An-Najah National University
Faculty of Engineering and Information Technology

E-Governance in Palestine and the MENA Region (INDIGO) Project

Project#1
Water and You

This Project done in cooperation between:

Computer Engineering Department

Urban Planning Department

Urban & Regional Planning Unit

Jamain Municipality

GIZ

IND'GO Towards Citizen-Centered and Inclusive Digital Governance in Palestine

التعاون الألماني DEUTSCHE ZUSAMMENARBEIT

Implemented by giz

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DISCLAIMER

This report was written by Walaa Dweikat and Sabah Ba'ara at the Computer Engineering Department, Faculty of Engineering, An-Najah National University. It has not been altered or corrected, other than editorial corrections, as a result of assessment and it may contain language as well as content errors. The views expressed in it together with any outcomes and recommendations are solely those of the students. An-Najah National University accepts no responsibility or liability for the consequences of this report being used for a purpose other than the purpose for which it was commissioned.

Acknowledgment

First, praises and thanks to God, the Almighty, for His showers of blessings throughout our graduation project work to complete it successfully. We would like to express our extreme and sincere gratitude, thankfulness and love to our families for being with us and keep guiding us throughout our lives to reach this point and to be able to finish this graduation project.

We are extremely grateful to our supervisor Dr. Anas Toma. Absolutely, we would like to express our thankfulness to our friends and out great doctors and all of the computer engineering teaching staff and all of the department

1 Abstract

Water is considered to be a very important part of life. However, there are many regions in Palestine suffering from the lack of water that is provided to citizens from municipalities. Many municipalities in Palestine buy quantities of water and distribute it to industrial facilities, as well as the homes of citizens. Moreover, there is high population growth, where all of this led to disproportional water distribution. In addition, there is the problems with the scarcity of data available, as there is only an old water system scheme that needs to be modernized.

This project proposes a solution which is to build a mobile application as well as a website based on the human centred design; this proposed solution is focusing on the citizens needs and municipality's members in Jamain, how could we make municipality's work easier and how to meet the needs of citizens. this project is targeting both citizens and water department employees. It is consisting of a service request system, a complaints system, and a billing system, in addition to collecting information about citizens, organizing the management of water taps according to a number of standards, and creating a water network diagram showing the location of the main water valves and subscribers to each valve. Finally, there will be the distribution system which tries to distribute water all over the citizens to get the less total amount of complaints.

Water Service has both a website and a mobile application; the mobile application is built using Flutter framework which is based on Dart programming language, while the website is built using ReactJs.The back-end is build using flask framework which is used to build a REST API with python. The back-end is communicating with the database to fetch the data. MY-SQL database is used for this project. The website is using leaflet maps,while the mobile app is using google maps. Python was used to build the distribution system which calculate the time needed for every distribution area to pump enough water. The project went through the entire development process from scratch, starting from building the interfaces (the GUI) for the website and the mobile app, then the database using MY-SQL with Apache web server, then, the distribution system was build. Finally, putting everything together.

2 Introduction

2.1 Problem

- disproportional water distribution which could led to lack of water for some citizens.
- the scarcity of data available, They don‘t have a database to document the data related to water services, or the maintenance work for the water network. There is only an old water system scheme that needs to be modernized.

2.2 Objectives

Developing a software to redistribute the water from municipalities to the citizens in order to reduce the number of complaints, and creating a database to store all of the water services information to help in the process of documenting their data. Finally, showing all of the data on a map the water network, the water services, and the complaints

2.3 Project Scope

In this project, we focused our work on Jamain Municipality, we studied and collected our data from it.

2.4 Report Organization

Third chapter (Constraint, Standards , Earlier Coursework)
At first, it explains the limits and the constrains in this project , then it mentions the previous courses we took which were helpful for us to complete out project.

Forth chapter (Literature Review)
it discuss the previous related work and explains the differences between it and our work.

Fifth chapter (Problem Core)
it explains what is the exact problem and what is used to solve it.

Sixth chapter (Methodology)
it explains the whole process to build this project and shows the tools and the languages were used.

Final chapter (Conclusion and Future work)
this chapter shows what we have learnt in the development process and will mention some future work.

3 Constraints, Standards, Earlier Coursework

3.1 Constraints

3.1.1 Data and requirement collecting

The process of collecting the data was difficult and needed some time to finish it. We needed to go to Jamain Municipality to understand the requirements and collect the data.

3.1.2 Time limit

About 3 months to build the whole application, from collecting the requirements,building the database, designing and building the interfaces (GUI) for both website and mobile app , the back-end, and finally putting all the things together was a big work to do and a huge challenge for us.

3.2 Standards

3.2.1 Client Server Model

The Client Server Model is used to build this project using the 3 tiers model [4]. The project is divided into three tiers as the following.

- **Server**:
  it is written using flask (python) ans it is responsible of the application logic, sending requests to the database and serve the coming requests from the front-end (the client)
- **Client**:
  it is the interfaces that the user sees (the website and mobile app GUI), it is sending requests to the back-end and shows the result.
- **Database**:
  it is built using MY-SQL database with Apache web server. It is responsible of serve the request coming from the back-end server

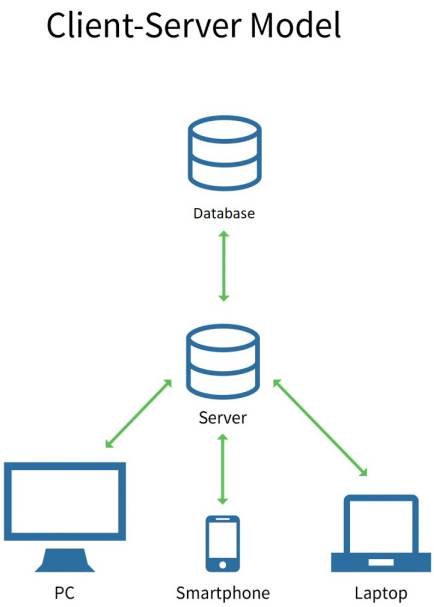


Figure 1: client server model

3.2.2 Water-Flow Model

We used Water Flow mode for this development process. The following is the steps and tasks throughout the development process:

- Understanding the problem, gathering all of the needed requirements and data
- building the database
- design and build the website and mobile app GUI
- build the back-end server using flask.

3.3 Earlier Coursework

The course we took in Computer Engineering Department has helped us to develop this project, such as Web Programming, Database, and Object-Oriented Programming. Moreover, we took online courser for leaning ReactJs, Flutter, Flask and python.

4 Literature Review

Municipal drinking water is considered one of the most critical issues due to population growth, scarcity of water sources, and the diversity of components of the water network such as stopcocks, municipal tanks, and subscribers citizens. Over many years, efforts have been made to reduce costs, whether maintenance costs, purchase costs, etc.

There are many mobile applications related to municipalities, such as the Nablus municipality application, but these applications are similar to our applications only in complaints and services. They do not provide the advantage of improving the time required for pumping, as they only tell us the places of pumping for that day This research [2] use a genetic algorithm in order to schedule pumping time, the giving time depends on technical constraints like Sufficiently fulfill water demands, pressure level and water tank level

But this paper aims to give the minimum amount of time needed to meet the needs of citizens for water, explain how to achieve an equitable distribution of water to citizens, and facilitate the process of collecting water network data through the phone application and website.

5 Problem Core

5.1 Description of the problem

There are set of services that belong to citizens' homes or even their facilities. Those services got water from the municipality through water pipes which run from its tanks to citizen tanks. Receiving water or not depends on whether the stopcock is open or not.Each stopcock should be opened for a given period of time which is enough for services belonging to it to fill their tanks

When determining the time required for each stopcock, the number of complaints and the time period for one cycle are taken into account

5.2 Implementation

Having class was given by the water engineer, this class determine border for each stopcock, in other words, divide the country into areas each area has one stopcock this class called distribution area.

By applying constraint satisfaction problem to distribution areas the time required for each stopcock will be calculated.

5.3 Constraint Satisfaction Problem

The constraint satisfaction technique is a problem-solving technique. The technique consists of a set of variable each of which need to be assigned to value from a finite domain but because of the constraint set the value of the variable is restricted.

How Constraint Satisfaction Problem used in distribution system

5.3.1 Initial Solution

- Calculate the required amount of water for each stopcock, this calculation depends on service type. In general, this is done by multiplying the number of people for that service by the per capita consumption rate
- calculate water average for each area from total tank water
- Calculate the percentage of the area from the time period of one cycle

Now the initial solution is ready, this is will apply for the first time. when the time period of the cycle is terminated, it will start trying to reach the optimal solution which is represented in minimizing total complaints.

5.3.2 Improve The Solution

In this stage maximum two areas will adjust their required time depending on their complaints.

- Counting complaints for each area, and adjust total complaint.
- Compare total complaints about the latest two distribution systems.
- if the total amount is less this means that the system goes right.
  - check if one of area has no complaints but previous it has. this will add new constrain for that area which is the minimum time required is greater than opening time in this system.
  - check if their is an area which has complaint but in step before hasn't.This means a new constraint added to the set.its constraint will be the minimum required time for that area is greater or equal opening hours in the previous system.
- if total amount is greater, this means that the system goes wrong. There is a need to go back one step and adjust for different area.

which areas adjusted?

The area with maximum complaints need to have more time which is one time unit, But because their is a constraint which is the summation of opening times shouldn't exceed total period cycle. Another area should have adjusted by removing one time unit.this area should have no constraints, and its complaint the minimum.

when did system fail?

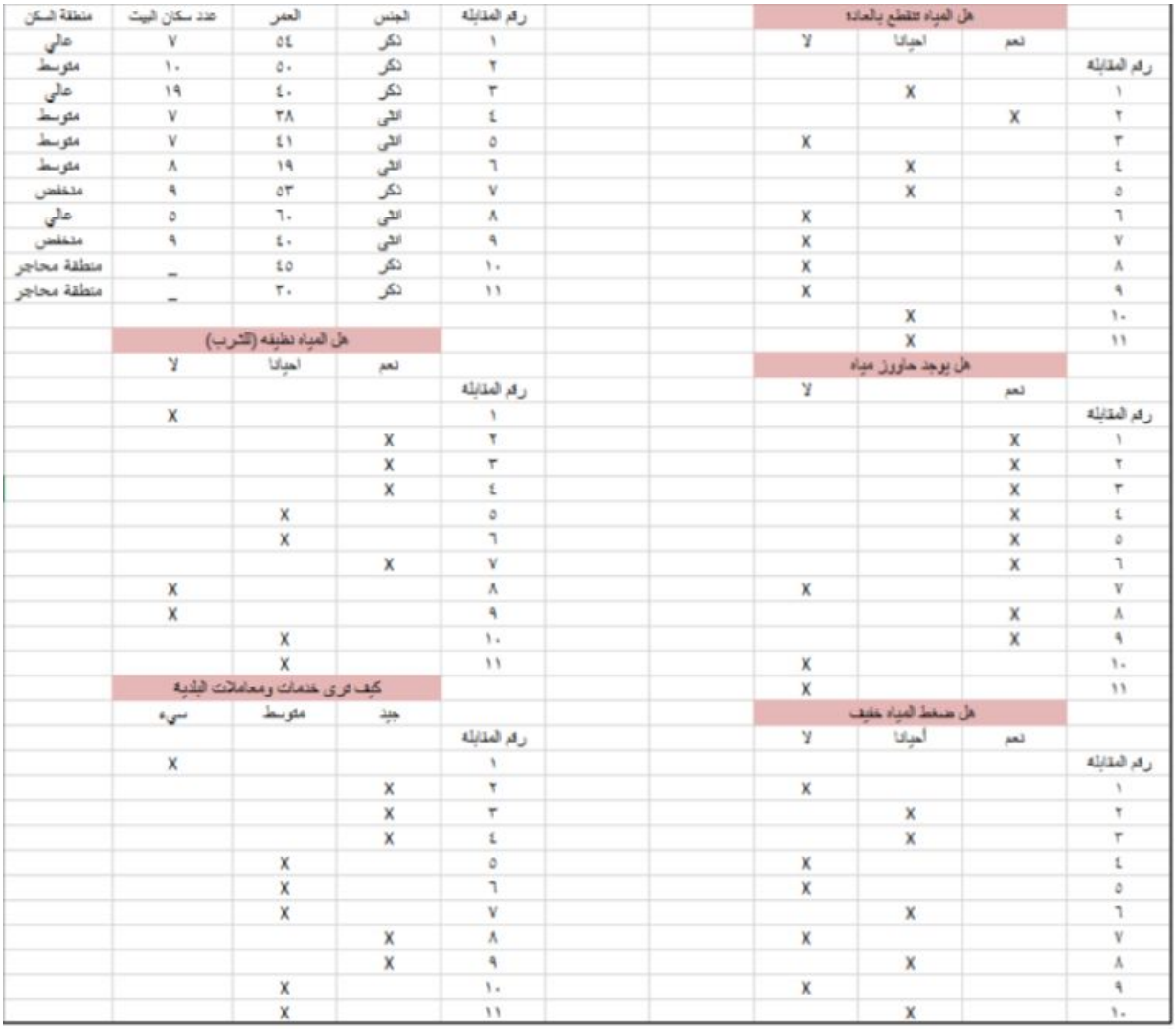
In each cycle system will try to find more optimal solution but if all areas assigned to constraint and still having complaints there is no way to adjust without exceeding time period of the cycle so system wont give an optimal solution

6 Methodology

6.1 Human Centred Design

This project was done according to the Human Centred Design approach. The following describes the phases has been followed during this project:

- **Inspiration Phase**:
  In this phase, We made several interviews with targeted users for this app and website. We started from knowing the problem and what is the main point to focus on. After this, we started the interviews with citizens and municipalities. At first, we went to Jamain municipality and met with the Water Engineer and the Water Technician, we understood the problem with water they suffer from, there was problems with water distribution, the water was pumped all of the day regardless the needs of the different regions of water, as a result, there were some regions suffers form water lacking and other regions have more water than they need. Moreover, the municipality did not has a database to store its data. most of the data was not documented. We also met with the IT section in the municipality and asked about the servers, database, electronic systems if they have and some other technical issues. Then, we made interviews with the citizens, we asked them about what the problems they have , and if they willing to use a mobile app for sending water orders to municipality and if this would make it easier for them. Finally, we had a good view of the problem and what are we finding solutions to. We started with the Ideation Phase



منطقة السكن	عدد سكان البيت	العمر	الجنس	رقم المقابله
عالي	٧	٥٤	ذكر	١
متوسط	١٠	٥٠	ذكر	٢
عالي	١٩	٤٠	ذكر	٣
متوسط	٧	٣٨	انثى	٤
متوسط	٧	٤١	انثى	٥
متوسط	٨	١٩	انثى	٦
منخفض	٩	٥٣	ذكر	٧
عالي	٥	٦٠	انثى	٨
منخفض	٩	٤٠	انثى	٩
منطقة محاجر	_	٤٥	ذكر	١٠
منطقة محاجر	_	٣٠	ذكر	١١

هل المياه تنقطع بالعاده		
نعم	احيانا	لا
رقم المقابله		
١	X	
٢		
٣		X
٤	X	
٥	X	
٦		X
٧		X
٨		X
٩		X
١٠	X	
١١	X	

هل يوجد خاوزل مياه		
نعم		لا
رقم المقابله		
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٧		X
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١٠		X
١١		X

هل ضغط المياه خفيف		
نعم	أحيانا	لا
رقم المقابله		
١		
٢		X
٣	X	
٤	X	
٥		X
٦		X
٧	X	
٨		X
٩	X	
١٠		X
١١	X	

هل المياه نظيفه (للشرب)		
نعم	احيانا	لا
رقم المقابله		
١		X
٢	X	
٣	X	
٤	X	
٥		X
٦		X
٧	X	
٨		X
٩		X
١٠		X
١١		X

كيف ترى خدمات ومعاملات البلدية		
جيد	متوسط	سيء
رقم المقابله		
١		X
٢	X	
٣	X	
٤	X	
٥		X
٦		X
٧		X
٨	X	
٩	X	
١٠		X
١١		X

Figure 2: Interviews Summary

- **Ideation Phase** :
  In this phase,we started to execute the solution. After writing the distribution system code, we tested it and made improvements according to the results. the application was developed for citizens, engineers, water technicians, and others. The purpose of its development for citizens is to collect information about their services so that the application asks about the location of the service and the number of people benefiting from it. In addition to have the ability to make a complaint,and order. Moreover the citizen can immediately give a feedback about the new water cycle.

  In the other hand the app will help municipal employees in adding tanks and stopcocks, viewing water network map, knowing all services that related to a specific stopcock.In addition to providing citizens with updates on their orders and complaints and finally give pumping time needed for each stopcock. In this phase, we added a rating from, the user of the mobile app or the website can give as a feedback about the app or the website to be able to improve it as the users needs.

- **Implementation Phase**:
  This phase containing the final development phase of the project and finalizing all of the features for all of the users; citizens, admin ,water engineer, water technician and other employees. The finalizing of the project was based on the feedback from the users. The following sections explain in more details about the development process and what the features the app and the website contains.

6.2 Servers Design

We used the client server model as mentioned before, so every client will be able to use the same API. We have two servers; the back-end server which is written as REST API using flask platform. The database server; we used MY-SQL database .

6.3 System tree

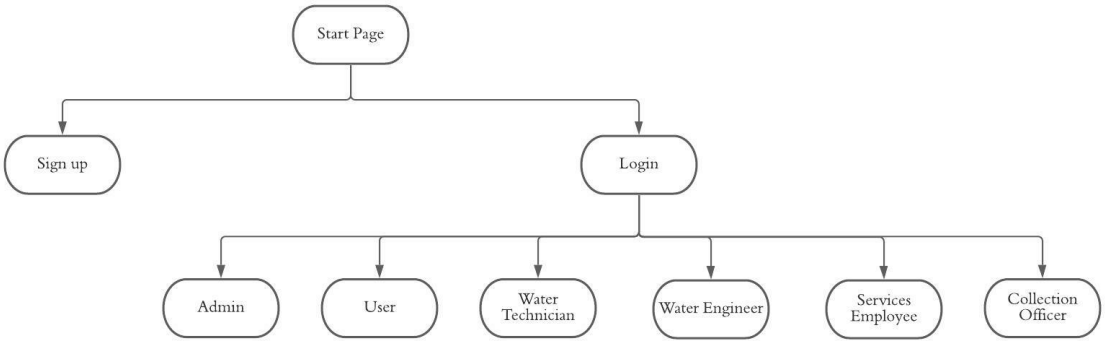


Figure 3: system tree

The previous figure shows how the system is designed, The first interface is the start page, from this page you can either choose to log in to your account or to create a new account. The users is divided into Admin, User (which is the ordinary user, the citizen), Water Engineer , Water Technician, Services Employee and the Collection Officer.

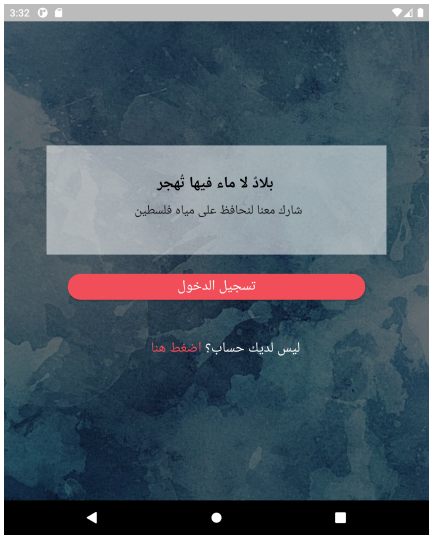


Figure 4: Mobile's start page

Figure 5: Website's start page

6.4 Accessing the app and website

6.4.1 Log-in

All users should be able to enter the system by giving both username and password. For citizens, the username is his identification number. Actually, not all citizens could have an account, if someone owns a water service he should enter the identification number related to that service. But Any employee its username is a generated username derived from its identification number. And finally, the username of the admin is admin

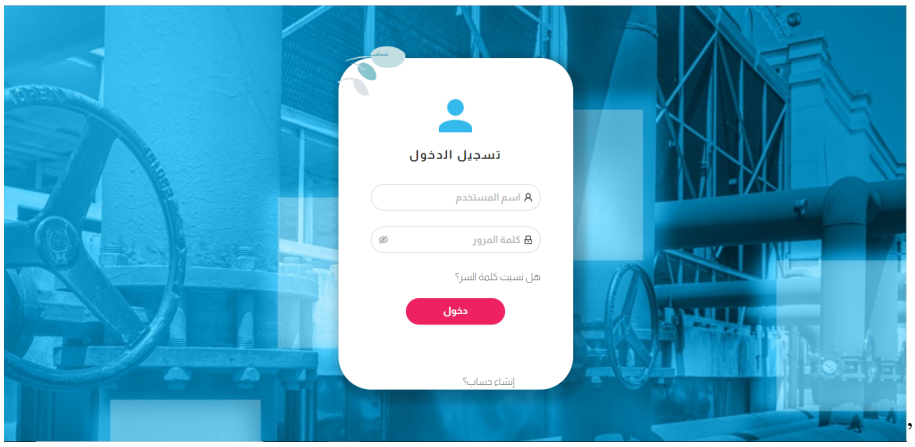


Figure 6: Website's login screen

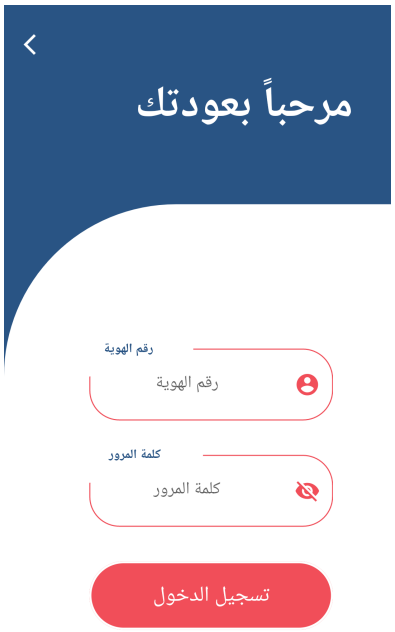


Figure 7: Mobile's login screen

6.4.2 Sign up

The only user who could make new accounts by themselves are citizens. Because admin will make for employees. In the sign-up process firstly the citizen will provide basic information like his identification number, email, phone number, and password. after clicking the bottom check if there is a service that belong to that identification number if true then an activation code will send to the citizen's email. The next step is to identify service information like location, tank numbers, and the number of family members

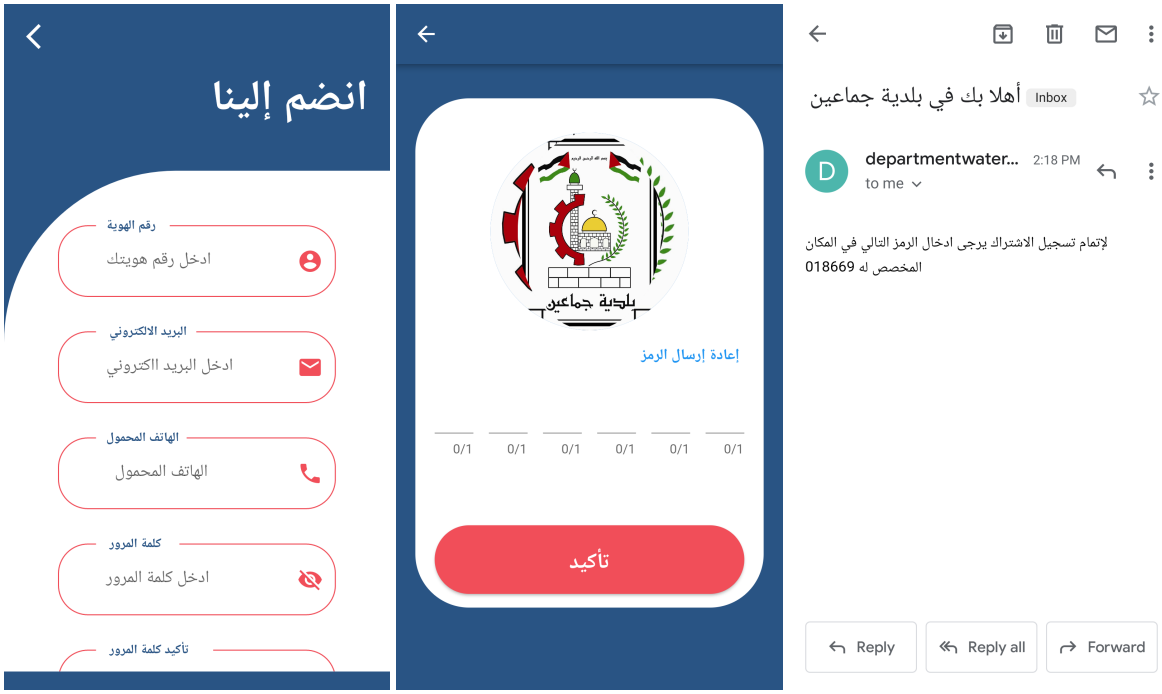


Figure 8: Mobile's Sign-up screen

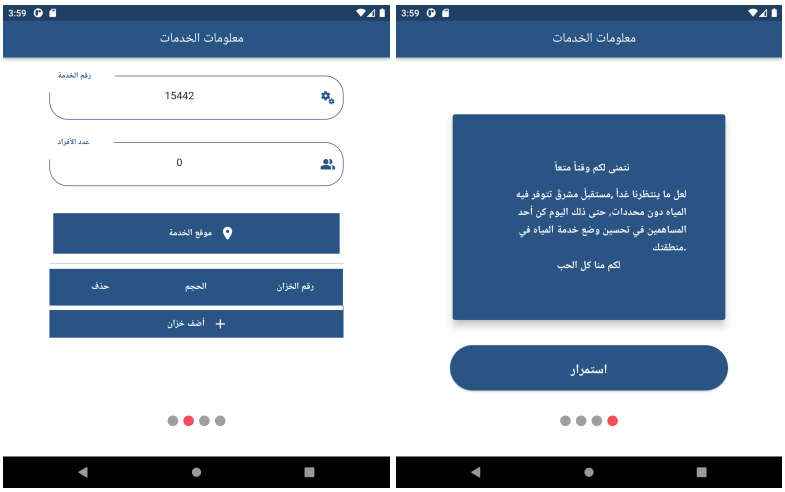


Figure 9: Mobile's Sign-up screen

Figure 10: Website's Sign-up screen

6.5 Password Recovery

Any user expected to forget the password so to deal with this problem forget password button is supported. An email with a random password is sent to that user. the email of the receiver is set in before

6.6 Citizen

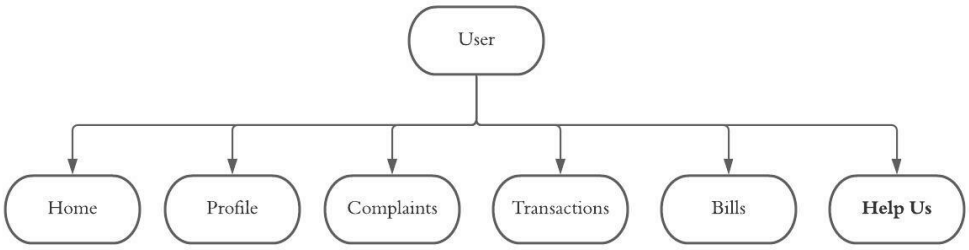


Figure 11: User Interface Tree

The citizen interface includes the following :

- Home Page

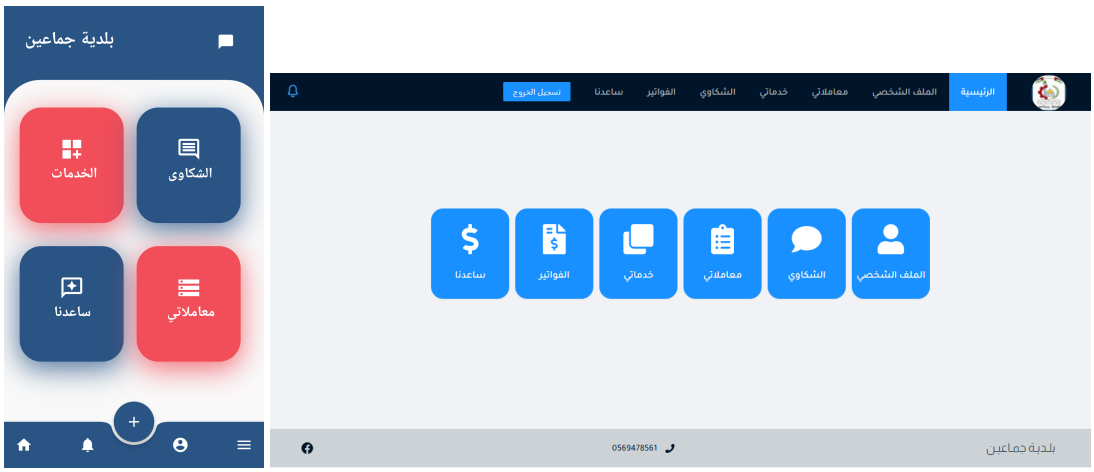


Figure 12: User Home

- Profile
  user can update her/his information and the services information and change the password

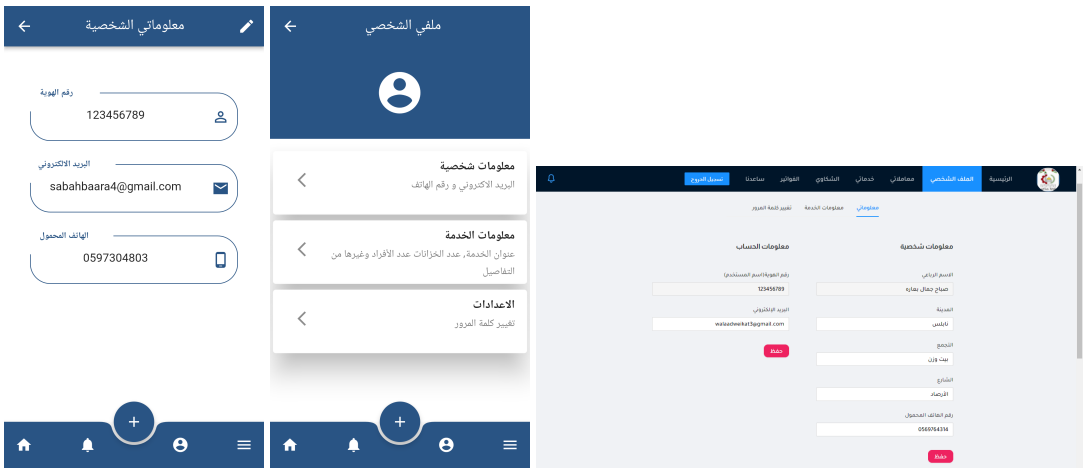


Figure 13: User Profile

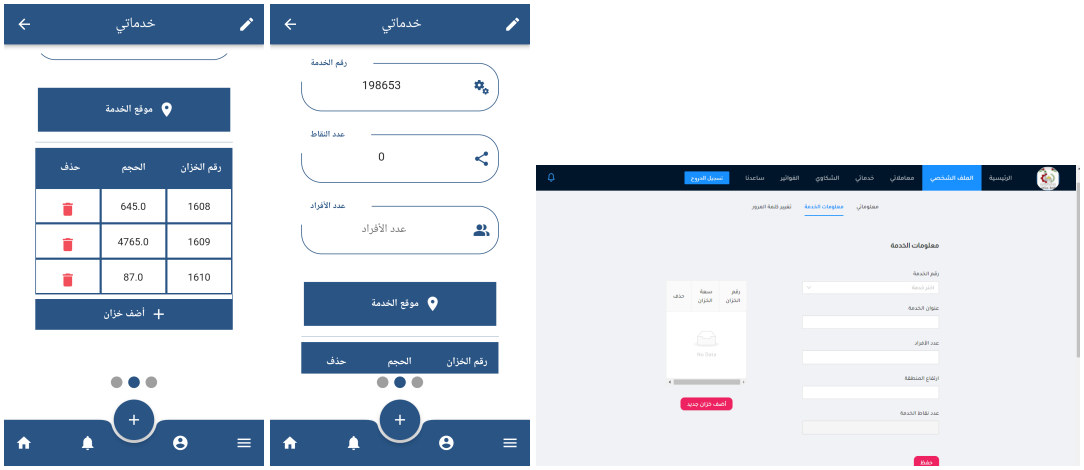


Figure 14: User Services

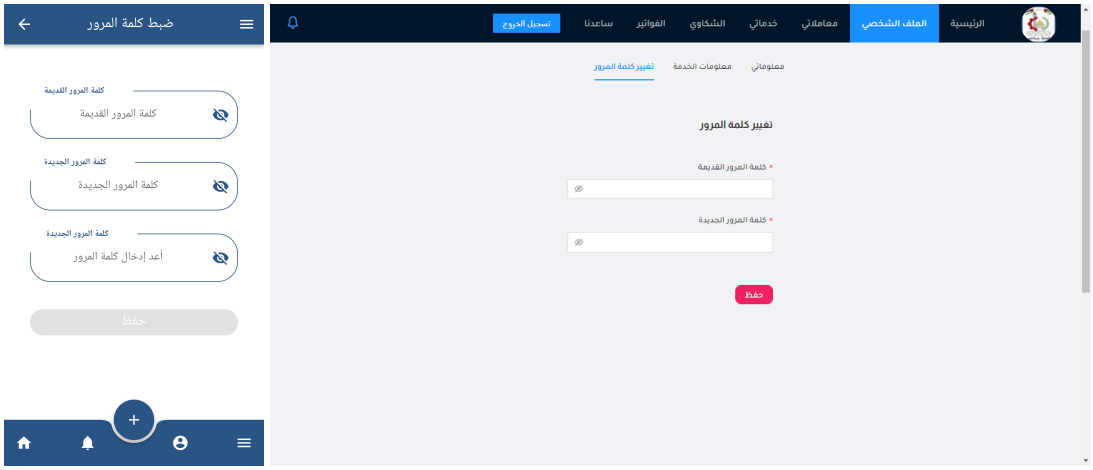


Figure 15: Change Password

- Complaints
  user can add a new complaints and send it to the municipality.

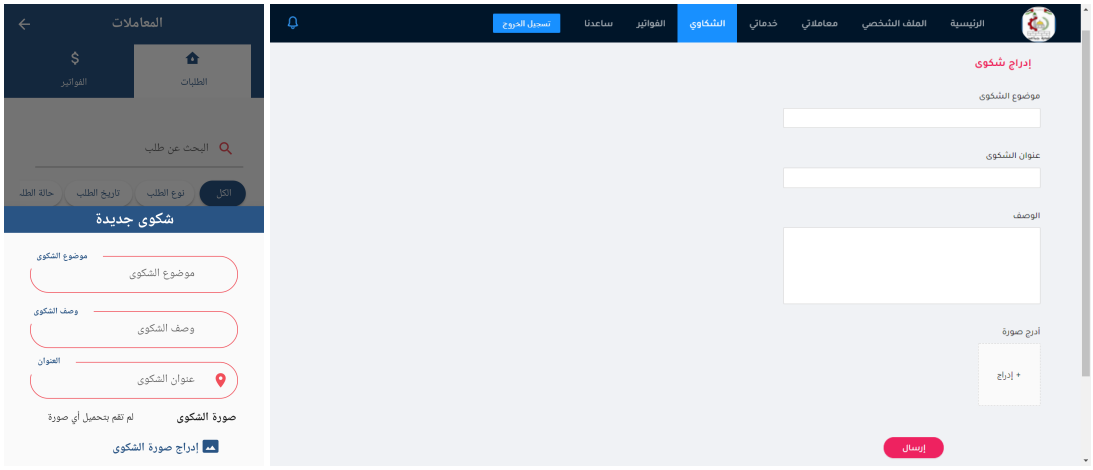


Figure 16: User new complaints

- Transactions
  user can show his/her complaints and orders and see what has happened with the order if it is acceptable or regrettable.

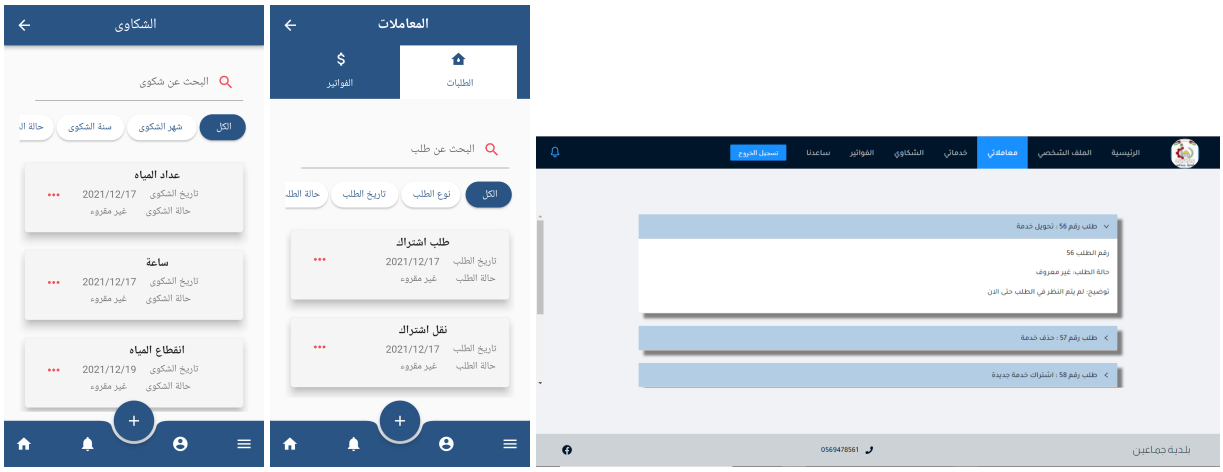


Figure 17: Show orders

- Services
  user can order a new service , delete it or change it’s location. the service location can be determined by the map.

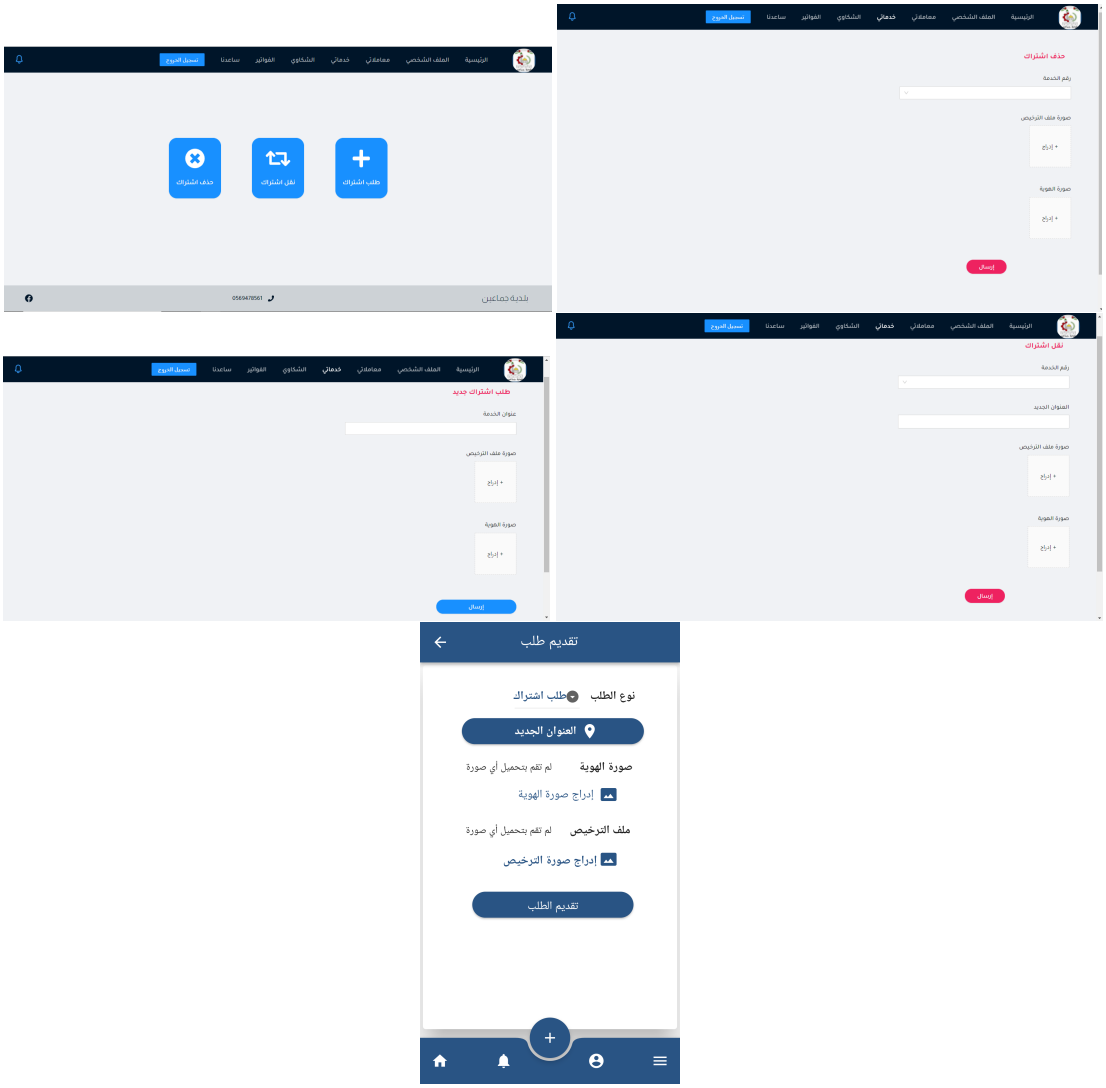


Figure 18: User order

- Invoices
  user can show the water invoices.

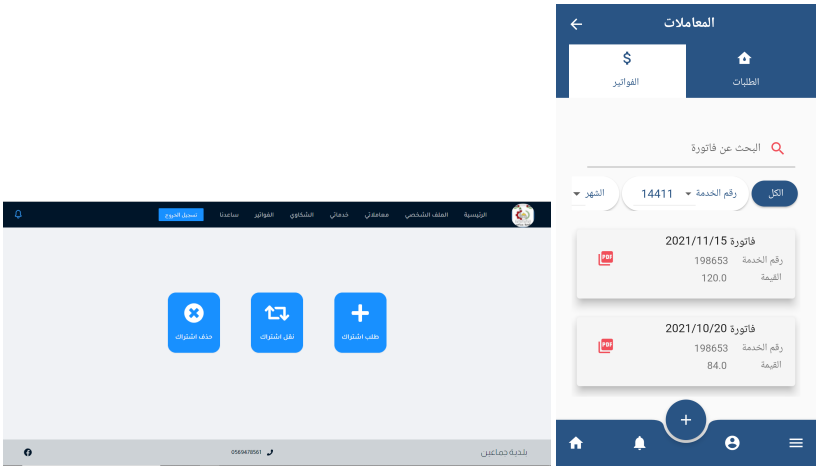


Figure 19: User Invoices

- Help Us
  In this section, we are asking the user to help us collecting the data by providing us with the water meter readings before the opening the stopcock and after it, to know whether the water reached to him or not, the user rate the reaching water percentage. The system will send a notification to the user before and after the water pumping process so he can provide us with the readings.

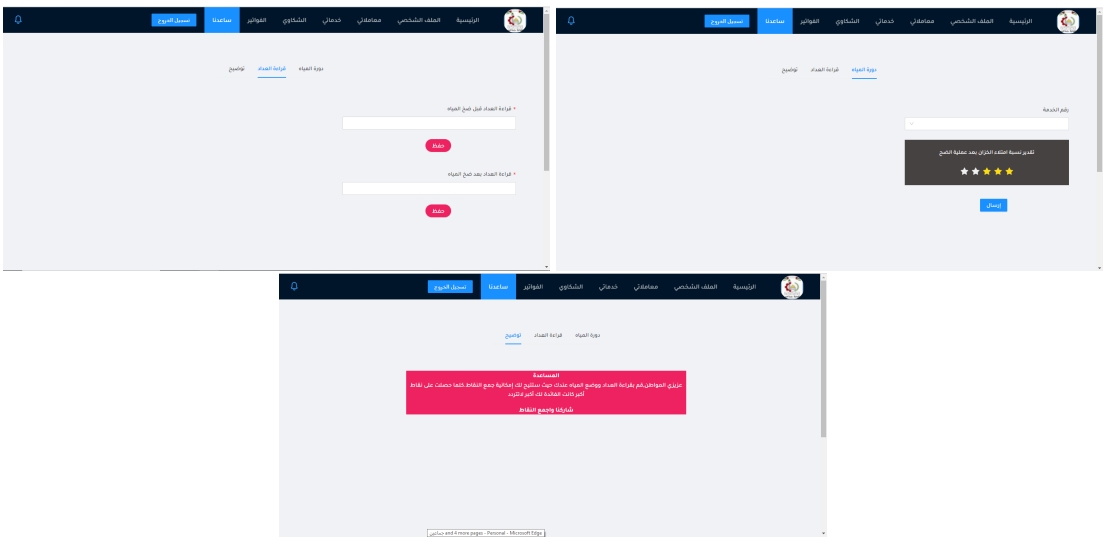


Figure 20: Help Us for Website

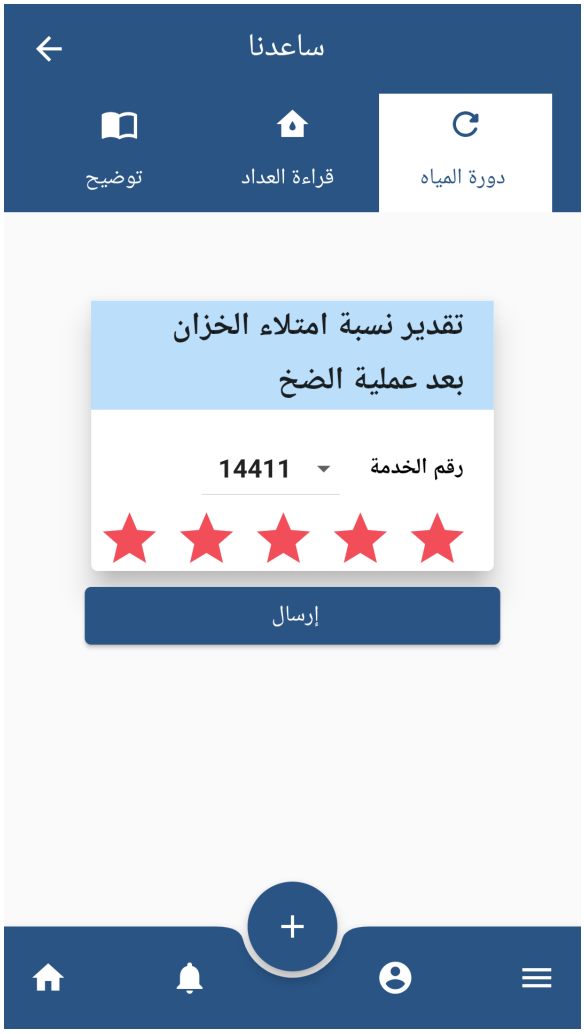


Figure 21: Help Us for mobile app

6.7 Employees

Editing personal information especially communication information is essential because many notifications will send to their emails. So this information should be up to date.

For security changing the password is supported in order to change the password employee must provide an old password and a new one. If there is a match between the old provided password and the one in the database the password will change to the new one

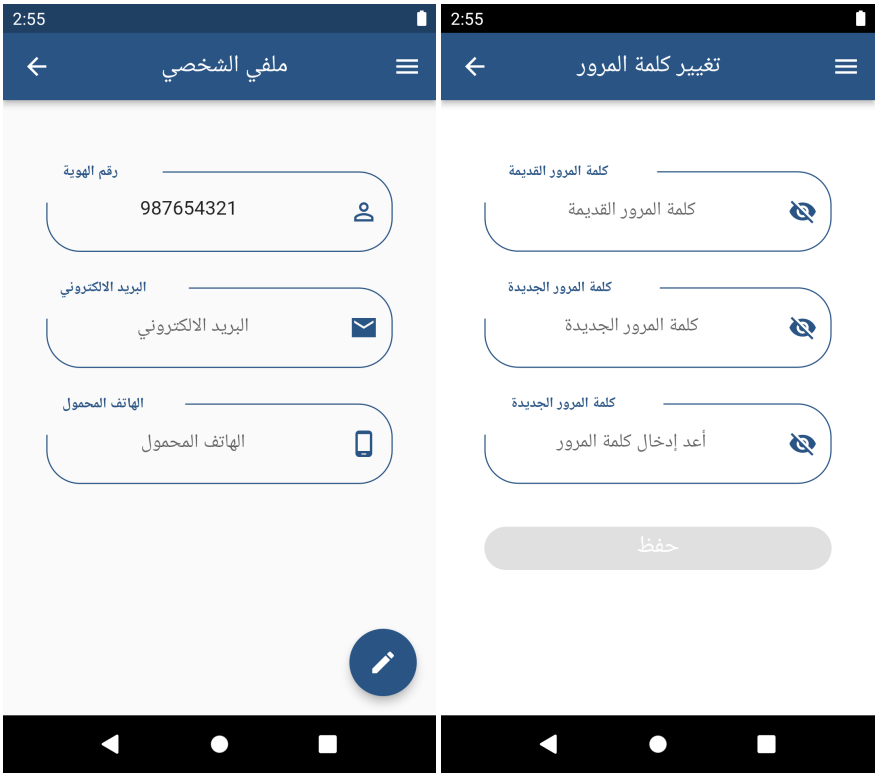


Figure 22: Mobile's Employee changing info screens

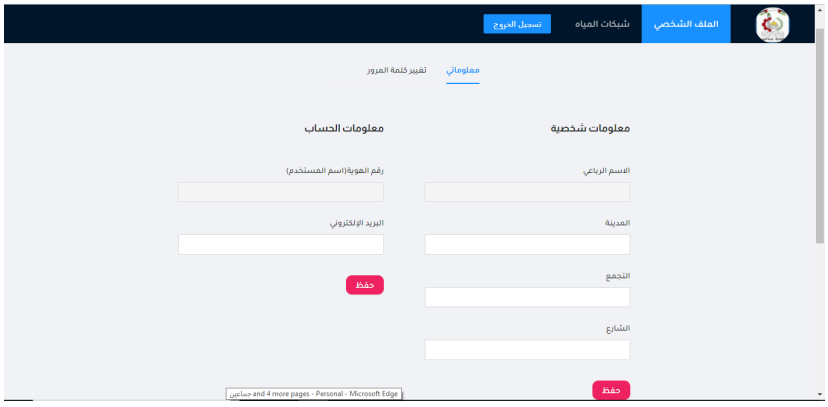


Figure 23: Website's Employee changing info screens

6.7.1 Water Engineer

One of the main stakeholders which his main responsibility is to identify distribution areas, these distribution areas will facilitate assigning services to Municipality stop-cocks. home screen for this user will represented as showing current system and pie chart for citizen review.

Distributing Areas added by specifying points on a map clicking on pen icon then the engineer can select one, and delete it.

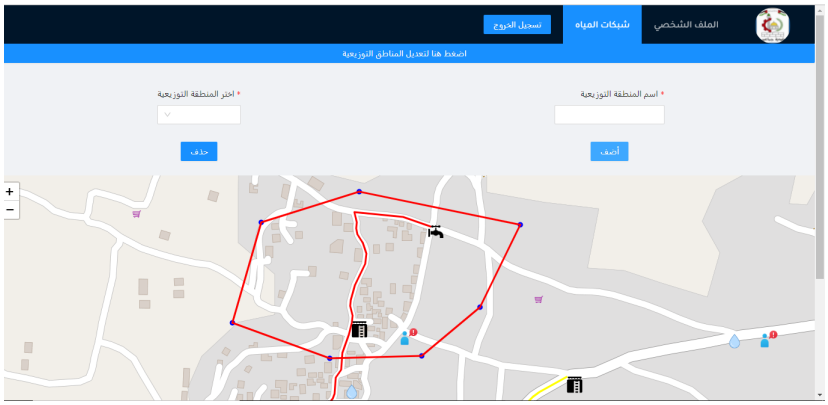


Figure 24: Website's Water Engineer Screen

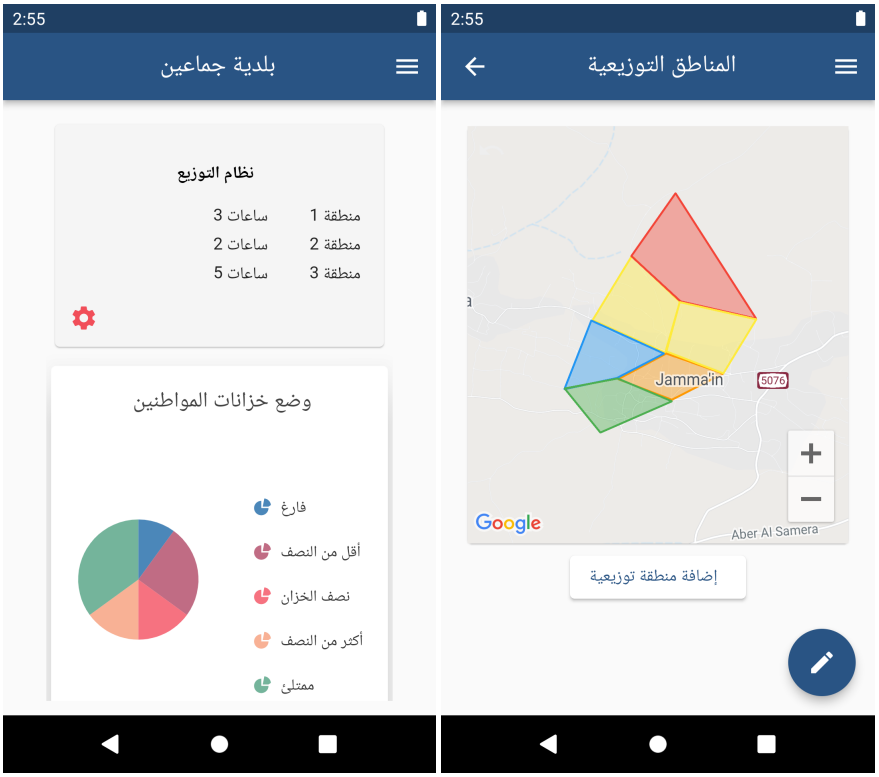


Figure 25: Mobile's Water Engineer screens

6.7.2 Water Technician

Water Technician has critical responsibilities, starting from the most important one which is opening and closing stopcock. In order to register everything when he closes or opens any stopcock, he should reflect this to the system using mobile or even the website.

Actually, this user will be provided with the output of the constraint satisfaction problem. In order to give each stopcock amount of water needed. The system will notify employees when the time is about to run out. Also will notify citizens when opening or closing stopcock in order to make the system more accurate and aware of exactly which citizen connected to each stopcock.

Dealing with citizen's complaints, when new complaints are sent from citizens these complaints need someone to work on them so assigning it to a specific employee depends on the number of water technicians the municipality has, number of complaints that belong to them.

Starting specific complaint depend on if there are urgent complaints which are the one that belongs to the citizen who rarely complains

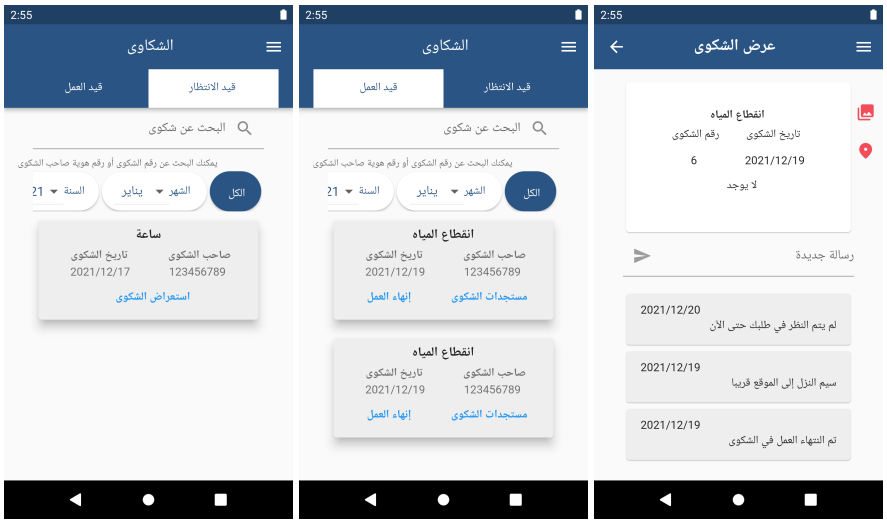


Figure 26: Mobile's Water Technician complaints screens

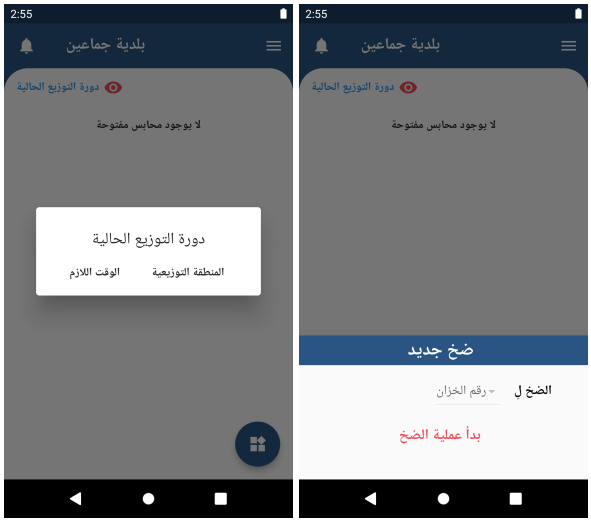


Figure 27: Mobile's Water Technician Home screens

Other employees could use the system who are collection officers, service employees, and Water card charging employees but they have limited access.

Collection officers will use the app to enter readings of citizen's water meters. Water card charging employees will enter the amount of water purchased from citizens.And finally service employees will receive citizens order, adding complaints.

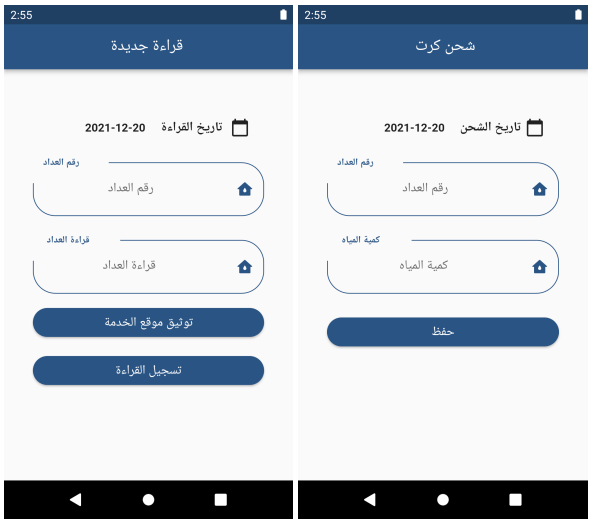


Figure 28: Mobile's Water card charging / water meters employees screen

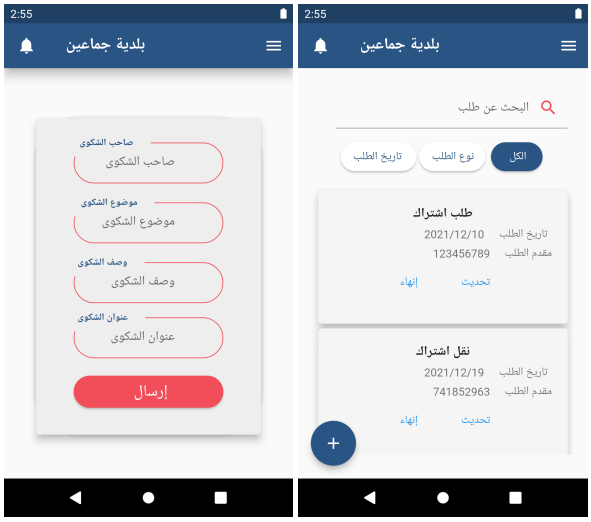


Figure 29: Mobile's Water Service Employees Screen

Having other screen for rating app in order to improve it in future as what user see the app now.

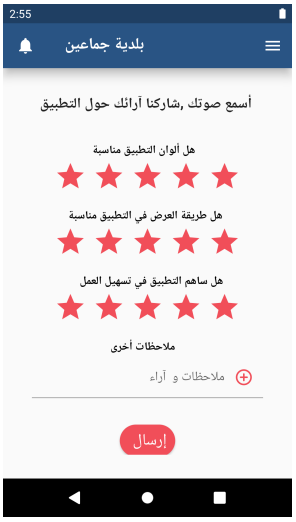


Figure 30: Mobile's Rate Screen

6.8 Admin

The admin is responsible of adding, deleting and editing the tanks and the stopcocks. He is also can show all of the water services. when there is a new employee the admin will adding him to the system, the username and password of new employee will send to him through his email.In addition to support searching and having charts which will make system more understandable.Finally, all of the data considering the services, the complaints, the water network is projected on the map, the Admin can see this map.

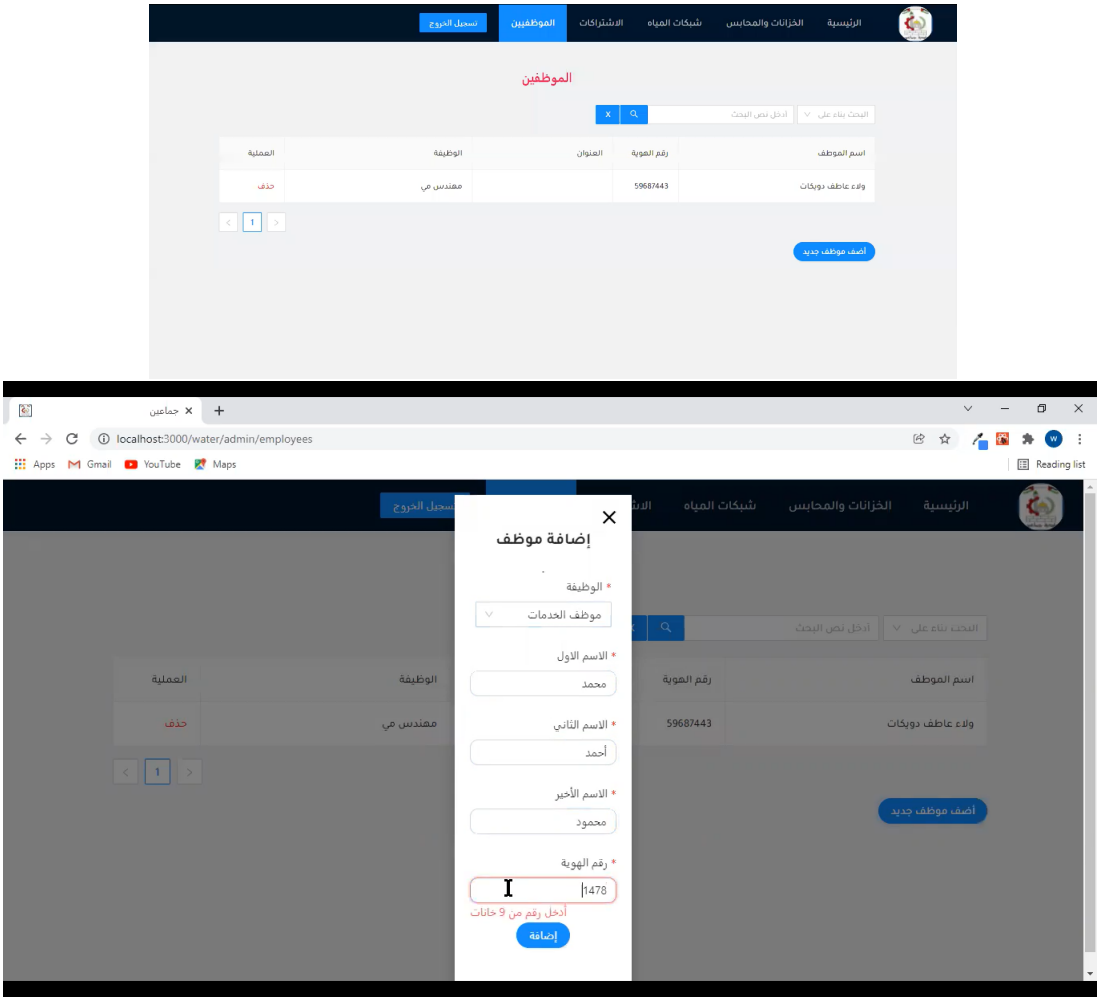


Figure 31: Employees

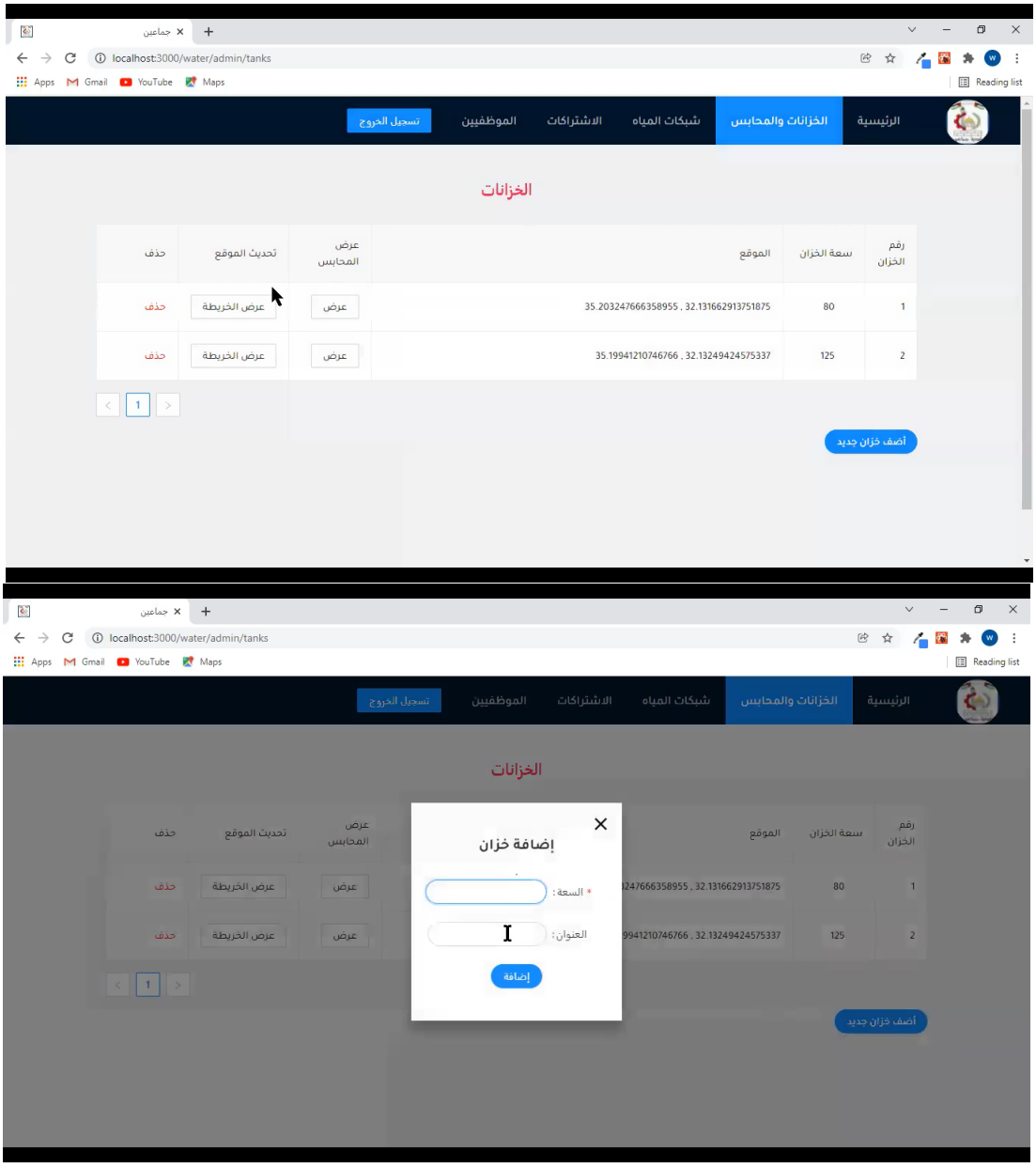


Figure 32: Tanks

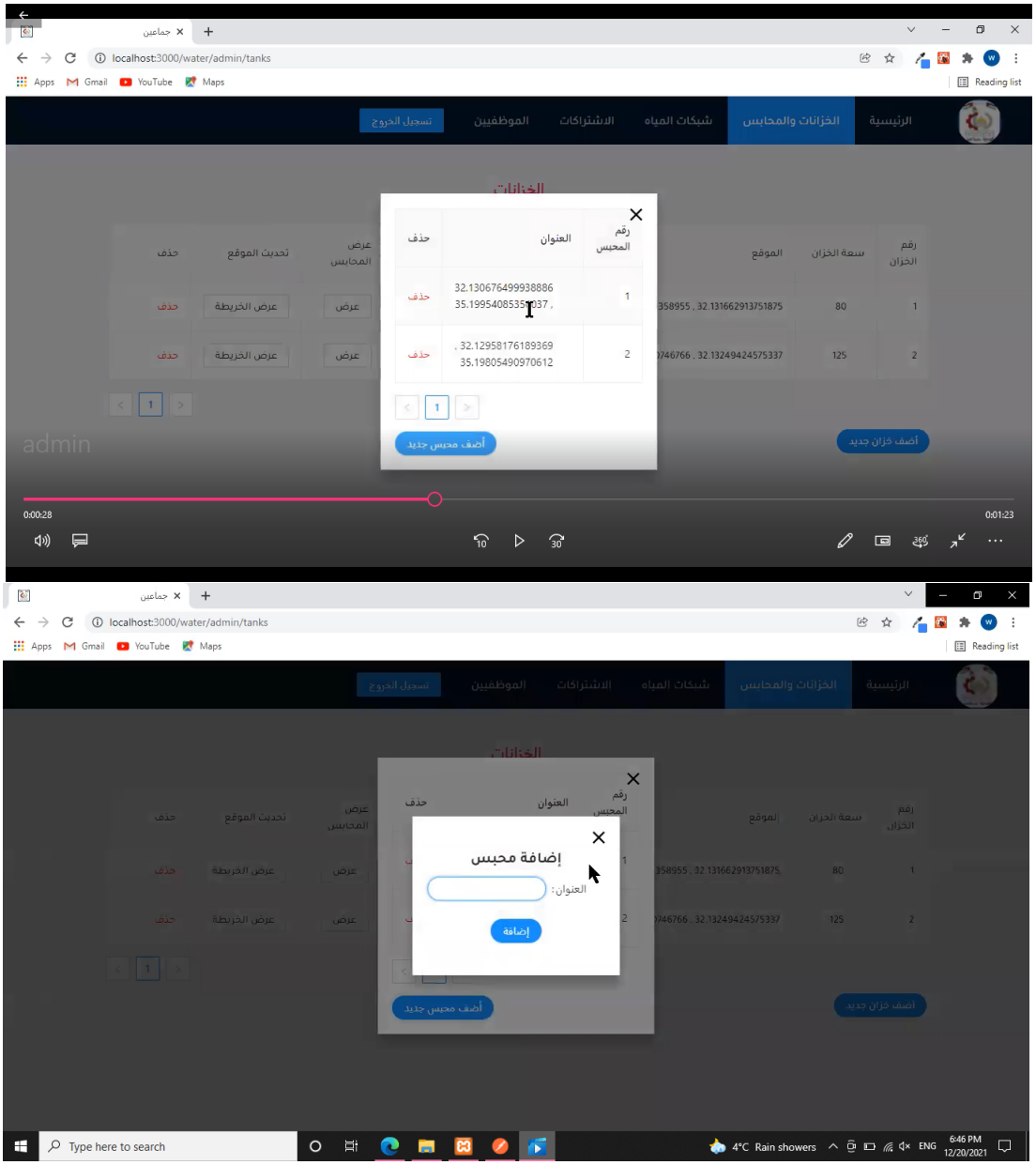


Figure 33: Stopcocks

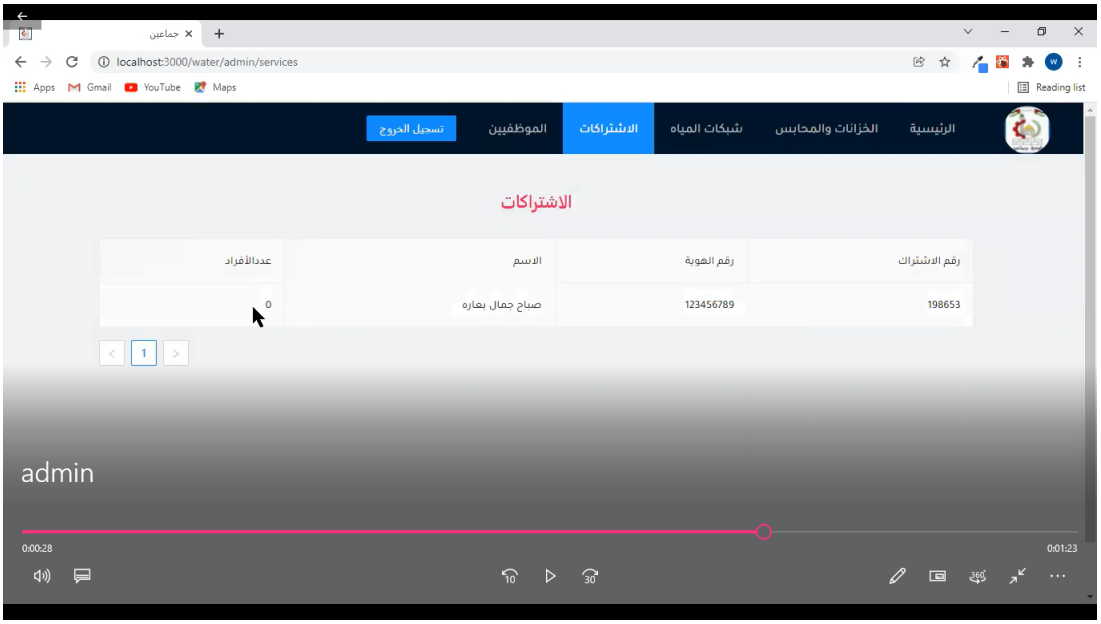


Figure 34: Services

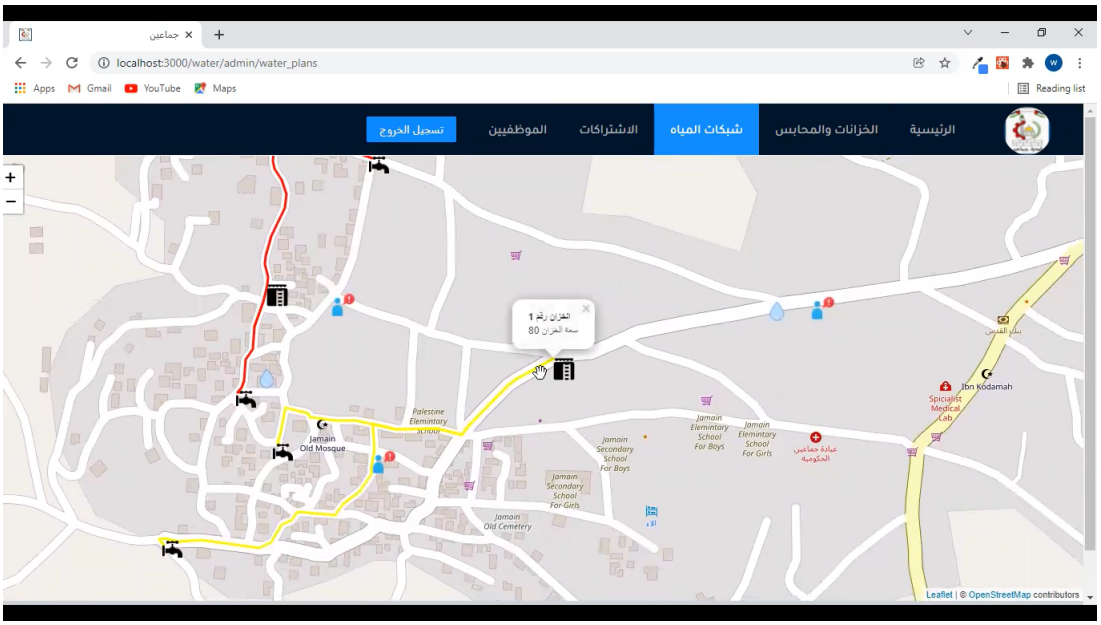
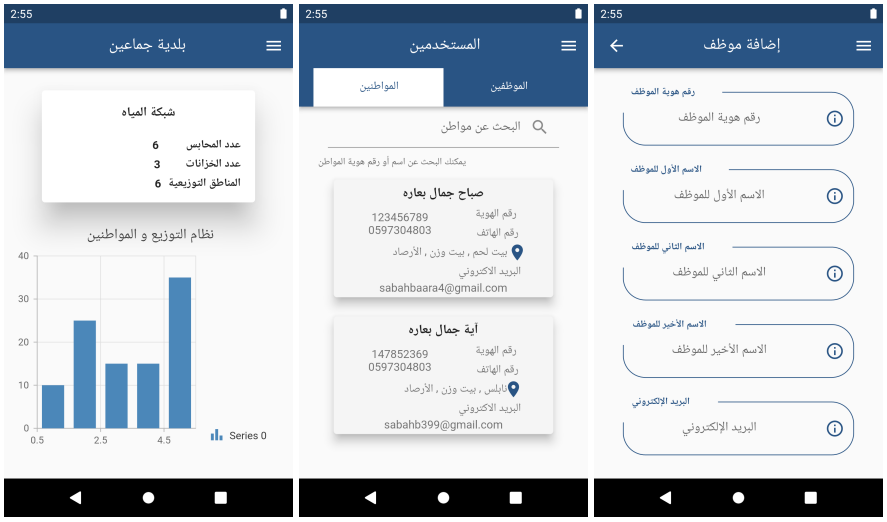
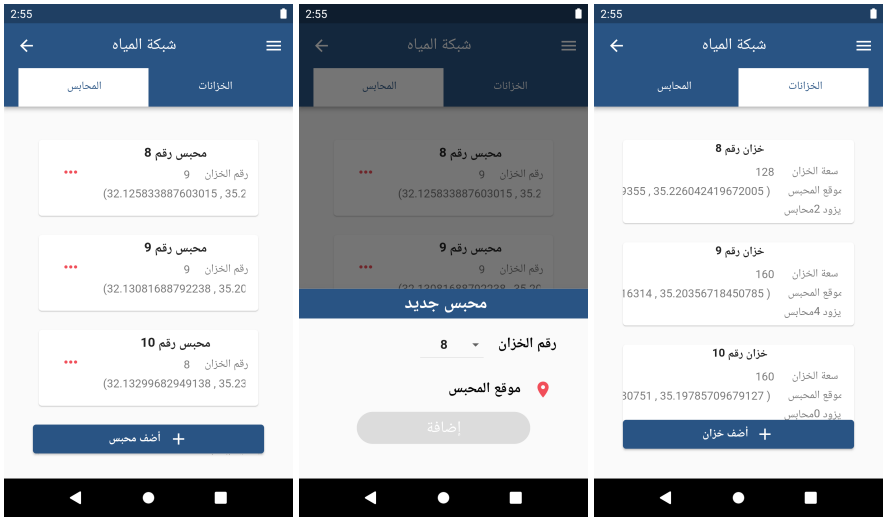


Figure 35: Water Network





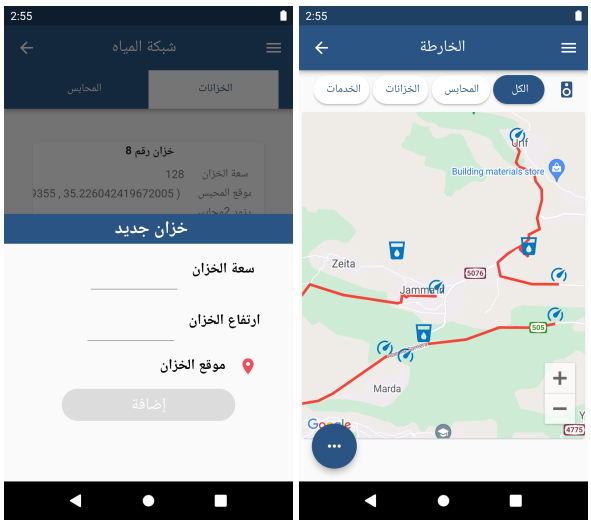


Figure 36: Mobile's Admin Screen

6.9 Languages and Tools

6.9.1 Database Design

We used a relational database with MY-SQL database with Apache server and we used and we used structured query language (SQL) to send queries to it.

6.9.2 Back-end Programming Languages

Flask is used for the back-end server, it is a platform using to write API using python language.

6.9.3 Front-end Programming Languages

- ReactJs[5]: it was used to build the website.
- Ant Design[1]
- Flutter[3] : a cross-platform that was used to build the mobile app interface.
- Dart and Java Script

6.9.4 IDEs

- Visual Studio Code (VS code) : Code is a lightweight,powerful source code editor. It has built-in support for Java Script. It available for window, MacOS and Linux.
- PyCharm IDE.
- Android Studio.

7 Results and Discussion

A distributing water system implemented, depends on the number of services, number of stopcock in addition to number and size of main tanks. The output will change depending on citizens' complaints in order to reach an optimal solution which represents the minimum time required for each stopcock.

Developing a mobile application and website that facilitates a lot for citizens in particular and employees in general. There is no need to visit the municipality many times in order to obtain a service, apply complaint, or inquire about the progress of work as it will be done remotely

8 Conclusion and Future Work

8.1 Summary

Bring able to help the municipalities and people and reducing the number of complaints from citizens to the municipalities by creating a system that automates (make it electronic) the process of ordering a new water services will reduce the time and the effort and make it easier. The system also helps in the process of distribution water. Flutter, ReactJs, Flask, MY-SQL database was used to build this system.

8.2 What did we learn?

1. Building a website using reactJs
2. Building cross-platform mobile app using Flutter
3. Building a REST API using flask
4. Using maps leaflet and google maps

8.3 Future Work

- Expand the project to include the other services provided by municipalities
- developing the mobile app and the website after taking feedback from the users

References

[1] *Ant Design*. URL: https://ant.design/.

[2] Luigi Cimorelli, Andrea D'Aniello, and Luca Cozzolino. "Boosting genetic algorithm performance in pump scheduling problems with a novel decision-variable representation". In: *Journal of Water Resources Planning and Management* 146.5 (2020), p. 04020023.

[3] *Flutter*. URL: https://docs.flutter.dev/.

[4] Haroon Shakirat Oluwatosin. "Client-server model". In: *IOSRJ Comput. Eng* 16.1 (2014), pp. 2278–8727.

[5] *React Js*. URL: https://reactjs.org/.