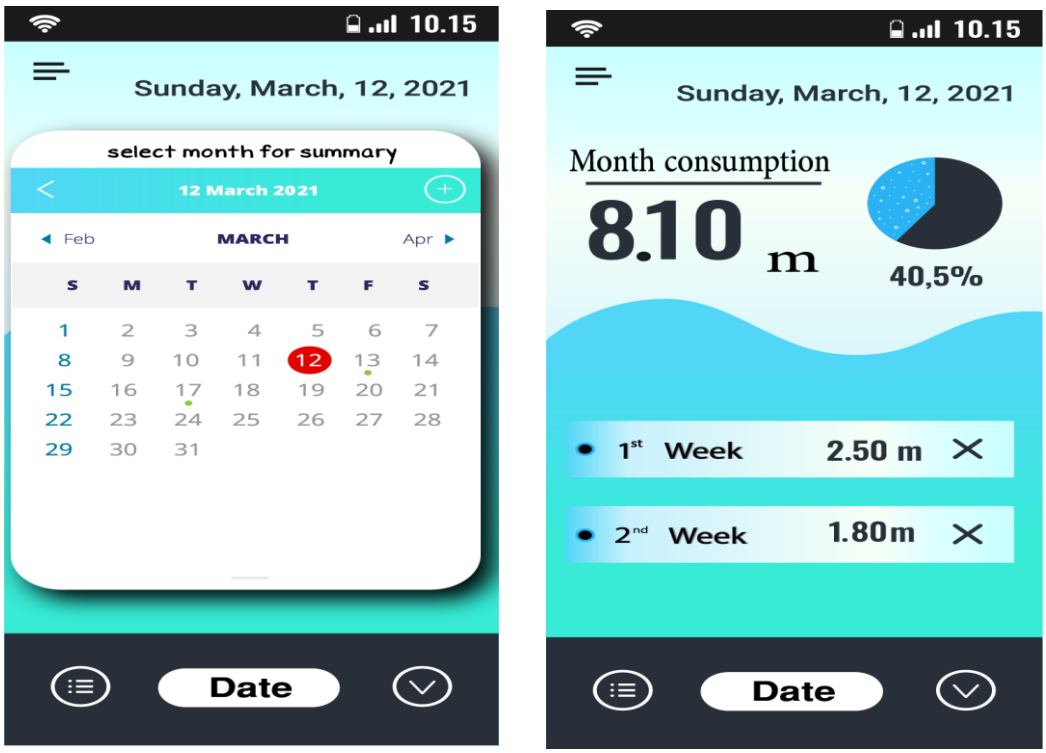


Figure 4.21: Second-User Interface

4.9 Summary

In this chapter, the overall structure was represented using many diagrams to help the analyst in understanding the functionality of the system. Also, functional requirements specifications were matched using the sequence diagram which makes it easier to understand the system.

5.0 CHAPTER FIVE: SYSTEM IMPLEMENTATION

5.1 Introduction

Up to now the system has been planned, analyzed, and designed. Now we will start with the implementation phase, in the implementation, we will use different programming languages for different parts of the website. The User Interface will be built using PHP Laravel framework in addition to JavaScript, jQuery, Bootstrap, CSS, HTML, PHP, SQL, and MySQL. And as for the Arduino part, it will be implemented on the Arduino IDE and the meter will be connected to both the website and the Arduino IDE. The website will contain a feature that will allow them to predict water consumption, and this feature will be implemented in the data science section using python.

In this chapter, we will go through Database Implementation, Graphical User Interface Implementation, Arduino implementation, Generated data implementation and lastly prediction models implementation.

5.2 Database Implementation

For our database implementation, we used PhpMyAdmin relational database which intends to handle the administration of MySQL over the Web. This database stores all the data needed for the website in two tables (Readings, Users). Below, you can see a specific description of each table.

5.2.1 Readings Table

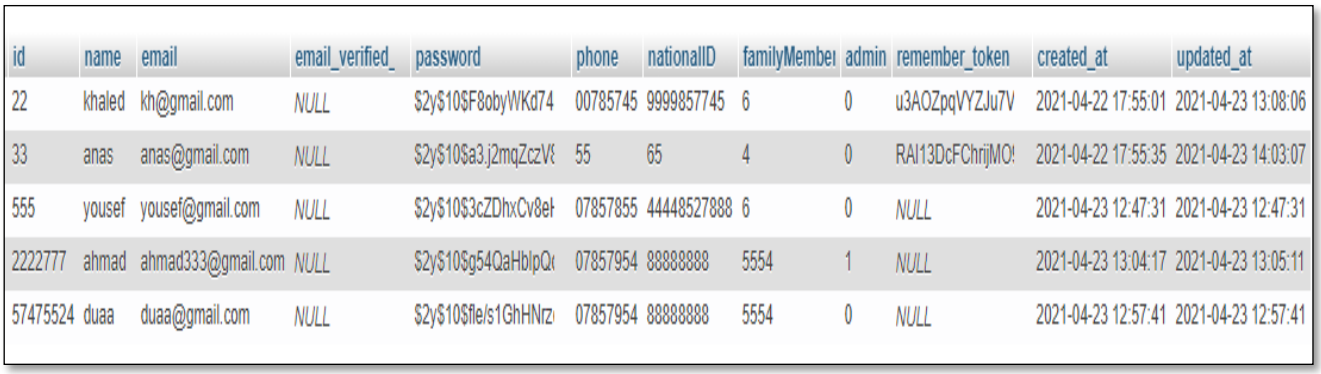
id	value	user_id	created_at	updated_at
2	55	33	2021-04-22 22:39:43	2021-04-25 20:09:52.000000
3	88	33	2021-04-22 22:58:46	2021-04-29 20:10:33.000000
5	6	22	2021-04-23 22:39:46	2021-04-30 20:10:50.000000
6	4	22	2021-05-01 20:44:32.000000	2021-05-07 20:11:24.000000
7	8	22	2021-05-14 20:44:30.000000	2021-05-21 20:11:45.000000
8	7	22	2021-05-22 20:44:29.000000	2021-05-29 20:12:05.000000
9	7	22	2021-05-29 20:44:27.000000	2021-06-06 20:12:27.000000
10	5	22	2021-06-07 20:44:23.000000	2021-06-14 14:28:19.000000
13	58	33	2021-05-07 12:11:28	2021-05-07 12:15:05

Figure 5.1: Readings Table

This Table has four attributes which are:

- ID: which is of type BIGINT (20), it stores the id of the meter and it is the primary key of the table.
- Value: which is of type DOUBLE (11), it contains the meter readings.
- Created at: which is of type TIMESTAMP. It stores the date and time the meter is read at.
- Updated at: which is of type TIMESTAMP. It stores the date and time the meter readings are updated at.

5.2.2 Users Table



id	name	email	email_verified_	password	phone	nationalID	familyMembe	admin	remember_token	created_at	updated_at
22	khaled	kh@gmail.com	NULL	$2y$10$F8obyWKd74	00785745	9999857745	6	0	u3AOZpqVYZJu7V	2021-04-22 17:55:01	2021-04-23 13:08:06
33	anas	anas@gmail.com	NULL	$2y$10$a3.j2mqZczV(	55	65	4	0	RAI13DcFChrijMO!	2021-04-22 17:55:35	2021-04-23 14:03:07
555	yousef	yousef@gmail.com	NULL	$2y$10$3cZDhxCv8eł	07857855	44448527888	6	0	NULL	2021-04-23 12:47:31	2021-04-23 12:47:31
2222777	ahmad	ahmad333@gmail.com	NULL	$2y$10$g54QaHblpQ(	07857954	88888888	5554	1	NULL	2021-04-23 13:04:17	2021-04-23 13:05:11
57475524	duaa	duaa@gmail.com	NULL	$2y$10$fle/s1GhHNrz	07857954	88888888	5554	0	NULL	2021-04-23 12:57:41	2021-04-23 12:57:41

Figure 5.2: Users Table

This Table has 12 attributes which are:

- ID: which is of type BIGINT (20), it stores the id of the meter and it is the primary key of the table.
- Name: which is of type VARCHAR (255). It stores the name of the user.
- Email: which is of type VARCHAR (255). It only accepts a unique email and stores the email address that the user chose to log in with.
- Email verified: which is of type TIMESTAMP. It stores a state if the email was verified or not.

- Password: which is of type VARCHAR (225). It stores the password of the user. It is encrypted using the Laravel Hash facade, which provides a secure Bcrypt hashing. Its length should be at least of 8 characters.

- Phone: which is of type VARCHAR (225). It stores the number of the user.

- National ID: which is of type VARCHAR (225). It stores the national ID of the user and its unique.

- Family member: which is of type INT (11). It stores the family number of the user.

- Admin: which is of type TINYINT (1). It stores 1 if its admin and 0 if not.

- Remember Token: which is of type VARCHAR (100). It stores a unique token to save the username and password of the user to the browser if the user checks the "Remember Me" checkbox in the login page.

- Created at: which is of type TIMESTAMP. It stores the date and time the user is created at or registered.

- Updated at: which is of type TIMESTAMP. It stores the date and time the user is updated at.

5.3 Graphical User Interface Implementation

Below you can see a screenshot of the actual website which we have built, with these screenshots we will show you what is the output of every button you press or operation you do.

5.3.1 Registration page

The Registration page where you enter your information to successfully enter to the system and be a user by having a record in the database. See figure (5.3) below.

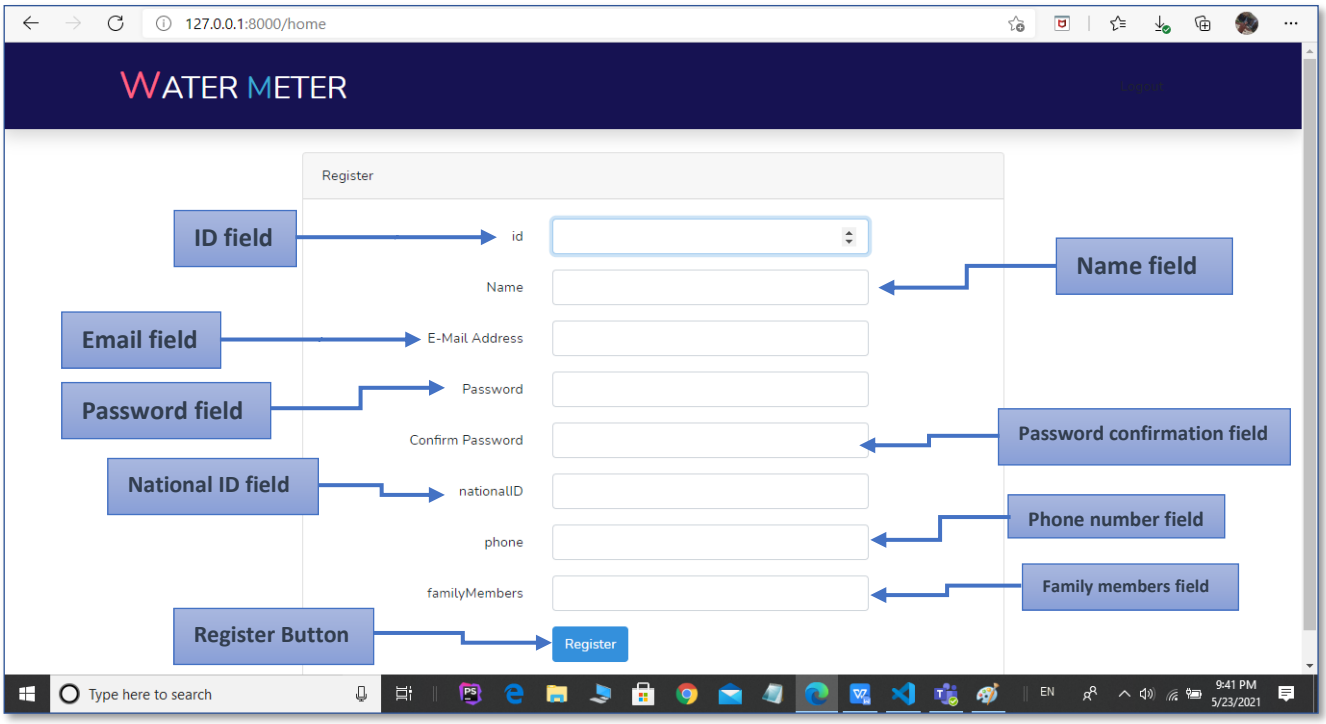


Figure 5.3: Registration Page

5.3.2 Login Page

The login page where you enter your email and password to successfully enter to the system (you must be registered in the system's database to be able to login successfully). See figure (5.4) below.

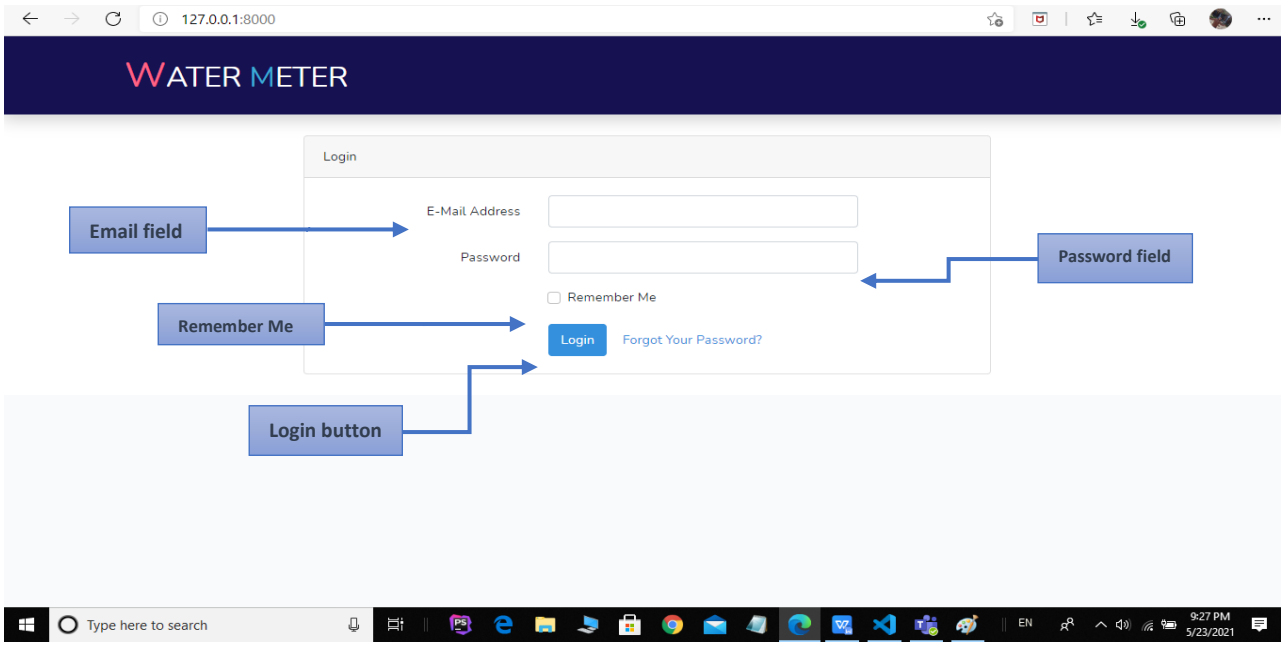


Figure 5.4: Login page

5.3.3 Home Page

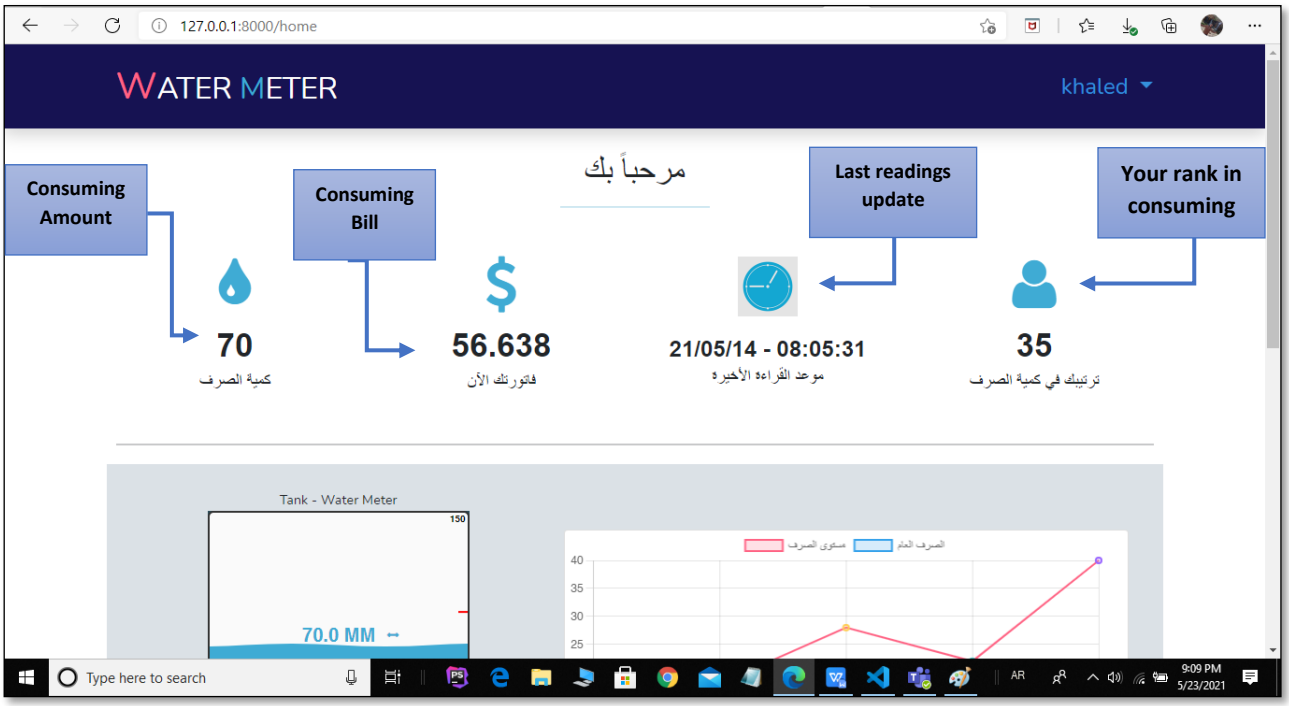


Figure 5.5: Home page 1

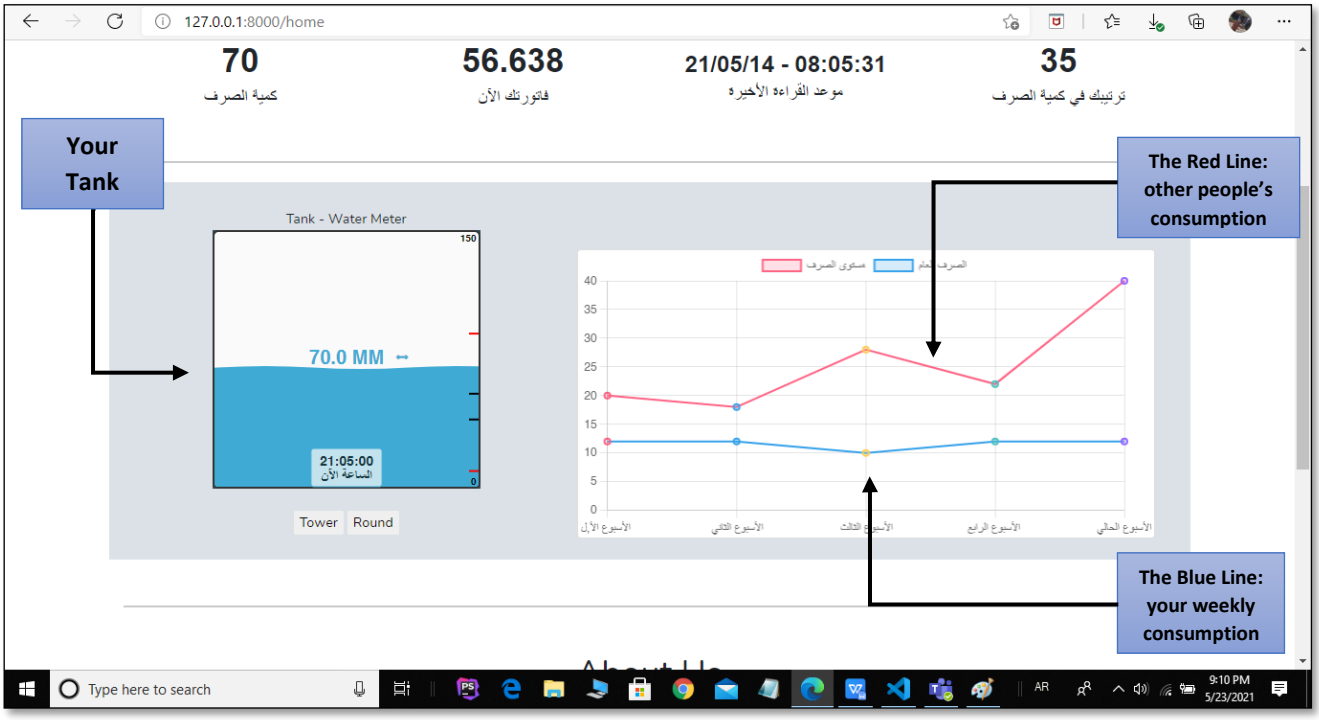


Figure 5.6: Home page 2

The home page where you can see your meter readings and many other features as appeared in figure (5.5) and (5.6) above.

- Consuming amount: Your water readings (every 3 months) will be appeared on the website under the drop icon as soon as you log in.

- Consuming bill: Your bill will be calculated as soon as you enter the website under the dollar sign icon.
- Last reading updates: your meter readings will be updated every 3 months, by the hour and date on the website under the hour icon.
- Your rank in consuming: you will be ranked based on your weekly water consuming in comparison with other families with similar number of family members.
- Your tank: it shows an easier way to know your water readings, also it ranges between the minimum and maximum value. The water increases as your consumption increases.
- The line graph: it shows two lines one with the red color indicates the other people's consumption and one with the blue color indicates your consumption.

Figure 5.7: Home page 3

About Us: at the end of the home page a brief description of our project was added including the idea, problem statement, and the project aim and objectives.

5.3.4 Phone GUI

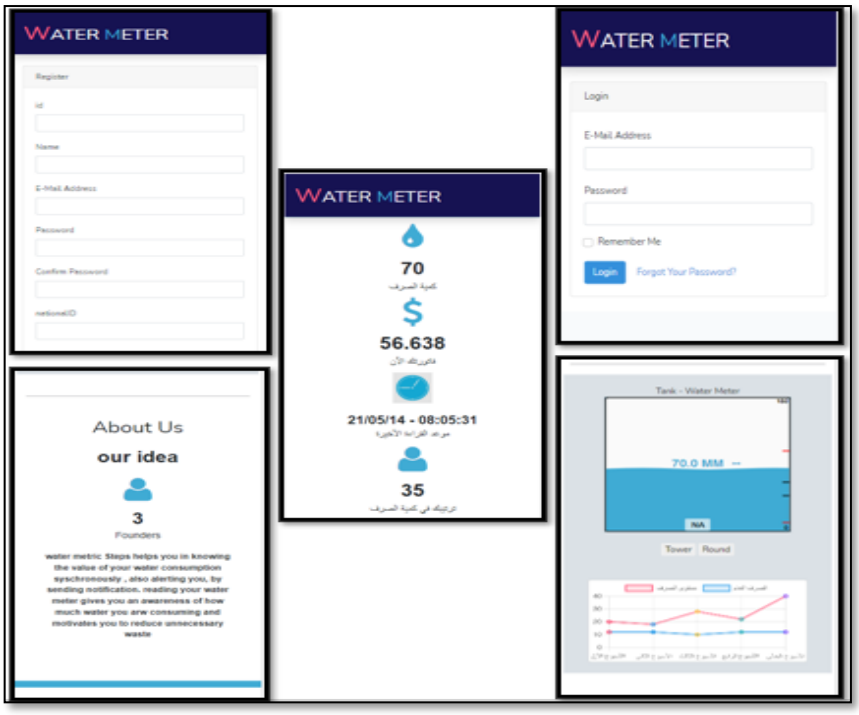


Figure 5.8: Phone GUI

5.4 Other Components Implementation

5.4.1 Arduino Implementation

We connected three pieces to the Arduino to build our water meter, as appeared in figure (5.9) below:

Figure 5.9: Meter pieces

These three pieces were the meter which deliver the water readings to the website:

- **Node MCU**: is an open-source LUA based firmware developed for the ESP8266 Wi-Fi. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware, which is based on the ESP-12 module. The firmware uses the Lua scripting language. It is based on the Elua project and built on the Espressif Non-OS SDK for ESP8266.
- **Power Bank**: is a portable charger designed to recharge your electronic devices when you are on the move. It is used to recharge the meter that will be connected to it.
- **Water Flow Meter**: A water flow meter is a device that measures the amount of water flowing through a pipe. It will be connected to both the Node MCU and the power bank.

These components were connected to present a whole one piece as a water meter, then this piece was programmed through the Arduino IDE with a well-written program after that it was added next to the tank in an appropriate place. Please refer to Appendix (A) for more details and the Arduino code.

5.4.2 Generated Data Implementation

A simulation of a dataset was created due to the lack of having a real dataset and the need for a very long time to collect readings of water consumption. In the beginning, the personal information of 10,000 users was generated which consists of national numbers, quadruple names, and device ID, as we will detail below. The other generated values were about individuals' water consumption rates and there were many influential factors the effects the amount of consumption, so we considered the user with a big

family will consume more than the one with a small family (unconscious numerical bias).

User ID	ID national	full name	family mer	seasons	weekly	monthly	by cycle
11666	9873698843	منير مد مد حميد	8	Spring	7.11	33.14	83.61
75296	9456605169	هبة عبد الساتر مجدلاوية علان	2	Summer	2.07	8.05	25.89
20350	9451799815	سامر عبدالغني مرزوق بداير	4	Summer	4.70	15.89	55.92
94396	9582029028	حنين عبد الحميد مجدي البسطامي	8	Winter	4.13	14.74	44.70
19178	9507702961	ايه محمد مرجان عقيل	9	Spring	8.63	30.77	102.08
71573	9773012954	ملك مخلوف مرزوق الفرج	8	Autumn	5.29	22.91	72.04
48541	9803107428	عبد الرحمن محسن محمود العزه	6	Winter	2.56	11.23	38.85
67042	9831238257	رؤى محمود مرزوق عربيات	8	Winter	3.96	16.25	53.99
95723	9683463637	همسه عبد الله عبدالفتاح جدو	6	Spring	5.91	25.85	68.53
77335	9802575548	فارس عبد الخالق يعرب لوباني	4	Spring	3.60	16.76	43.32

Figure 5.10: Sample of the data

As appeared in figure (5.10) a screenshot of the generated data was taken, and will be explained below:

- User ID: Consists of 5 numbers, a random function was used and called recursively. If the number was already created it will not be added to a list and written in the excel sheet, else it will be added.
- ID National: these numbers were formed starting from 9411 to 9972, which means who was born from 1941 to 1997, with ages ranging from 24 to 80 years old.
- Full Name: a file containing approximately 1000 quadruple names was used, where the names were separated and re-grouped randomly, and with this, we obtained 10,000 different quadrant names.
- Family members: a variable with a random number of members per family were created, where the range was from 2 to 9 individuals per family.
- Seasons: we have created a random value that bears one of the four seasons for each family. Where the average impact of the seasons was multiplying the consumption value by the value of the season and the range of the impact was from 0.6 to 1.4 per capita consumption according to the season, so that the distribution of the impact of the seasons was as follows:

Summer = consumption * [1.2 - 1.4)
Spring = consumption * [1.0 - 1.2)
Autumn = consumption * [0.8 - 1.0)
Winter = consumption * [0.6 - 0.8)

The last parameters, which are weekly, monthly and by cycle were generated based on this conception:

- As in most cases the consumption of a person in a family of 3 members is relatively less if the same individual is in a family of 9 members. We called this effect (unconscious numerical bias) because by increasing the number of individuals they go without

Consumption value + (consumption value x (number of people + 10/200))

Consumption value + (consumption value * (0.060 - 0.095))

realizing the increase in water consumption and the equation for this bias is the number of individuals plus 10 divided by 100. And that's the parameter according to the number of individuals is from 0.12 to 0.19 of the total value, with the rate of bias added as in the following equation:

Thus, it affects a small percentage of the consumption of the small family, while its influence is relatively large in the large family. Using the previous factors, we constructed random consumption values (weekly - monthly - periodic "three months") for each family. As a result, the equation will be as follows:

```
family_member   = random(2,10)
consumption     = random (90,125) Litter #diffrance random for each equation
Seasons_factor = random (0.6,1.5)
numerical_bias =(family_member+10)/200)*family_member -
                                    - * consumption*Seasons_factor*90/1000)

Equation :
weekly = family_member*consumption*Seasons_factor*7/1000)+numerical_bias
monthly = family_member*consumption*Seasons_factor*30/1000)+numerical_bias
periodic = family_member*consumption*Seasons_factor*90/1000)+numerical_bias
```

Figure 5.11: The equation of consumption

And since the data science needs many records for each family, to predict the water consumption, we repeated this process to obtain 10 records for each family, with a total of 100,000 records. Please refer Appendix (A) for more details with the full data and code.

5.4.3 Prediction Model Implementation

We used data science in our project to build a prediction algorithm and since it is a university project, we did not have the time to collect users' patterns in consuming water. As explained above generated data for 100,000 users were applied on two prediction models: Multiple Linear Regression, and Supported Vector Regression (SVR). This algorithm is important in predicting the water consumption (every 3 months) that a user is expected to consume based upon the number of their family member, the current season, and their weekly, monthly consumption. After comparing the results of each model, we got an accuracy of 0.952905 for the multiple linear regression and 0.952243 for the SVR model. And Since the multiple Linear regression had a slightly higher accuracy, we decided to use its equation as explained below:

$$\gamma = B_0 + B_1 * x_1 + B_2 * x_2 + B_3 * x_3 + B_4 * x_4 + B_n * x_n + \epsilon$$

This equation will be added to the website, so users can have predictions based on their uses. Please refer to Appendix (A) for more details on the preprocessing, training, and testing of the data to come up with results.

5.4.4 Arduino Model Implementation

A model for the meter pieces was built using SketchUp, the right measurements were taken and applied to the model. This model will act as a container to place the meter pieces in it and will save the model from rainy or sunny weather. Please refer to Appendix (A) for an illustration.

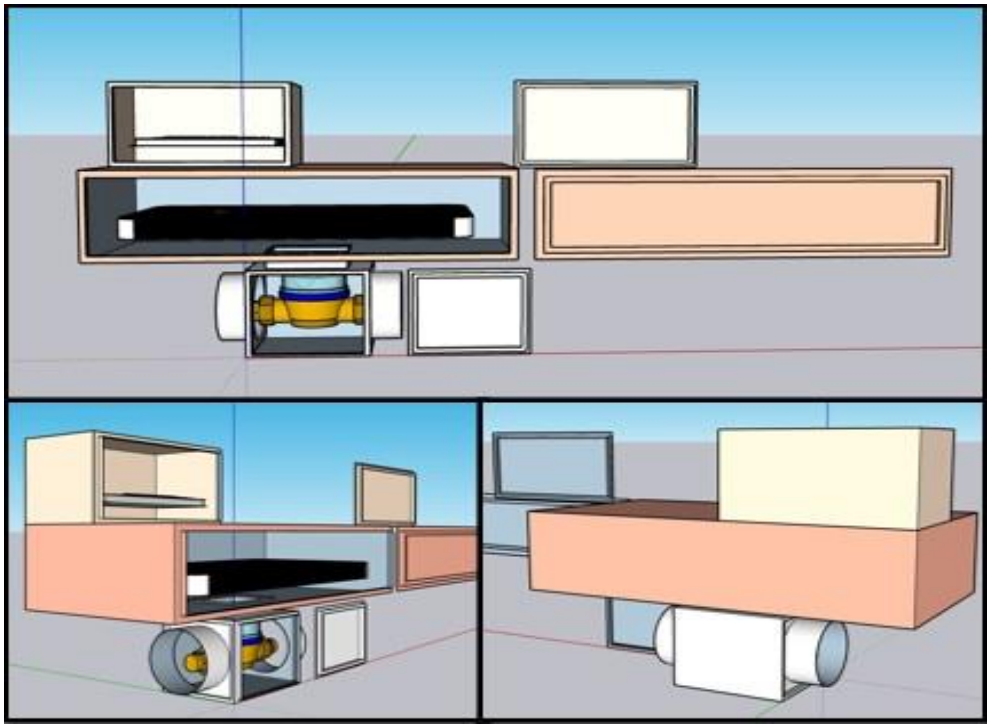


Figure 5.12: Meter model

5.5 Summary

For this project, a database with 2 tables was built using PhpMyAdmin. PHP Laravel were used to build the whole website shown in the figures in this chapter. And as for the other components Arduino IDE was used to implement the Arduino code. PyCharm also was used to build the generated data. And for the prediction algorithm google colab were used. Lastly, the Arduino model was created on SketchUp.

6.0 CHAPTER SIX: SYSTEM TESTING AND INSTALLATION

6.1 Introduction

System Testing is performed on the complete built system to evaluate its compliance with the corresponding requirements. To detect any irregularity between the units of the system, two evaluations will be performed; Heuristic Evaluation: will involve a small set of expert evaluators who examine the interface and assess its compliance with recognized usability principles, and Cooperative Evaluation: End-user will collaborate in evaluation. Finally, requirements will be tested to see whether the system accomplished them or not.

6.2 Heuristic Evaluation

Heuristic evaluation is a process where experts use rules of thumb to measure usability, such as lists, combo box, and database connection, and compare it against accepted usability principles. This evaluation was performed on a website by experts who basically examined the interface and judged its compliance with any heuristic techniques that employ a practical method that is not guaranteed to be optimal, perfect, or rational, but is nevertheless sufficient for reaching an immediate, short-term goal or approximation.

Kindly find below Heuristics in Table (6.1), and Severity Ratings in Table (6.2).

Table 6.1**:**Heuristics

Heuristics		Description
H1	Visibility of system status	Users should always be informed of system operations with easy-to-understand and highly visible status displayed on the screen within a reasonable amount of time.
H2	Match between system and the real world	The system should speak the users' language, with words, phrases, and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.
H3	Consistency and standards	Users should not have to wonder whether different words, situations, or actions mean the same thing.
H4	Aesthetic and minimalist design	The display must be reduced to only the necessary components for the current tasks, whilst providing clearly visible and unambiguous means of navigating to other content.

Table 6.2: Severity Ratings

Problem Type	Severity	Rating Description
No problem	0	I do not agree that this is a usability problem at all.
Cosmetic	1	The cosmetic problem only: needs not to be fixed unless extra time is available on the project.
Minor	2	Minor usability problem: fixing this should be given low priority.
Major	3	Major usability problem: important to fix, so should be given high priority.
Catastrophe	4	Usability catastrophe: imperative to fix this before the product can be released.

Table 6.3: Summary of Violations by Heuristics

Heuristic Numbering Scheme	Frequency	Ratio%
H1	3	21.428
H2	3	21.428
H3	4	28.571
H4	4	28.571
Total	14	100%

Table 6.4: Summary of Violations by Severity Rating for Participant A

Severity Rating	Frequency	Ratio%
0	8	57.142
1	4	28.571
2	2	14.285
3	0	0

4	0	0
Total	14	100%

Table 6.5: Summary of Violations by Severity Rating for Participant B

Severity Rating	Frequency	Ratio%
0	6	42.857
1	3	21.428
2	2	14.285
3	2	14.285
4	1	7.142
Total	14	100%

Table 6.6: Summary of Violations by Severity Rating for Participant C

Severity Rating	Frequency	Ratio%
0	10	71.428
1	3	21.428
2	0	0
3	1	7.142
4	0	0
Total	14	100%

6.3 Cooperative Evaluation

Cooperative Evaluation is a procedure for obtaining data about problems experienced when working with a software product so that changes can be made to improve the product. In this type of evaluation, end users are included. Please find participants' details in Table (6.7).

Table 6.7: Participants' Details

	Participant 1	Participant 2	Participant 3
Age	26	30	34
Gender	Male	Female	Male
Educational Level	BSc	BSc	BSc

6.3.1 Pre-Evaluation Procedures

Before the collaborative evaluation begins, a form of it and a questionnaire were well prepared. The participants were contacted and asked to participate in the cooperative evaluation and a brief introduction about the website was explained to them. Then, the participants were told that they will be asked to perform a list of tasks that will be monitored and timed, and they were also asked to think out loud while performing the tasks.

6.3.2 Evaluation Procedures

During the evaluation session, participants were accompanied to help them when they face problems in performing a specific task. The table below shows the Cooperative Evaluation tasks that are tested by the participants. As a user and admin. However, the actual testing forms are included in Appendix B.

Table 6.8: Cooperative Evaluation Tasks

Task #	Task	Time	Comments
1	Sign Up		
2	Log in		

3	Forget password		
4	Log out		

Table 6.9 includes results of the Cooperative Evaluation showing task completion times for participants compared against the default time allocated for each task.

Table 6.9: Task Completion Times in Minutes and Seconds

Task #	Default Time	Participant 1	Participant 2	Participant 3
1	00:30	00:33	00:37	00:40
2	00:10	00:15	00:11	00:19
3	00:05	00:05	00:08	00:03
4	00:03	00:05	00:04	00:02

6.3.3 Post-Evaluation Procedures

After completing the Cooperative Evaluation, participants were given a post-test questionnaire to fill in. This questionnaire was important to capture their thoughts and feelings about the website. Table (6.10) shows the responses of a scale from 1 to 5 of the three participants to the post-test questionnaire.

Table 6.10: Participants Responses to the Post-Test Questionnaire

#	Question	Participant A	Participant B	Participant C	Average
1	Water Metric Steps is easy to understand?	4	5	3	4
2	Did you find Water Metric Steps useful?	4	5	5	4.6
3	Water Metric Steps accomplished its goals?	5	4	4	4.3

4	Would you recommend this app to your friends?	5	5	5	5
5	Are the measurements accurate?	5	4	5	4.6
6	Did the website help you in rationalizing water consumption?	4	3	5	4
Average		4.5	4.3	4.5	26.5

6.4 System Installation

6.4.1 Laravel Framework

To install Laravel framework once Composer is installed, download the 4.2 version of the Laravel framework and extract its contents into a directory on your server. Next, in the root of your Laravel application, run the php composer. Phar install (or composer install) command to install all the framework's dependencies. The link bellow shows how to install the Laravel framework step by step:

https://laravel.com/docs/7.x/installation

6.4.2 PhpMyAdmin

To install PhpMyAdmin download the installer .exe from the Toolbox App web page. Run the installer and follow the wizard steps. After you run the Toolbox App, click its icon in the notification area and select which product and version you want to install. The link bellow shows how to install the PhpMyAdmin step by step:

https://www.phpmyadmin.net/downloads/

6.4.3 Php Storm

To install Php Storm download the installer .exe from the Toolbox App web page. Run the installer and follow the wizard steps. After you run the Toolbox App, click its

icon in the notification area and select which product and version you want to install. The link bellow shows how to install the Php Storm step by step:

https://www.jetbrains.com/help/phpstorm/installation-guide.html

6.4.4 Visual Studio

Visual Studio can be downloaded from the following link:

https://visualstudio.microsoft.com/downloads/

Firstly, click on the downloaded .exe file, then click continue, Visual Studio will start downloading the initial files. The download speed will vary as per your internet connection. After that, click install. The link below shows how to install the Visual Studio step by step:

https://www.guru99.com/download-install-visual-studio.html

6.4.5 XAMPP

To install XAMPP download the installer .exe from the Toolbox App web page. Run the installer and follow the wizard steps. After you run the Toolbox App, click its icon in the notification area and select which product and version you want to install. The link bellow shows how to install the XAMPP step by step:

https://www.wikihow.com/Install-XAMPP-for-Windows#Steps

6.4.6 Arduino IDE

To install Arduino IDE, download the installer .exe from the Toolbox App web page. Run the installer and follow the wizard steps. After you run the Toolbox App, click its icon in the notification area and select which product and version you want to install. The link below shows how to install the Arduino IDE step by step:

https://www.arduino.cc/en/guide/windows

6.4.7 PyCharm

To install PyCharm download the installer .exe from the Toolbox App web page. Run the installer and follow the wizard steps. After you run the Toolbox App, click its icon in the notification area and select which product and version you want to install. The link below shows how to install PyCharm step by step:

https://www.jetbrains.com/help/pycharm/installation-guide.html#toolbox

6.4.8 SketchUp

Visit the download page on SketchUp's website:

https://www.sketchup.com/try-sketchup

Pick how you intended to use Sketchup. You can choose between Professional, Personal, Higher Education, or Primary & Secondary. To try Sketchup Pro, you'll have to choose Professional. If you choose Personal, select your field of interest and agree to the Sketchup Privacy Notice. You should be directed to the free browser-based version. If you entered Professional, you will have to input information about your company, where you live, as well as your profession. You may also be prompted to create an account before proceeding. Fill in your information. Click the "Download Sketchup Pro" button. The website should start to download the appropriate installer.

6.5 Summary

Each of the Heuristic and the Cooperative Evaluations has its own method in assessing the overall usability of the application. After performing both evaluations, results were represented in tables as shown earlier, some issues were considered and fixed.

7.0 PROJECT CONCLUSION AND FUTURE WORK

7.1 Introduction

A conclusion is often referred to as the last section of any paper, research, or report. It recaps ideas in a clear, summarizing manner. In this chapter, section 7.2 introduces the overall weaknesses that have been issued, as well as mentioning some features that can improve the website but unfortunately are missing. On the other hand, overall strengths are stated in section 7.3. Future work and a summary are also included in sections 7.4 and 7.5 subsequently.

7.2 Overall Weaknesses

Heuristic and Cooperative Evaluations were used in specifying the usability weaknesses of our website. The results and statistics of these evaluations are detailed in chapter 6. However, using the website offline would not give any updates on the water readings and the other features, also the need to recharge the power bank that is connected to the water meter almost every week is a must. And the generated data is not real, so this affects the prediction accuracy.

7.3 Overall Strengths

Comparing with the related existing systems, Water Metric Steps is considered the only website that provides the user updates about their water consumption every 10 minutes, also provides predictions before the user consumes water based on their past consumptions, so this will help them in rationalizing the water consuming. And the user can notice an abnormal decrease or increase in consumption, so this will give them a sign that they have to check if there is a problem in their water tank.

7.4 Future Work

Future work is either to fix issues addressed in the current release of the website or suggest new ideas, features, and requirements that are not implemented. The following are some ideas and requirements we are planning to be implemented in Water Metric Steps in the near future.

- Develop our project in the Android system.
- Add exclusive tips for users.
- Add the calculated bill and paying it through our system.
- The warning notifications of an abnormal decrease or increase will be sent automatically to users.
- The water meter will be charged through solar energy.
- The user's data will be collected for analysis and prediction algorithms.
- The water meter will be resized to a smaller size.

7.5 Summary

All systems undergo many challenges and issues addressed after the system has been developed. Overall weaknesses and strengths have been stated to inform the reader of the capabilities of Water Metric Steps, in addition to the future work planned to be achieved regarding the website that involves the adding of new features and requirements to the system.

8.0 References

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Appendix A

Implementation's Code

1. The Arduino Full code is in the below link:
   https://drive.google.com/file/d/1apI_htNF-eP4_c8PKvr8yGFdbsLXtzNu/view?usp=sharing

2. The generated data documentation, code, and the data is in the below link:
   https://drive.google.com/drive/folders/1VF30gIFQ2iuHLviJfi8iB-TCLS4imr8R?usp=sharing
3. The prediction algorithm code is in the below link:

https://drive.google.com/file/d/1KjvBdVAMjVxp-d9B6Sqo-bKpKfMx0Wab/view?usp=sharing

4. A capture of the model is in the below link: https://drive.google.com/file/d/14V1TwdBPZ4Q5HWONBam1f6FGNXyDtYOV/view?usp=sharing

Appendix B

Heuristic Evaluation System Checklist

Please fill in the evaluation form below, which is a form of checklist, by circling the appropriate place which mostly describes the best answer to the corresponding criterion. This form is to be filled after you have investigated the system interface i.e., have looked at and examined the interface. The answer to each criterion is either:

0: I do not agree that this is a usability problem at all.

1: Cosmetic problem only: need not be fixed unless extra time is available on project.

2: Minor usability problem: fixing this should be given low priority.

3: Major usability problem: important to fix, so should be given high priority.

4: Usability catastrophe: imperative to fix this before product can be released.

H1. Visibility of System Status

The system should always keep user informed about what is going on, through appropriate feedback within reasonable time.

Review Checklist	Severity	Comments
Is there some form of system feedback for every operator action?	(0) (1) (2) (3) (4)	
Are responses times appropriate to the users cognitive processing?	(0) (1) (2) (3) (4)	
Is there visual feedback in after hovering on the graphs?	(0) (1) (2) (3) (4)	

H2. Match between System and the Real World

The system should speak the user's language, with words, phrases, and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.

Review Checklist	Severity	Comments
When prompts imply a necessary action, are the words in the message consistent with that action?	(0) (1) (2) (3) (4)	
Are the graphs and icons familiar to the users?	(0) (1) (2) (3) (4)	
Are icons concrete and familiar?	(0) (1) (2) (3) (4)	

H3. Consistency and Standards

Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.

Review Checklist	Severity	Comments
Are icons labeled?	(0) (1) (2) (3) (4)	
Is vertical and horizontal scrolling possible in the window?	(0) (1) (2) (3) (4)	
Does the window have a title?	(0) (1) (2) (3) (4)	
Is the content of the graph understandable?	(0) (1) (2) (3) (4)	

H4. Aesthetic and Minimalist Design

The display must be reduced to only the necessary components for the current tasks, whilst providing clearly visible and unambiguous means of navigating to other content.

Review Checklist	Severity	Comments
Are the icons visually and conceptually distinct?	(0) (1) (2) (3) (4)	
Does each icon stand out from its background?	(0) (1) (2) (3) (4)	
Does each data entry screen have a short, simple, clear, distinctive title?	(0) (1) (2) (3) (4)	
Are field labels brief, familiar, and descriptive?	(0) (1) (2) (3) (4)	

Appendix C

Cooperative Evaluation

Cooperative Evaluation tasks testing forms for participant 1:

Task #	Task	Time	Comments
1	Sign Up	00:30	No Comments
2	Log in	00:10	No Comments
3	Forget password	00:05	No Comments
4	Log out	00:03	No Comments

Cooperative Evaluation tasks testing forms for participant 2:

Task #	Task	Time	Comments
1	Sign Up	00:37	No Comments
2	Log in	00:11	No Comments
3	Forget password	00:08	No Comments
4	Log out	00:04	No Comments

Cooperative Evaluation tasks testing forms for participant 3:

Task #	Task	Time	Comments
1	Sign Up	00:40	No Comments
2	Log in	00:19	No Comments
3	Forget password	00:03	No Comments
4	Log out	00:02	No Comments