

**ECOSNAP: A MOBILE APPLICATION FOR ENHANCING
GOVERNANCE AND ADDRESSING ENVIRONMENTAL
ISSUES IN SMART CITIES**

**ECOSNAP: AKILLI ŐEHİRLERDE YÖNETİŐİMİN
GELİŐTİRİLMESİ VE ÇEVRESEL SORUNLARIN
ÇÖZÜMÜ İÇİN MOBİL UYGULAMA**

İLYAS ÇOKAN

ASSOC. PROF. DR. BERK ANBAROĐLU

Supervisor

Submitted to Institute of Sciences of Hacettepe University as a
Partial Fulfillment of the Requirements
for the Award of the Degree of Master
in Geomatics Engineering

June 2023

ABSTRACT

ECOSNAP: A MOBILE APPLICATION FOR ENHANCING GOVERNANCE AND ADDRESSING ENVIRONMENTAL ISSUES IN SMART CITIES

İlyas ÇOKAN

Master of Science, Department of Geomatics Engineering

Supervisor: Assoc. Prof. Dr. Berk ANBAROĞLU

June 2023, 86 pages

With the increasing population and urbanization, urban planning has become a complex and challenging task. In recent years, the concept of smart cities has emerged as a potential solution to these challenges by integrating technology into urban planning. Participatory Planning Geographic Information System (PPGIS) is one such technology that involves the public in the planning process by providing them with a platform to share their opinions and ideas. PPGIS, coupled with mobile applications, can enhance public participation by allowing citizens to provide feedback on the go. This thesis aims to investigate the use of PPGIS mobile applications in urban planning for smart cities.

The study provides a platform for citizens to report on issues around them and track progress. This platform allows users to interact with each other and collaborate in solving problems. The application is designed to be user-friendly and accessible to a wide range of users. The study will also evaluate the effectiveness of the implementation in facilitating citizen participation and its impact on city planning outcomes.

The research will use a mixed-methods approach, including a literature review, case studies, surveys, and interviews with stakeholders, to explore the potential benefits and limitations of PPGIS mobile applications in urban planning for smart cities. The findings of this study will provide valuable insights into the use of PPGIS mobile applications in urban planning for smart cities and inform the development of future urban planning policies and strategies.

Keywords: crowdsourcing, smart city, ppgis, urban planning, mobile application

ÖZET

ECOSNAP: AKILLI ŞEHİRLERDE YÖNETİŞİMİN GELİŞTİRİLMESİ VE ÇEVRESEL SORUNLARIN ÇÖZÜMÜ İÇİN MOBİL UYGULAMA

İlyas ÇOKAN

Yüksek Lisans, Geomatik Mühendisliği Bölümü

Tez Danışmanı: Doç. Dr. Berk ANBAROĞLU

Haziran 2023, 86 sayfa

Artan nüfus ve kentleşme ile birlikte, şehir planlaması karmaşık ve zorlu bir görev haline gelmektedir. Son yıllarda gelişen akıllı şehirler kavramı ile teknolojiyi şehir planlamasına entegre ederek bu zorluklara potansiyel bir çözüm olarak ortaya çıktığı görülmektedir. Katılımcı Planlama Coğrafi Bilgi Sistemi (PPGIS), halkı görüş ve fikirlerini paylaşmaları için bir platform sağlayarak planlama sürecine dahil eden teknolojilerden biridir. PPGIS, mobil uygulamalarla birleştiğinde vatandaşların hareket halindeyken, anlık geri bildirimlerde bulunmalarına olanak tanıyarak halkın katılımını artırır. Bu tez, akıllı şehirler için kentsel planlamada PPGIS mobil uygulamalarının potansiyel faydalarını araştırmayı amaçlamaktadır.

Çalışma, vatandaşlara çevrelerindeki sorunları raporlamaları ve ilerlemeleri takip etmeleri için bir platform sağlamaktadır. Bu platform, kullanıcıların birbirleriyle etkileşim kurmasına ve sorunların çözümünde işbirliği yapılmasına imkan sağlamaktadır. Uygulama, kullanıcı dostu ve geniş bir kullanıcı yelpazesi tarafından erişilebilir olacak

şekilde tasarlanmıştır. Çalışma ayrıca, uygulamanın vatandaş katılımını kolaylaştırmadaki etkinliğini ve şehir planlama sonuçlarına etkisini değerlendirecektir.

Araştırma, akıllı şehirler için şehir planlamasında PPGIS mobil uygulamalarının potansiyel faydalarını ve sınırlamalarını keşfetmek için bir literatür taraması, vaka çalışmaları, anketler ve paydaşlarla görüşmeler dahil olmak üzere karma yöntemli bir yaklaşım kullanacaktır. Bu çalışmanın bulguları, akıllı şehirler için şehir planlamasında PPGIS mobil uygulamalarının kullanımına ilişkin değerli bilgiler sağlayacak ve gelecekteki şehir planlama politikalarının ve stratejilerinin geliştirilmesine bilgi sağlayacaktır.

Anahtar Kelimeler: kitle kaynak kullanımı, akıllı şehir, ppgis, şehir planlama, mobil uygulama

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to the following individuals for their invaluable support and assistance throughout my academic journey:

My thesis advisor Assoc. Prof. Dr. Berk Anbarođlu, for their guidance, encouragement, and feedback throughout the research process. His expertise and insights have been instrumental in shaping the direction and scope of this thesis.

My family, for their unwavering support and encouragement. Their belief in me has been a constant source of motivation and inspiration.

CONTENTS

ABSTRACT	i
ÖZET	iii
ACKNOWLEDGEMENT	v
CONTENTS	vi
LIST OF FIGURES	ix
LIST OF TABLES	xi
ABBREVIATIONS	xii
1. INTRODUCTION.....	1
1.1. Problem statement	2
1.2. Contributions and Organization	2
2. SMART CITY	4
2.1. What is a smart city?	4
2.2. Participatory Mapping	5
2.3. Relationship between smart cities and participatory mapping	7
3. RELATED WORKS	9
3.1. Characteristics of selected crowdsourcing platforms	9
3.1.1. Territorial scope	9
3.1.2. Source of initiative	10
3.1.3. Platform addressees	11
3.1.4. Scope of government support	11
3.1.5. Scope and type of feedback	12
3.2. Applications	12
3.2.1. FixMyStreet	12
3.2.2. SeeClickFix	14
3.2.3. Ushahidi	16
3.2.4. Burgernet	18

3.2.5. Other Works.....	20
4. CHALLENGES FOR APPLICATIONS.....	25
4.1. Quality Management.....	25
4.2. Ethics and Privacy	26
4.3. Sustaining Motivation.....	28
4.3.1. Extrinsic Motivations.....	29
4.3.2. Intrinsic Motivations.....	30
4.4. Adoption of gamification.....	31
5. PROPOSED SYSTEM	33
5.1. Project Creation	34
5.2. Domain Driven Design	38
5.2.1. Layers in EcoSnap Domain Design	39
5.3. Account Screens	43
5.3.1. Login Screen	43
5.3.2. Forgot Password Screen.....	44
5.3.3. Registration Screen	45
5.3.4. Change Password Screen	45
5.4. Activity Screens.....	46
5.4.1. Friendship Screen	46
5.4.2. Activity Feed Screen.....	47
5.4.3. Activity Creation Screen.....	48
5.5. Ranking Screen	49
5.6. Configuration Screen	50
6. RESULTS AND DISCUSSION	52
6.1. General statistics of EcoSnap	52
6.2. Use case Hacettepe University Uni101 Course	59
6.3. Survey	60
6.4. Log Analysis	62
6.5. Limitations	67
7. CONCLUSION.....	69

8. REFERENCES.....	71
9. APPENDICES.....	79
Appendix 1. Reviewed crowdsourcing application links.....	79
Appendix 2. Volunteer survey	80
Appendix 3. Ethics Committee Approval Letter.....	84
Appendix 4. Thesis Originality Report	85
CURRICULUM VITAE	86

LIST OF FIGURES

Figure 2-1 Comparison of VGI, PGIS and PPGIS according to various concepts.....	6
Figure 3-1 Bottom-up approach model.....	10
Figure 3-2 Top-down approach model	11
Figure 3-3 Screenshot of the FMS interface	13
Figure 3-4 Screenshot of SeeClickFix interface	15
Figure 3-5 Screenshot of Ushahidi interface	18
Figure 3-6 Screenshot of Burgernet web interface	20
Figure 5-1 EcoSnap architecture.....	34
Figure 5-2 The popularity scale of the 4 most well-known Javascript frameworks.....	36
Figure 5-3 Dependencies between layers in DDD.....	39
Figure 5-4 Dedicated READ and WRITE models.....	41
Figure 5-5 DDD layers in EcoSnap	43
Figure 5-6 User login screen.....	44
Figure 5-7 User registration screen.....	45
Figure 5-8 User password change screen.....	46
Figure 5-9 Friend search & followings screens	47
Figure 5-10 Activity feeds screens	48
Figure 5-11 Activity creation steps.....	49
Figure 5-12 Ranking screen	50
Figure 5-13 Application settings screens	51
Figure 6-1 Number of users who installed the app - All users	53
Figure 6-2 User loss over time for EcoSnap	54
Figure 6-3 Returning users over time for EcoSnap	54

Figure 6-4 Percentage of installed Android versions	55
Figure 6-5 Distribution of reported problems in Ankara	57
Figure 6-6 Usage areas of using EcoSnap	58
Figure 6-7 An example of an incorrectly shared photo.....	59
Figure 6-8 Photo reported by the user during the Uni101 course	60
Figure 6-9 Log files collected daily	63
Figure 6-10 The used HTTP verbs and server response status codes	65
Figure 6-11 Hourly distribution of user requests	66
Figure 6-12 Log records of incorrect user login requests	66

LIST OF TABLES

Table 3-1 Applications in Five Categories.....	22
Table 3-2 Crowdsourcing platforms - summary of key data	23
Table 3-3 Crowdsourcing platforms - summary of key data (cont.).....	24
Table 6-1 Problem counts by type	57
Table 6-2 Number of requests to the server and average response times	63

ABBREVIATIONS

API	Application Programming Interface
BBoM	Big Ball of Mud
CDN	Content Delivery Network
CLI	Command Line Interface
CQRS	Command Query Responsibility Segregation
DDD	Domain-driven design
EF	Entity Framework
FMS	FixMyStreet
GPS	Global Positioning System
ICT	Communication Technology
JSON	JavaScript Object Notation
JSX	JavaScript Extension Syntax
JWT	JSON Web Tokens
MPA	Multi-Page Applications
ORDBMS	Object-Relational Database Management System
ORM	Object to Relational Mapping
OSM	Open Street Map
PGIS	Participatory GIS
POCO	Plain Old CLR Objects)
PPGIS	Public Participation Geographic Information System
SPA	Single-Page Applications
XML	Extensible Markup Language
VGI	Volunteered Geographic Information

1. INTRODUCTION

In today's world, there is a rapidly increasing growth in urban areas. According to the United Nations study [1], it is predicted that the global population living in cities will reach 60% by 2030. Until then, it is projected that approximately one-third of the global population will reside in cities comprising a minimum of half a million residents. People's demands for their basic needs will increase and it will be difficult to maintain the city's quality of life [2]. Therefore, urban growth should be considered now and measures should be taken to manage it in a sustainable way. Today, the term "smart city" is directly associated with the combination of city and technology. In response to the challenges of creating sustainable cities and mitigating climate change, this concept emerged towards the end of the 20th century, aiming to optimize resources through extensive utilization of technology. The growth of cities is closely tied to the citizens, specifically their way of living, as they are the ultimate consumers of urban infrastructure. Therefore, comprehending their behavior is crucial in sustainable urban planning [3].

Public participation in smart cities is an important component of urban governance that can bring numerous benefits to citizens and local authorities alike. By engaging the public in the planning, implementation, and evaluation of smart city projects, local governments can ensure that these initiatives are tailored to the needs and expectations of the community, and that they align with the broader goals of sustainable development.

One of the key benefits of public participation in smart cities is increased transparency and accountability. When citizens are involved in the decision-making process, they can provide valuable feedback and insights that help ensure that smart city initiatives are implemented in an open and accountable manner. This can foster trust between citizens and local governments and promote a sense of ownership and responsibility among the public. Another benefit of public participation is the ability to tap into the collective intelligence of the community. Citizens can provide valuable input on issues related to mobility, energy, security, and other areas that are central to the smart city agenda. By engaging with a diverse range of stakeholders, local governments can gain a more comprehensive understanding of the challenges and opportunities facing their communities and develop more effective strategies for addressing them.

Public participation can also help to promote social inclusion and equity. By involving marginalized and underrepresented groups in the smart city planning process, local governments can ensure that the benefits of these initiatives are shared fairly and that the needs and concerns of all citizens are taken into account. This can help to reduce inequalities in access to services and opportunities and promote greater social cohesion and solidarity.

One of the main technologies to address this is to develop mobile applications. Mobile applications can provide a user-friendly interface that allows citizens to report issues, provide feedback, and participate in decision-making processes related to urban development and public services. With the help of these applications, citizens can easily report issues such as potholes, damaged sidewalks, or broken streetlights, and track the status of their reports in real time. Mobile applications can also provide real-time updates on public services, and other relevant information. By providing easy and accessible ways for citizens to participate in solving problems in cities, mobile applications can play a significant role in creating more inclusive, sustainable, and livable urban environments.

1.1. Problem statement

Most of the previously developed applications for public participation were insufficient to reach large masses. They are not available to all audiences, as they can only respond to issues shared from a specific geographic region or support the use of several languages. In some applications, it was not possible to download and review from our region due to geo-restrictions. Many applications require various fees from researchers who want to use the feedback they provide to users, to obtain the shared data by governments or for analysis purposes only. In addition, gamification, which refers to the practice of incorporating game-like elements such as scores, badges, and leaderboards, into non-game contexts to increase user engagement and motivation, is not available in many other applications [4][5][6][7].

1.2. Contributions and Organization

This study provides citizen participation in smart cities with a mobile GIS application that will be developed using completely free and open source and will be called EcoSnap. Unlike other applications, gamification techniques and socialization have been emphasized in terms of including the infrastructure to support all languages and providing user motivation so that people from all walks of life can contribute. The successful

completion of the EcoSnap project would have the following advantages, some of which are mutually inclusive between the following stakeholders:

1. citizens would quickly report problems or concerns they encounter,
2. researchers could analyze the collected geospatial data on urban issues,
3. municipalities could act promptly to solve the issues and gain wider public support, and
4. companies would have a chance to recognize citizens' efforts by providing discounts.

The aim of this project is to develop EcoSnap, a cross-platform mobile application that can be used to report urban issues by combining gamification components. Consequently, the objectives are as follows:

1. enabling citizens to report city problems quickly and efficiently
2. improving communication channels between citizens and municipalities and create a sense of responsiveness and accountability
3. providing a platform where citizens can discuss reported issues, propose solutions and engage in dialogue with other users
4. improving service delivery by ensuring that reported issues are dealt with efficiently by the responsible authorities
5. providing information on reported problems, measures taken and solution statuses

This dissertation, prepared for these purposes, is organized as follows: The second chapter provides general information about smart cities and participatory mapping are provided, which are the two main concepts that are linked within EcoSnap. The third chapter consists of the literature study about mobile crowdsourced applications is given. Information about popular applications is given, and then comparing the features they have, missing areas are tried to determine. The fourth chapter contains explanations about the difficulties encountered in the implementation and sustainability of mobile applications. It also provides solutions that can be used to address these challenges. The fifth chapter includes information about the content of EcoSnap mobile application, its software design, and its capabilities. The sixth chapter is the results and discussion section, which includes the use of EcoSnap by the citizens and the analysis of the collected data. The last chapter summarizes the key findings, draws the conclusions of this thesis, and discuss possible future works.

2. SMART CITY

In this chapter, the concepts of smart cities and participatory mapping are explored. After providing information about the importance of smart cities, the main components of a smart city are outlined. Then, the concept of participatory mapping, which is one of the methods of creating smart cities, and its sub-titles Participatory GIS (PGIS), public participation geographic information system (PPGIS), and Volunteered Geographic Information (VGI) will be explained.

2.1. What is a smart city?

In recent years, the term smart city has gained popularity and has become a kind of buzzword. The smart city concept has gained more attention and momentum due to the increasing availability and affordability of digital technologies, the growing concerns about urban sustainability and resilience, and the recognition of the potential of data-driven decision-making to improve urban governance. Another reason for this concept to come to the fore is the desire and increasing interest of people to live in an urban environment. In the forecasts made for the future, it is predicted that the world population will increase rapidly until 2050 and that approximately 65% of the population will live in cities [8]. Uncontrolled population growth will make it difficult to meet needs such as transportation, education, health, and security in cities. Smart cities benefit from modern technologies to solve such problems, contributing to the integration of people, creating a sense of responsibility towards the environment, and improving the quality of life. With the use of smart technologies (eg, smartphones, wearables, cameras), people's living standards are increased and cities become more liveable, environmentally friendly, and efficient [9].

The smart city is a complex concept and covers many social, technical, and human areas, so there is no single definition accepted by everyone. According to Komninos [10], a smart city is not simply about technology, but also about social and environmental sustainability, economic development, and citizen engagement. He argues that a smart city should be able to learn from its citizens, respond to their needs and desires, and foster innovation in both the public and private sectors. On the other hand, Giffinger's concept of the smart city [11] is more holistic and includes multiple dimensions such as governance, economy, mobility, environment, people, and living. He developed a

framework of six smart city characteristics, which are: smart economy, smart governance, smart mobility, smart environment, smart living, and smart people. Each of these dimensions represents a key area that must be considered when designing and implementing a smart city strategy.

With the discourse of smart cities, technology is often presented as a solution to urban problems, but the deeper social and political factors that shape urban life are ignored. Hollands' research [12] highlights the need for a more critical and reflexive approach to the development of smart cities. Hollands critiques the way that smart cities are often designed and implemented without sufficient consultation with local communities. He argues that this approach can lead to a "top-down" approach to urban development that fails to address the needs and aspirations of residents. He suggests that a greater emphasis on democratic decision-making and public participation in urban planning, as well as a more nuanced understanding of the social and political implications of new technologies.

To sum up, the concept of the smart city has been defined in various ways by researchers, but there are common threads that run through these definitions. At its core, a smart city is a city that uses digital technologies to enhance the quality of life for its residents, while also promoting sustainability, efficiency, and innovation. While there are challenges associated with the development and implementation of smart city technologies, such as privacy concerns and potential biases, the potential benefits are significant. As cities around the world continue to adopt and evolve smart city strategies, it will be important for researchers, policymakers, and citizens to work together to ensure that these strategies are equitable, effective, and sustainable for all members of the community.

2.2. Participatory Mapping

Participatory mapping is a collaborative and community-based process of creating maps that reflect local knowledge and perspectives. Over the years, various terms have been used to describe this approach, including PGIS, PPGIS, and VGI [13]. They are spatial terms derived to express these concepts that are close to each other and actually contain many minor differences [14]. They are called by different names as shown in Figure 2-1 according to the weight of the contents and features they have [11].

Renee Sieber [15] describes PPGIS as an approach that seeks to involve the public in the process of geographic information creation and decision-making. This approach places more emphasis on the involvement of the wider public in the decision-making process. It

typically involves the use of web-based GIS tools and social media platforms to engage with a larger audience and gather input from the public. PPGIS can be used for a wide range of applications, such as urban planning, transportation planning, and environmental management.

PGIS is a type of PPGIS that focuses on engaging local communities and stakeholders in the planning and decision-making process. Brown [14] defined PGIS as "a set of tools, techniques, and methods for enabling communities to participate in decision-making and take an active role in managing local resources, using spatial information as a basis for discussion and analysis." PGIS is more focused on community-based decision-making processes, while PPGIS places more emphasis on engaging with the wider public in the decision-making process.

VGI encompasses the range of information that is produced by individuals or groups who voluntarily undertake to create and share spatial information using Web 2.0 technologies. It is a new form of user-generated content, where the content is explicitly georeferenced and often directly linked to geospatial databases or Web-based mapping tools [16]. This definition emphasizes the use of Web 2.0 technologies and the georeferencing of content as key features of VGI. It is often used in disaster management, urban planning, and environmental monitoring. VGI has the potential to provide large volumes of data at a relatively low cost, but its quality and reliability may vary depending on the source and method of collection .

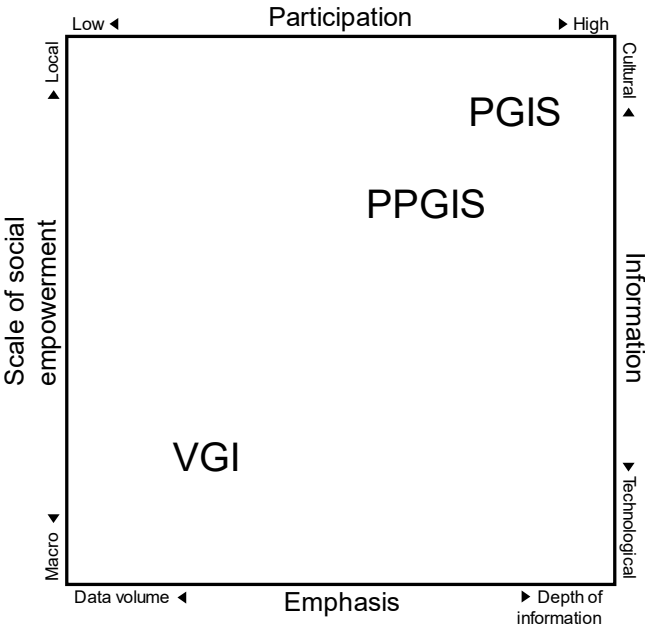


Figure 2-1 Comparison of VGI, PGIS and PPGIS according to various concepts

Understanding the various terms and concepts related to participatory mapping is crucial for engaging communities in decision-making processes and creating more inclusive and equitable societies. The mentioned terms offer a range of approaches and methods for incorporating local knowledge and perspectives into spatial data collection, analysis, and decision making. While each approach has its strengths and weaknesses, the common thread among them is the importance of empowering communities to participate in the production and use of spatial information. By adopting a collaborative and inclusive approach that values the diverse perspectives and knowledge of all stakeholders, participatory mapping can contribute to more sustainable and equitable outcomes in a variety of contexts.

2.3. Relationship between smart cities and participatory mapping

The relationship between smart cities and participatory mapping is rooted in the shared goal of engaging citizens in urban decision-making and shaping the future of cities. Participatory mapping involves involving communities and individuals in the process of creating and updating maps that reflect their lived experiences and local knowledge. Smart cities leverage participatory mapping as a powerful tool to gather valuable insights from residents and incorporate their perspectives into urban planning and development. By providing platforms and tools for citizens to contribute geospatial data, such as identifying community resources, highlighting areas of concern, or suggesting improvements, participatory mapping enables a bottom-up approach to urban governance. Smart cities can integrate these citizen-generated maps with other data sources, such as sensor networks or administrative databases, to create comprehensive and accurate representations of urban environments. This integration enhances decision-making processes and enables cities to address the diverse needs and aspirations of their communities.

Participatory mapping, in turn, benefits from the technological advancements and infrastructure of smart cities. Smart cities provide the necessary digital platforms, connectivity, and data analysis capabilities that enable participatory mapping initiatives to scale and have a broader impact. Through smart city infrastructure, such as mobile applications, geospatial tools, or data visualization platforms, participatory mapping efforts can reach a wider audience and facilitate meaningful community engagement. Smart cities also provide opportunities for real-time data collection and analysis, allowing participatory mapping to capture dynamic urban changes and respond to emerging issues

promptly. By incorporating participatory mapping into their frameworks, smart cities promote transparency, inclusivity, and citizen empowerment, transforming urban governance into a collaborative process between city authorities and the communities they serve.

3. RELATED WORKS

Services such as increasing the quality of life of citizens, solving environmental problems, and ensuring public safety are very expensive and labor-intensive processes for municipalities. For the citizens to continue their daily lives, these services must be constantly monitored, maintained, and intervened. Minor disruptions in this order could cause major problems. Thanks to specially designed platforms and mobile applications, governments can consistently obtain and collect it with the participation of the public. In this type of view, city dwellers are assumed to be a source of valuable up-to-date information. Access to this data, which is provided by the public, significantly increases the efficiency of the administration. These applications are special solutions that enable citizens to report problems such as potholes, broken traffic lights, and fallen road signs, and add them to the map. Reported problems are published over the application and reported to the relevant department of management. On the other hand, administrations can follow these problems, provide solutions and inform the reporters about various updates.

3.1. Characteristics of selected crowdsourcing platforms

The selected platforms were analyzed in terms of the following criteria: territorial scope, source of initiative, platform addresses, types of feedback, cooperation with the authorities, and gamification.

3.1.1. Territorial scope

The regional coverage is one of the main criterion that substantially differentiates the developed initiatives. The developed initiatives offer a spectrum ranging from local to covering all regions and countries. In this regard, the initiatives are divided into four:

1. Local scope, local problems - platforms originating from local communities and aimed at their development;
2. Regional coverage, local problems (expanded by multiple organizations) – national and broader platforms that focus on local community issues;
3. National scope, supra-local problems - platforms dedicated to universal problems, covering the entire country
4. Global scope – Maps and platforms used to support information and crisis management

3.1.2. Source of initiative

The source of the initiative is an important parameter proving how different the process of creating this type of initiative is. There are two creation channels in this area:

Bottom-up – the source is the needs of the inhabitants. As depicted in Figure 3-1, the creator/initiator of change is a citizen, a group of residents, a social organization, or a group of volunteers, often in cooperation with another organization or with the support of government funds. The process cycle is bottom-up and starts with the citizen/group of citizens. Changes are often initiated by circles focused around a given aspect related to a serious social problem.

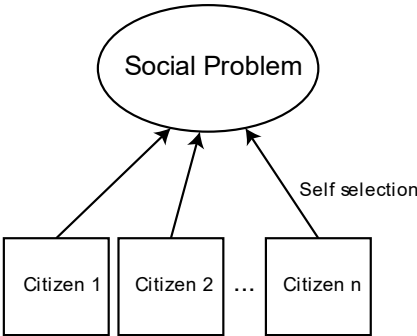


Figure 3-1 Bottom-up approach model

Top-down – the source is the need to strengthen the communication of government/self-government institutions with the citizen. Here, the initiator of the change is the institution, the process takes place on the line between the institution and society. The target is to strengthen cooperation between the city and its inhabitants and to establish a new information and data distribution channel. Figure 3-2 depicts the overall of top-down approach.

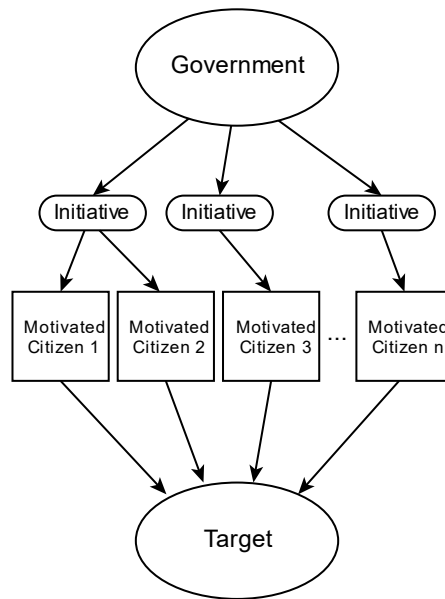


Figure 3-2 Top-down approach model

3.1.3. Platform addressees

The interlocutors of a crowdsourced mobile application are the individuals or entities that engage in communication or interaction within the app's ecosystem. They are the users who actively participate in the crowdsourcing process, contributing their knowledge, opinions, or resources to the platform. Interlocutors can be diverse and include the local people, neighborhood groups, researchers, businesses, and governmental organizations. The interlocutors play a vital role in the success of the app, as their engagement and contributions drive the collective intelligence, problem-solving capabilities, and community-building aspects of the crowdsourcing platform.

3.1.4. Scope of government support

The scope of government support for crowdsourcing platforms can vary depending on the priorities, resources, and policies of each government. It is essential for governments to understand the potential of crowdsourcing platforms and tailor their support to facilitate their growth, while also ensuring legal and ethical considerations are met. Regarding this issue, it was divided into two categories as cooperating and non-cooperating according to the attitudes of the administrations towards the platforms.

3.1.5. Scope and type of feedback

Crowdsourcing applications can provide various types of feedback to participants and users. Here are some common forms of feedback that crowdsourcing apps may offer: Daily, weekly, and monthly reports, maps and geospatial information, marking/visualizations of dangerous places, or rankings of shares. These types of feedback provided by crowdsourcing applications may vary depending on the nature of the crowdsourcing project, the goals of the app, and the features and functionalities it offers.

The applications mentioned in this study will be compared based on the aforementioned criteria in Table 3-2 and Table 3-3, and similarities and differences between them will be shown.

3.2. Applications

With the rise of mobile technology, PPGIS has become more accessible than ever, and many successful implementations of PPGIS mobile applications have emerged in recent years. These applications have been used to tackle a wide range of issues, from urban planning and environmental management to disaster response and community development. In this section, some notable examples of successful PPGIS mobile applications will be reviewed and discussed the potentials of applications for EcoSnap, comparing the features considered useful or lacking in these technologies.

3.2.1. FixMyStreet

Shown in Figure 3-3, FixMyStreet (FMS) is a map-based application that helps citizens of the United Kingdom to report street and street concerns to local government officials and municipalities and is developed in collaboration with the Young Foundation and mySociety. The application, which supported iPhone users in 2007, started to support Android devices in later periods. The intense interest in FMS across the country has led to the implementation of similar applications and the release of different versions in other countries.

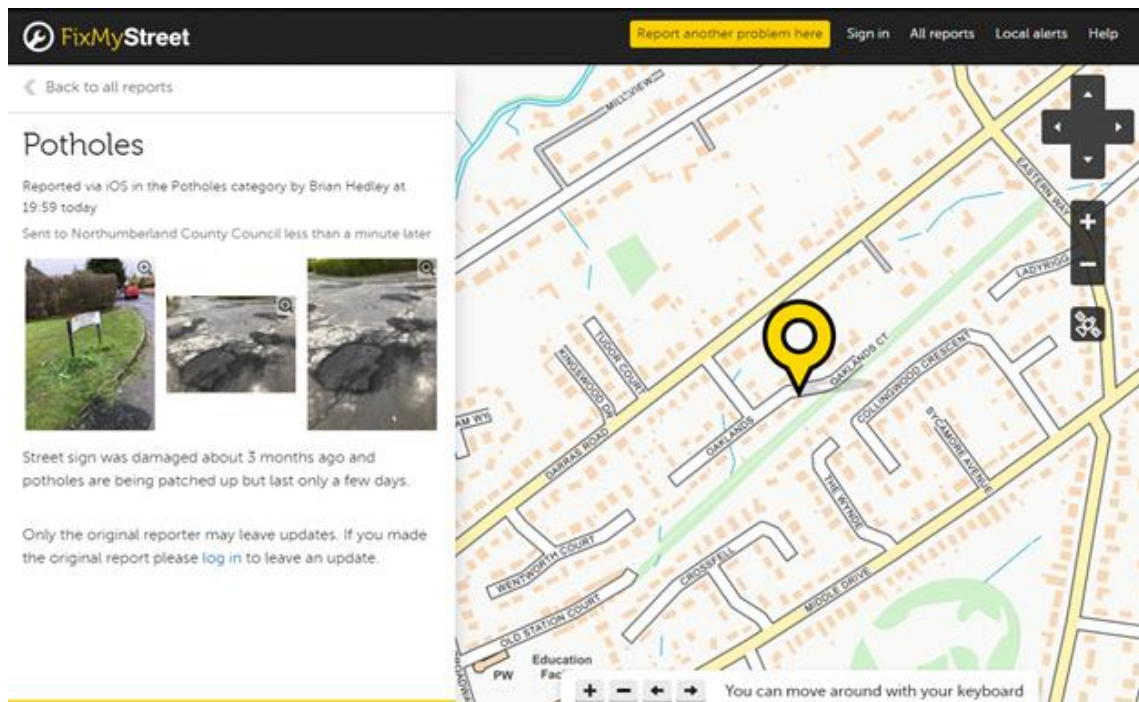


Figure 3-3 Screenshot of the FMS interface

Citizens can create records about physical problems such as bad sidewalks, potholes, and batons around them through the application, view similar records in their environment, and follow the solutions provided by the authorities. The reports submitted by the citizens are matched with the postal code of the users and the category of the problem and sent to the relevant municipalities via e-mail. At the end of the four weeks, FMS will contact users who have created reports to check the latest status of their issues, during which time it is also possible for any user to submit their reports and provide updates on the issue. According to their homepage, ~20K problems are reported weekly and solutions are developed. In addition, nearly 7 million updates have been made so far.

The values emphasized in the FMS project are transparency, efficiency, and accountability. At the beginning of the project, it was aimed to increase the quality of the services provided during meetings between authorities and developers and it was associated with efficiency. For developers of the application, design concerns to ensure transparency in public utilities have an important place. FMS is designed to be easy to use. This convenience can enable more citizens to reach the authorities and report problems online. For example, reporting a problem on other websites provided by municipalities is sufficient to report problems with just three clicks with FMS, although it consists of multiple stages. All complaints and responses are public, so citizens can

easily follow what's going on in their local government district or other neighborhoods. Providing quick solutions to reported problems is the motivation of users to continue without leaving the application. However, citizens are not appreciated and rewarded in any way for their reports or sharing. Users are given the option to remain anonymous while reporting their reports in the application. They can create accounts to access reports submitted by other users and track municipalities' responses to these issues and compare all municipalities and see how they are performing.

On the other hand, although efficiency is set as the target in the design of the application, very few features are included in this regard. Citizens are limited to predefined categories when reporting their problems. If they wanted to choose categories other than these, they were asked to contact the authorized municipalities directly. Although the reports and their results are transparently shared with the public, users can't have sufficient knowledge about the operation of the application from the beginning. There is no clear information about the citizens who want to report a problem, how long they should wait for a solution for their reports, and what kind of way they should follow in case the problem is ignored or not solved. Local authorities do not provide enough information on how they handle complaints and processes. In most cases, updating the status of the reports is done by users. Municipalities are not obliged to provide solutions to the reported problems, people can only check whether they have solved the problem. When their problems are not resolved, users can only report their problems again or they can put pressure on the authorities by commenting on reports together. Also, any gamification techniques are not included in the application. The fact that the application does not support languages other than English stands as an obstacle for communities speaking different languages to use the application.

3.2.2. SeeClickFix

In the USA, direct phone calls or e-mails are common communication channels for reporting problems to local authorities. Most of these reported calls remain unanswered and it is not possible to be informed about the latest status of the problem [17]. The communication gap between the demands of the citizens and the services of the government results in one-way feedback of the parties, unaware of each other. In such an environment, SeeClickFix, a crowdsourcing application, was developed in 2008. Figure 3-4 shows the details of a report of this application. In ten years, it has grown into a platform with over one million users in 25K towns and 8K neighborhoods. It has been

diversified and priced according to the scope of services it provides over time. Local governments and organizations are required to pay \$40 per month for basic features and \$100 per month for every 100,000 users for an upgraded "Plus" account. Thanks to these accounts, the sustainability and maintenance of the application are done by the company, it does not require any technical expertise in the usage process.

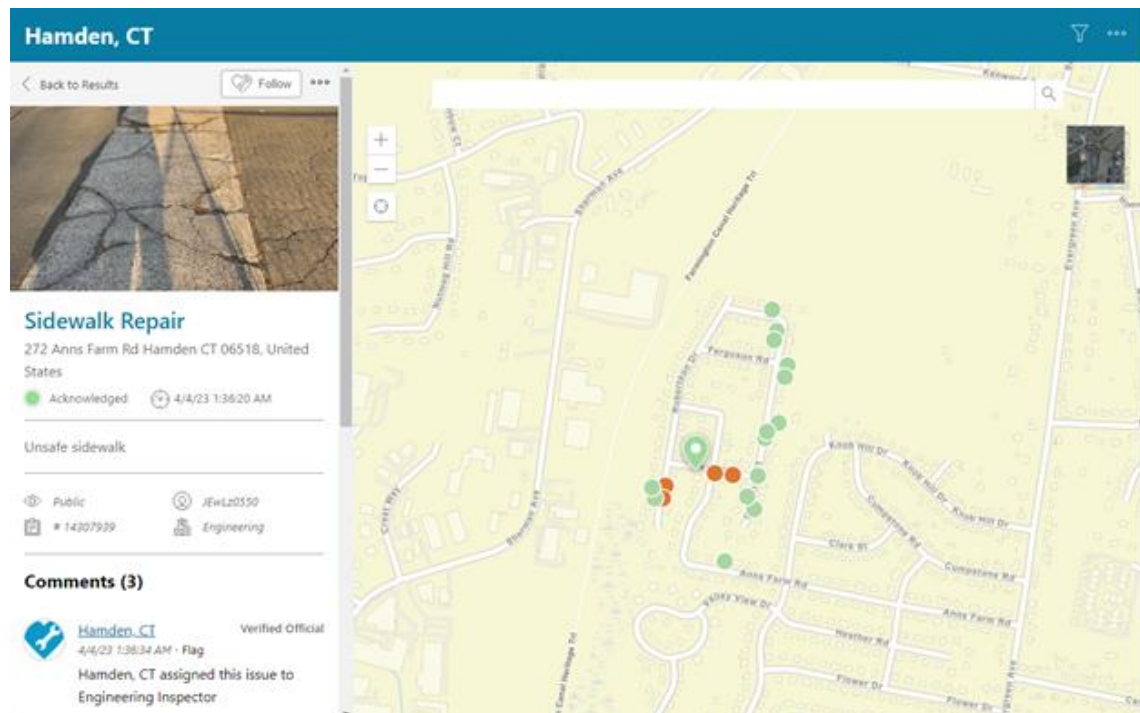


Figure 3-4 Screenshot of SeeClickFix interface

The application can be downloaded for free on both Android and iOS devices and enables citizens to report problems around them to authorities through both web and mobile devices. Users can take photos with their cameras, add geographic locations, and detailed explanations about the problem. It provides cooperation between citizens and the authorities and also contributes to authorities presenting solutions. It is possible to report problems in 35 categories such as graffiti, broken street lamps, broken infrastructure, and garbage problems through the application. Authorities receive reported problems by e-mail. When problems are raised to authorities, they can be answered directly or can be forwarded to the relevant department for resolution. Notifications are sent to all followers in the community when any changes are made by the officials to solve the problems.

To increase the inclusiveness of the application, users are allowed to provide their likes or add comments about the reports and earn points from their participation. Also, apart

from smartphones, widgets are provided to news sites, social awareness sites, and Facebook application, and reports are created and displayed from these mechanisms. According to information on the SeeClickFix website, repeated requests can be detected automatically before being forwarded to authorities. In addition, it is possible to adjust visibility to protect privacy and control the access levels of other users.

Although many users register and use the application, almost 10% of the people report any issues, they only follow the reported ones [17]. In addition, due to the limited options that the application offers to users during reporting, it may cause ambiguities in terms of location information. Another negative situation is that the updates are reflected too late by the municipalities. Almost one year after the situation is reported, messages about the solution are sent and these messages are sent more than once. In some cases, reports may remain unsolved. Also, users cannot choose information about the organization or department to which the complaint will be sent while creating a report, which adds additional burden to the users.

In conclusion, the application can be used as a tool to gather information from the participants, so that potential urban-issues can be recognized at an earlier stage and ultimately contribute to prioritization and pre-preparation of municipal services.

3.2.3. Ushahidi

Ushahidi, which means witnessing in Swahili, is a website that emerged in 2008 to collect and map information about the violence that developed after the elections in Kenya. It was also used in many emergencies in later periods such as monitoring the anti-immigrant situation in South Africa in 2008, Haiti earthquake in 2010, and forest fires in Russia the same year. The main idea of the application is to collect data from disaster areas, taking into account internet speed and population density, visualize them on maps, and offer solutions for help. As an example of this, Figure 3-5 shows an example of this and contains an aggregated map on map of the problems reported in a particular area. It is aimed to develop technologies that can work even in regions with low technical opportunities. Supporting both iOS and Android environments, the site integrates with Facebook, Twitter, and e-mail, making it possible to send media such as pictures and videos. The operation of the system is as follows:

1. Individuals send An SMS message to a predetermined number by authorities
2. SMS services integrated with the Ushahidi platform forward these messages

3. These messages are displayed on the Ushahidi site
4. The authorities then decide whether or not to reply to the sender

Every incoming message is divided into categories such as public health, infrastructure damage, security threats, natural hazards, etc. Administrators evaluate the accuracy and consistency of the reports and create an archive according to locations and occurrence times of events. Emergency response teams and managers can monitor reports on the map according to timelines and coordinate dispatched assistance.

The application has been released for free and its codes are available on an open-source basis. In this way, it can be used while developing applications according to various emergency needs. By downloading the Ushahidi platform, it can be installed on local servers in a few hours and configured according to the determined needs (fire, landslide, etc.). It is allowed to add reports without registering to the system. Reports in the form of polygons, points, or lines are added on various map servers. However, these reports are not displayed on the site until approved by administrators. Approved reports are published on the site as maps and lists.

The platform has evolved over the years and now offers several different products and services, including Crowdmap, a hosted version of the platform, and Ushahidi Insights, which allows users to analyze data and create visualizations.

There have been great considerations in the recent use of Ushahidi, which was used in many regions before. Many experts reported that they did not use the application even though they knew it. Also, there are many obstacles to the use of the application in rural areas of developing or less developed countries. Applications that require such technologies in remote areas or rural areas are sometimes not possible. In remote areas where disasters take place with insufficient infrastructure, the lack of 2G phones and their inoperability make it impossible to collect text messages with low data size.

In addition, there are no motivating features for the use of the application. Features can be added that will sort users according to their shares and make collaboration possible. In this way, a competitive environment can be created among users who want to reach higher levels.

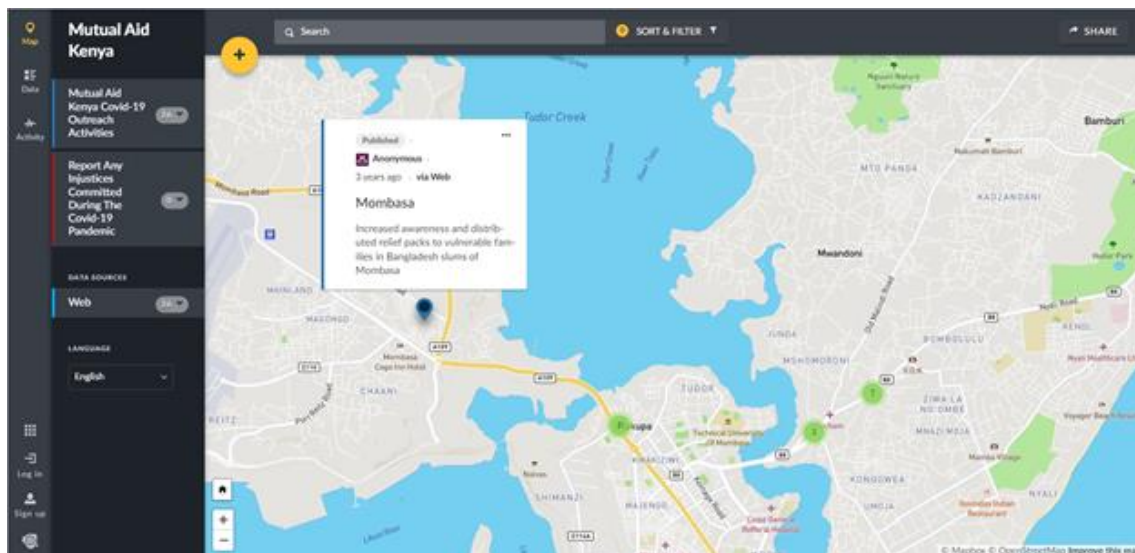


Figure 3-5 Screenshot of Ushahidi interface

As a result, Ushahidi enabled the determination of the needs of victims in distressed areas and managers to follow the situation with interactively rich visualization elements on various maps. This has been particularly useful where traditional media formats could be censored or restricted. In addition, Ushahidi has gained the ability to empower communities and give a voice to those who do not have access to traditional media channels. It has enabled cooperation and accountability among the relevant institutions.

3.2.4. Burgernet

Burgernet is a citizen alert system used in several countries, including the Netherlands, Denmark, and Belgium. It is designed to provide residents with quick and reliable information about criminal activities in their area, in the hope of reducing crime and helping law enforcement agencies apprehend perpetrators and as an example of this, the details and results of the report on the finding of a missing woman are shown in Figure 3-6. In the Netherlands, Burgernet was launched in 2009 and has since become an integral part of the country's crime prevention strategy. It allows the police to send alerts to registered participants via telephone, email, or SMS, providing them with descriptions of suspects, vehicles, or other relevant details. Burgernet participants can then report any sightings or provide additional information to the police, who can use this information to track down suspects and solve crimes. So far, 1.5 million people have participated in application across the country and its use become increasingly widespread. The working logic of Burgernet is as follows:

1. Issues are reported by citizens through the website or mobile application
2. According to the information given by the citizen, a system call is opened and a virtual community is created according to location information. In addition, if there is information about suspects or wanted persons, this is sent to community members via text messages or voice messages.
3. After the police report, information that members of the community know or see is collected.
4. Operators forward this information to the relevant police unit
5. According to updates provided by police, participants are informed about the situation.

Citizens provide their home or work address information while registering for the application. If police deem it necessary regarding a crime or a search, they can contact citizens to get information using address locations. For example, where the suspect person sought was last seen, the residents of that area are contacted. At last, the system sends an update message to the participants when the action ends. In this structure, police communicate with citizens only over the phone. And, the number of people contacted in the community is displayed on the website, and no other interaction information is published.

People are willing to use the application and provide information because it makes them feel safe and solves the problems encountered. However, a design has not been implemented to ensure the motivation of the citizens in the application. People may be losing their will and motivation to provide some key information because they think they may be in danger if they are involved in the events. In cases where police need to follow criminals or intervene urgently, their motivation decreases because they have to wait for adequate notifications. There are three main reasons why the police maintain this platform: The first aim is to create a sense of security in citizens towards their environment. When people do something for their safety, they feel more secure. The second purpose is to speed up police's pursuit of suspects or respond to incidents and increase efficiency. The last aim is to increase the trust of citizens in the police and to create a positive perception among citizens.

Burgernet has specific applications due to people's security concerns and the data collected is not entirely clear. It cannot be integrated into the platform with other sources and only superficial information such as the number of messages shared, the number of

problems solved, and the performance of cities are shared with the external environment. Also, standardized data formats such as Open311 are not implemented. Open311 is a mechanism launched by OpenPlans (<https://www.openplans.org>) that helps citizens to add their requests directly to the government's job lists and provides an easier, faster delivery of updates to citizens [18].

Despite concerns, Burgernet remains a popular and effective tool used by many municipalities and citizens, thanks to its contribution to the ability to catch platform criminals in early stages, which supports web, iOS, and Android environments.

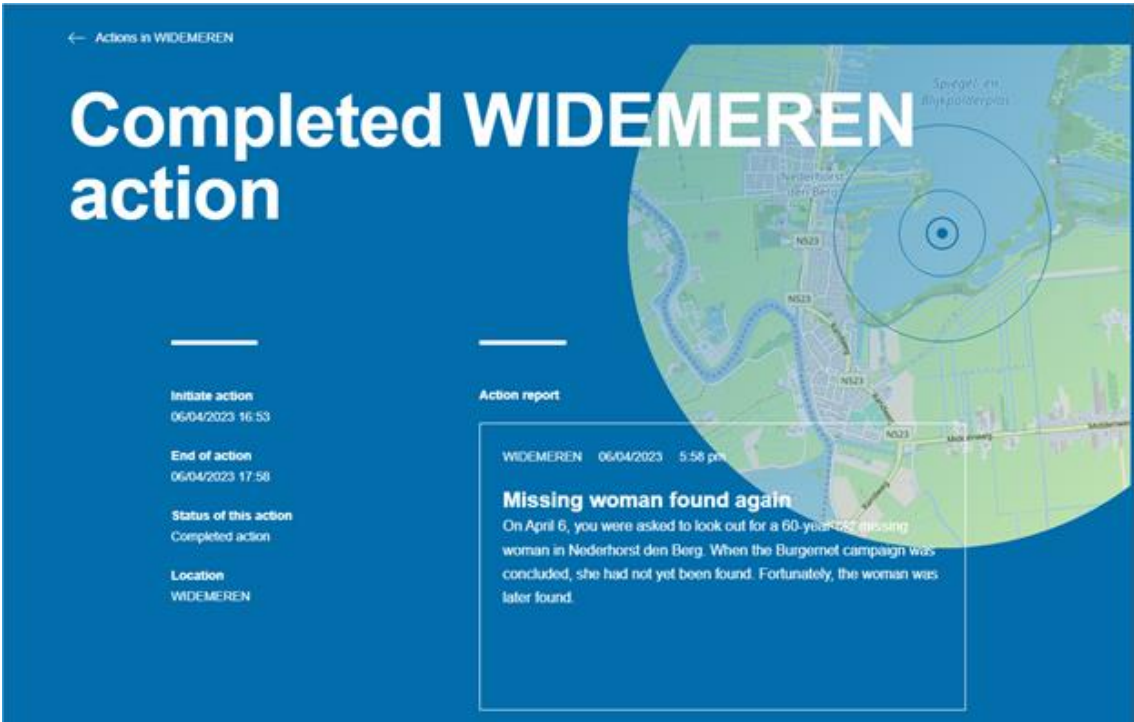


Figure 3-6 Screenshot of Burgernet web interface

3.2.5. Other Works

“Street Bump” is a mobile application developed by the City of Boston in partnership with a company called Connected Bits. The goal of the app is to help the city identify and repair potholes and other road hazards more quickly and efficiently. The way the app works is by using the accelerometer and GPS sensors on users' smartphones to detect bumps in the road as they drive. When the app detects a bump, it records the location and intensity of the bump and sends that information to the city's public works department. The data collected by the app helps the city identify problem areas more quickly and prioritize repairs based on the severity of the road hazards. The app also allows residents

to report road hazards directly to the city, which can help expedite the repair process. Street Bump has been used successfully in Boston since its launch in 2012 and has since been adopted by other cities in the United States and around the world.

“BOS:311” is the non-emergency contact center for the City of Boston, Massachusetts. It provides a convenient and easy way for Boston residents to report non-emergency issues, ask questions, and get information about city services. Residents can contact BOS:311 by phone, mobile app, or web form to report a wide range of issues, including potholes, graffiti, broken streetlights, noise complaints, and more. BOS:311 uses a sophisticated system to track and manage requests, ensuring that all issues are addressed in a timely and efficient manner. Requests are automatically routed to the appropriate department for action, and residents can track the status of their requests online or through the mobile app. In short, BOS:311 helps to improve the quality of life for Boston residents and keeps the city running smoothly. Similar applications have been applied in different states of the USA under different names such as NYC311 and Philly311.

“PublicStuff” was a mobile application that allowed residents to report non-emergency issues, such as potholes, graffiti, and broken streetlights, to their local government. The app was designed to improve government responsiveness and make it easier for residents to engage with their local government. The way PublicStuff worked was simple. Residents could download the app, select their location, and report an issue by taking a photo, adding a description, and submitting it to their local government. The app would then route the request to the appropriate department for action, and residents could track the status of their request and receive updates through the app. PublicStuff app was widely used by cities and towns across the United States, as well as in other countries around the world. The app was particularly popular among younger residents who preferred to use their smartphones to engage with their local government.

“Love Clean Streets” is a mobile application that allows citizens to report issues related to cleanliness, maintenance, and environmental concerns in their neighborhoods. The app is available in several cities across the United States and the United Kingdom and enables users to report problems such as litter, graffiti, potholes, and broken streetlights. Once a user submits a report, the Love Clean Streets app sends it directly to the local authority responsible for addressing the issue. The authorities can then prioritize the issue and take necessary actions to resolve it. In addition to reporting issues, the Love Clean Streets app also allows users to view the status of their previous reports and track the progress of any

reported issues. The app aims to empower citizens to actively participate in maintaining clean and healthy communities while promoting transparency and accountability among local authorities.

“Snap Send Solve” is a mobile application designed to simplify the process of reporting local issues and infrastructure problems to local authorities in Australia and New Zealand. The app allows users to quickly report issues such as litter, graffiti, damaged infrastructure, and other issues that require attention. Using the app, users can take a photo of the issue, add a description and geolocation, and submit it to the relevant local authority with just a few taps. The app uses the smartphone's GPS to automatically determine the user's location, making it easy to report issues on the go. Once a report is submitted, Snap Send Solve sends it directly to the relevant local authority, which can then prioritize the issue and take necessary action to resolve it. The app also allows users to track the progress of their reports and receive updates on the status of reported issues. It has been widely adopted in Australia and New Zealand and has helped to improve the responsiveness of local authorities to community issues.

Apart from these applications mentioned, there are many applications on various subjects. These applications are divided into five different categories according to their purposes as shown in Table 3-1.

Table 3-1 Applications in Five Categories

Public Utilities	Health	Safety	Pollution	Disaster Management
Love Clean Streets Snap Send Solve See Click fix CitySourced FixMyStreet Waze StreetBump	MomMaps Outbreaks Near Me SickWeather	CrowdSafe Crime Stoppers NextDoor	CreekWatch Widenoise iSpex	CrisisTracker Ushadidi Twitcident Crowdmonitor Did you feel it

Table 3-2 Crowdsourcing platforms - summary of key data

Platform name/Year of creation	Territorial scope	Purpose of action	Creators	Thematic scope	Addressees	Feedback	Cooperation with the authorities	Gamification
FixMyStreet (UK)/ 2007	National	Provide a platform that makes it easy for citizens to report these issues and to ensure that they are addressed by the appropriate authorities	A joint social initiative of MySociety and Young Foundation	Report and track issues in their local area, such as potholes, broken streetlights, or fly-tipping	Residents Local government and municipal authorities Service providers and contractors Community organizations	Reports Notifications and alerts Communication logs Data analytics	Yes	No
SeeClickFix (USA)/2008	Regional	Empower citizens to take an active role in improving their communities by providing a platform for reporting and resolving non-emergency issues, and to facilitate communication between citizens and local authorities	Grassroots initiative of a group of New Haven residents (USA)	Report and track non-emergency issues in community	Residents Local government and municipal authorities Service providers and contractors Community organizations and neighborhood associations	Statistics Comprehensive reports Maps	Yes	No
Ushahidi (Kenya)/2008	Global	Provide a platform for collecting, visualizing, and sharing information about crisis situations, disasters, and other events in real-time	A team of developers in Kenya	Incidents of violence, harassment, or other problems during the Kenyan elections	Citizens and individuals Humanitarian organizations Media outlets Government agencies and public authorities	Incident reports Maps (geospatial information) Response and relief reports	Yes	No
Burgernet (Netherlands)/ 2009	Regional	Enable citizens to report suspicious activity, missing persons, and other incidents in real-time, and to provide law enforcement agencies with the tools and resources they need to respond quickly and effectively to these incidents	The Dutch National Police	Identifying suspects or locating missing persons	Citizens, Police departments, Emergency services	Non-detailed statistical Reports	Yes	No
Street Bump (USA)/2012	Local	Collect data about road conditions and identify areas in need of maintenance or repair	Partnership of Boston City and Massachusetts Institute of Technology	Detect and record road roughness	Residents and drivers Local government and transportation authorities	Road condition data Visualizations and maps Analytics	Yes	No

Table 3-3 Crowdsourcing platforms - summary of key data (cont.)

Platform name/Year of creation	Territorial scope	Purpose of action	Creators	Thematic scope	Addressees	Feedback	Cooperation with the authorities	Gamification
BOS:311 (USA)/2015	Regional	Provide a centralized platform for citizens to report non-emergency issues and service requests to the City of Boston	The City of Boston's Department of Innovation and Technology (DoIT)	Manage and track service requests and other interactions with residents	Residents, Businesses, City officials and government agencies	Issue tracking Performance metrics Comprehensive reports Maps	Yes	No
PublicStuff (USA)/2010	Regional	Improve the communication and collaboration between local governments and their residents	Students at of University of Pennsylvania	Report and track non-emergency issues such as potholes, graffiti, or broken streetlights	Residents Local government officials Municipal service departments	Reports Geospatial information	Yes	No
Love Clean Streets (UK)/2020	Local	Promote community engagement, enhance environmental awareness, and improve the quality of life for residents and visitors by facilitating effective communication and collaboration between individuals and their local authorities	UK-based company called Keep Britain Tidy	Report issues such as litter, graffiti, and fly-tipping	Residents Local authorities Environmental services departments	Statistics Comprehensive reports Maps	Yes	Yes
Snap Send Solve (Australia)/2010	Regional	Enhance community engagement, promote accountability and transparency, and improve the quality of life for residents by facilitating effective communication between individuals and their local authorities	Australian company called Outware Mobile	Report issues such as potholes, damaged footpaths, and abandoned vehicles	Residents Local government and municipal authorities Service providers and contractors	Statistics Comprehensive reports Maps	Yes	Yes

4. CHALLENGES FOR APPLICATIONS

In the ever-evolving landscape of application development, crowdsourcing has emerged as a powerful approach that leverages the collective wisdom and expertise of a diverse crowd. By tapping into the knowledge and skills of individuals from different backgrounds and locations, crowdsourcing enables the creation of innovative and user-centric applications. However, this collaborative model comes with its own set of challenges that must be carefully addressed to ensure the success and integrity of the crowdsourcing process.

This chapter explores four crucial challenges that arise when crowdsourcing applications: Quality Management, Ethics and Privacy, Sustaining Motivation, and Gamification. Understanding and effectively managing these challenges are fundamental to harnessing the true potential of crowdsourcing and delivering high-quality, ethically sound, and engaging applications.

4.1. Quality Management

Quality management refers to the process of ensuring the quality and accuracy of the work submitted by the crowd. To ensure the quality of work produced by the crowd, quality management processes need to be put in place. These processes may include setting clear guidelines and instructions for the tasks, providing training and feedback to workers, and implementing quality control measures such as spot-checking or double-checking work.

There is a need for techniques that can measure the quality of the data collected, detect low-performance senders without the necessary skills, knowledge or motivation, or prevent spam senders who intentionally post irrelevant, unsolicited, or low-quality contributions. Verifying every answer collected is a very demanding process and makes crowdsourcing inefficient. The solution to this problem is to rely on repeated tags in the activity. In this method, a task to be given is performed by more than one volunteer. As a result, both the correct answers to the task are verified and the data collection quality of the volunteers is measured [19]. In a similar algorithm proposed by Dawid [20], the accuracy of the event was calculated using the quality of each employee and the situations tagged by the employees, and the quality of the participant was also estimated using the correct or incorrect answers.

In another technique, the duration of a participant for the given task is calculated, and the duration of the other participants is compared with this time, and it is calculated whether they have passed the assigned task or not [21].

Another way to ensure quality is to prequalify volunteers. At this stage, they can have information about the project with lessons and videos about carrying out their duties and can take precautions against the situations they will encounter [22]. Also, Wang [22] suggests a simple way for the selection of volunteers which is using a qualification test or gold-injected method. Before tasks are given to the volunteer candidates, an aptitude test including golden tasks is applied to measure their adequacy. Quality of candidates is calculated based on the responses to the golden tasks. Candidates or fraudsters whose participation probability is below a certain level are prevented from entering the project. In addition, in this way, the volunteers will be more familiar with the tasks that can be given.

Providers should first communicate their requirements to the volunteers in cases where a sufficient quality contribution is expected. These definitions help volunteers complete their tasks more reliably. In addition, volunteers' evaluation of each other is an effective way to increase quality. In this way, volunteers can contribute to quality by verifying each other's data [23].

Collected data from the community can sometimes be of poor quality. Some malicious volunteers may have deliberately given wrong answers. Sometimes, because volunteers have different levels of education and expertise, those with lower qualifications may not be able to fulfill their assigned tasks. In such cases, focus should be given to groups of participants with proven capabilities without significantly reducing quality [24].

In summary, providing quality in crowdsourcing projects is essential for reliable results, accurate information, effective problem solving, user satisfaction, reputation and trust-building, and upholding ethical standards. By prioritizing quality, crowdsourcing initiatives can maximize the value and impact of the collective wisdom of the crowd.

4.2. Ethics and Privacy

Protecting the ethics and privacy of volunteers in crowdsourcing projects is of utmost importance. Volunteers contribute their time, effort, and personal information to participate in these initiatives, and safeguarding their ethical well-being and privacy is crucial for maintaining trust and ensuring a positive experience.

Security and privacy problems encountered in projects where data collection from crowds is done through mobile applications is an issue that needs to be investigated and is a difficult situation to evaluate [25]. Because some applications collect a lot of data, including sensitive data, it is very important to protect this information from unauthorized access, misuse or disclosure. For example, data collected with built-in GPS tracking modules can cause the user's home and work locations to be easily found. Therefore, these platforms should ensure the privacy of users and include measures to give a sense of trust [26]. Maintaining confidentiality protects both the volunteers and the integrity of the project.

While crowdsourcing projects can offer valuable opportunities for volunteers, it's important to be aware of the potential negative aspects related to the earning aspect that can impact ethics and privacy. As the data collection process becomes automated without realizing, subjects may be unaware of how their data is processed and monetized [25]. There is a heightened risk of privacy violations if the organizers prioritize monetization over implementing robust data protection measures. Without appropriate safeguards, personal information may be mishandled, shared with unauthorized parties, or used for purposes beyond what volunteers and beneficiaries consented to.

In mobile applications used for data collection and analysis, the privacy issue is either ignored or users are not offered any options to ensure privacy [27]. Nicolosi [28] has planned that the participants choose the level of confidentiality they want at the time they provide data, transmit the data to the source provider, and then publish the data entered anonymously to the institutions that want to see it on their websites. Besides, [29], [30] has proposed a spatial cloaking technique to hide the position of users when they do not want to share their location. Li [31] has applied techniques such as blind signatures to ensure confidentiality and prevent malicious attacks.

Some studies involve utilizing encryption techniques to hide sensitive information while collecting and sending data. Gentry [32] has proposed a scheme that will ensure that the original data, the intermediate data generated in encryption, and the final output data remain fully encrypted. Some studies have used blockchain technology to ensure the confidentiality of data. Li [33] has created a framework in which the data contributed by the participants can be deciphered by certain employees without any authority institution and guaranteeing confidentiality. The blockchain-based system proposed by Yang [34] has not only included mechanisms aimed at protecting user privacy but has also increased

the success rate of users in the task. In the structure proposed by Tiwari [35], a biometric-based authentication mechanism is included to securely access and share data.

In some participatory data collection operations, only one participant receives the award. The fact that only one of the participants who participated in this situation knowingly received the award and the others were left without a prize despite their efforts, causes some ethical problems [25]. Providers of such applications are required to announce their expectations and demands from the winning participant before accepting the applications, and before organizing the contests with participation [36]. It is important to explain the characteristics of the performance criteria to be met and the problem being investigated and to determine the prize.

Another point to be considered about data protection is the good balance between the quality of the data collected and the reward to be given for confidentiality. Methods such as mosaicking, which can be done on collected images to protect privacy, degrade the quality of the collected data, and crowdsourcing negatively affects performance [27]. The decision of how to use these techniques should be based on the context, privacy requirements, and intended use of the data.

In conclusion, protecting the ethics and privacy of volunteers is essential for maintaining trust, engagement, and the overall success of crowdsourcing projects. It upholds individual rights, respects personal boundaries, and ensures that volunteers can contribute in a safe and supportive environment.

4.3. Sustaining Motivation

Motivation can be defined as an impetus to increase energy or the process of stimulating actions that help achieve a goal [37]. It is a crucial factor in crowdsourcing applications, as it influences the engagement and quality of contributions made by the crowd. Also, it is a multidisciplinary research topic discussed in many fields such as psychology, medicine, social sciences, and business. In another definition, motivation is considered to be the feeling that drives people to continue an action that is subjective (existing in the mind) or objective (a target related) [38].

People's participation in citizen science practices is affected by motivation factors in many ways [39]. The increase in the need for data to be collected through citizen science and the increase in projects created for this makes it very important that participation is sustainable [40]. According to various surveys, participant interviews, and interviews

with program leaders, motivations for participating in citizen science projects are listed as protecting the environment, contributing to science, or being part of a community [41]. Motivation is divided into two groups as intrinsic and extrinsic motivation. Intrinsic motivation is a type of motivation that comes from within an individual and is driven by internal factors such as learning, self-actualization and self-worth [42]. It refers to the natural desire to engage in an activity or pursue a goal simply because it is inherently interesting, challenging, or fulfilling. In contrast, extrinsic motivation is a type of motivation that is driven by external factors such as rewards, recognition, or fear of punishment [42]. It refers to the desire to engage in an activity or pursue a goal in order to obtain a tangible or intangible reward or avoid a negative consequence. Many citizen science studies reveal that intrinsic and extrinsic motivations are the main factors that affect users' active participation and production of quality results [43]. An experiment conducted with students showed that intrinsic motivation enables them to behave more well-intentioned in information sharing [44]. In another study on employee loyalty and their work, it was concluded that intrinsic motivation is more effective than extrinsic motivation, providing better performance and more return [45]. As a result, the increase in extrinsic motivation causes a decrease in intrinsic motivation. Because external factors such as reputation or money affect people and their behavior.

4.3.1. Extrinsic Motivations

Monetary rewards: It is the most common extrinsic motivation used among the factors that motivate the success of the information exchange and the competitors. Participants stated that monetary rewards affect their decision to participate in a task and their level of commitment [46]. A study concluded that, unlike the participants who did not receive any financial reward, those who work an extra day and earn monetary gain are more productive and willing [47]. In general, people are more likely to participate in these activities if they believe that the rewards are worth the effort required to participate. Thanks to the awards received, participants feel that they are more recognized by the employer and they respond with more commitment. The rewards obtained help them to put more effort to meet the expectation, believing that their work is an indication that they are appreciated.

Reputation: Reputation can be a powerful motivator for mass participation activities. People often participate in these activities to enhance their reputation, whether it's among

their peers, their industry, or their community. This can be obtained by solving problems effectively, assisting others, or compliments [48]. In addition, participants are likely to increase their motivation with the sense of protecting their reputation, winning the competition, and continuing to participate. A good reputation can bring many benefits, such as trust, respect, and admiration, while a bad reputation can lead to social exclusion, stigma, and even professional consequences. As such, people often go to great lengths to cultivate a positive reputation, whether by achieving excellence in their work, networking with influential people, or engaging in philanthropic activities. While reputation can be a powerful motivator, it can also be fragile and easily damaged, so it requires ongoing effort and attention to maintain.

4.3.2. Intrinsic Motivations

Self-efficacy: Self-efficacy refers to an individual's belief in their ability to successfully perform a specific task or accomplish a particular goal. It is a key concept in psychology and is closely related to the idea of self-confidence. Self-efficacy beliefs can have a significant impact on an individual's behavior, motivation, and overall well-being. It is believed that the participants with a high self-efficacy level put more effort to solve the given problems and are more effective solvers in crowdsourcing applications due to their tendency to endure difficulties [49]. Furthermore, it is determined that the participants, who are competitors and always thinking of winning, are more willing to participate in crowdsourcing tasks with the desire to win. By promoting self-efficacy, designers and managers of crowd-sourcing projects can encourage greater participation, higher-quality contributions, and greater satisfaction among participants.

Learning: Learning can have a significant impact on motivation by providing individuals with a sense of progress, achievement, and personal growth. Learning can be acquired through sharing ideas, brainstorming, solving other people's questions, and examining others' answers [48]. A community that provides an environment for its participants to learn new things every time can be motivating for people and keep them engaged and interact with the topics discussed in this environment [50]. In terms of education, it has been observed that learning from intrinsic motivations is in a parallel relationship with performance. Contests aimed at innovation and creativity, in which students participate, can inspire new ideas and solve problems. When students believe that they have gained new knowledge through these competitions, they are curious and more willing to spend their energies in this direction [51]. To sum up, learning can have a powerful impact on

motivation by providing individuals with a sense of progress, personal growth, and achievement. By promoting learning, organizations, and individuals can enhance motivation, increase performance, and achieve greater success.

4.4. Adoption of gamification

Gamification is the application of game elements to non-game contexts to strengthen volunteers' motivation and utilize information to achieve goals and/or engage in various behaviors [52]. Compared to a uniform application design, a gamified design can offer its users a more interactive environment and enable them to have a game-like experience, which can create value for the user [53]. In this way, a design has been widely applied in the fields of education, health, and marketing from the past to the present and has played an important role in the participation of users [54]. Similarly, crowdsourcing applications, which rely on the contributions of a large group of individuals to solve complex problems or complete tasks, can benefit greatly from gamification. By adding game-like features such as points, badges, leaderboards, and challenges, crowdsourcing platforms can increase user engagement, motivation, and participation. Gamification can also help to foster a sense of community and competition among users, which can lead to higher quality contributions and better outcomes. Overall, the use of gamification in crowdsourcing applications can enhance user experiences and improve the effectiveness of these platforms in solving real-world problems.

Gamification elements that can be implemented in a typical crowdsourcing platform are: scores (scores), leader boards (rankings), achievements (badges), progresses (levels), resources (virtual objects or territories), and missions, characters (avatars) [55]. By adding game-like features these platforms can increase user engagement, motivation, and participation. Hamari [56] has grouped these elements into three main categories: immersion, social, and achievement.

Immersion-related gamification is a strategy used in game design to engage and motivate players by immersing them in a game world or experience. It involves creating a game environment that is visually and audibly appealing, and that captures the player's imagination, emotions, and attention [57]. The goal of immersion-related gamification is to make the player feel like they are an integral part of the game world, rather than just an outside observer. By creating an immersive gaming experience, players are more likely

to become emotionally invested in the game and therefore more likely to continue playing.

Social-related gamification method includes making use of social networking tools such as chats, blogs, and peer ratings to provide users with a sense of belonging, to ensure that they are in close communication, and to establish a social network through mutual assistance [58]. The goal of social-related gamification is to make the application experience more social and interactive, which can lead to increased engagement and motivation to play. Social-related gamification can be used in a variety of contexts, such as in educational games to encourage collaboration and teamwork, or in fitness apps to encourage users to connect with friends and share their progress.

Achievement gamification is the use of game design elements and mechanics to motivate and engage users by providing them with a sense of achievement and progress with components such as points, levels, and badges. This type of gamification can increase competition among users and encourage users to keep them in continuous use by providing visible indicators to express level [59]. They can elevate their status by consistently achieving challenging goals, which fosters a sense of accomplishment and pride [55].

Overall, the use of gamification in crowdsourcing applications can enhance user experiences and improve the effectiveness of these platforms in solving real-world problems. But, as understood from the reviews, injecting gamification into applications is not an easy process. Complex design difficulties of a system that affects people's behaviors and motivations bring along very difficult conditions for system developers [60].

5. PROPOSED SYSTEM

This section presents the architecture of EcoSnap application as illustrated in Figure 5-1, and describe how it was developed. It provides an overview of the structural framework that underlies EcoSnap's functionality, emphasizing the careful design choices and technical considerations that have shaped its development. Through an in-depth analysis, it is aimed to showcase the robustness and efficiency of the application's architecture, highlighting its ability to handle user interactions, process data, and deliver a seamless user experience.

Basically, EcoSnap is composed of three main parts, database, backend, and frontend. For the database, PostgreSQL used, an open-source, platform-independent advanced object-relational database management system (ORDBMS) that is popular all over the world. PostgreSQL offers many innovative features that are attractive to database developers such as array data types, parallel queries, supporting JSON data type, and running queries on it. Moreover, you can manage your geographic data with PostgreSQL. PostgreSQL becomes a database to support spatial data structures with PostGIS plugin. Also, it is platform-independent, as it works on all modern operating systems (Linux, Unix, Windows, Mac OS, etc.) and processors (x86, x86_64, IA64, etc.). User data and activities are stored in a PostgreSQL database. Users do not have direct access here; they perform their requests through the a Rest API. This database, API codes, and assets are kept on the Ubuntu server with average features.

The next part is the Rest API application, which is used to perform database operations. We have taken care to abstract the application from frontend as much as possible and to be independent. This backend application can respond to requests from both frontend and external services independently. It has its own security, logging, authorization, and verification mechanisms. It is also responsible for saving the photos uploaded by the users on the server where it works and using it over an accessible link. In addition, it presents an interface for sharing the data recorded by the stakeholders. This interface is provided by Swagger component. This component automatically creates documents for methods and objects found in the API. This document not only allows people to better understand the backend, but also enables them to easily use the JSON content in their applications using the code language of their choice.

The last part is a frontend application. Cross platforms have been examined in order to make the frontend application work in the two most commonly used operating systems in mobile phones (ie., Andriod and iOS). React Native was chosen for EcoSnap, which is easy to learn, has more community, and includes many map components. Also, when faced with any coding problem, ready-made examples for solution can be found easily. There are two different ways to develop applications with React Native: Expo CLI and React Native CLI. Expo CLI is third-party service, but React Native CLI was developed by React Native team and community. Expo CLI was chosen because it offers a more streamlined application development environment. Although Expo CLI has many simplified libraries for accessing device features, React Native CLI has not so many. Also, expo is used to package of the application. EcoSnap packaged this way is available only on Google Play for now. It will also be presented in the Apple Store in the future.

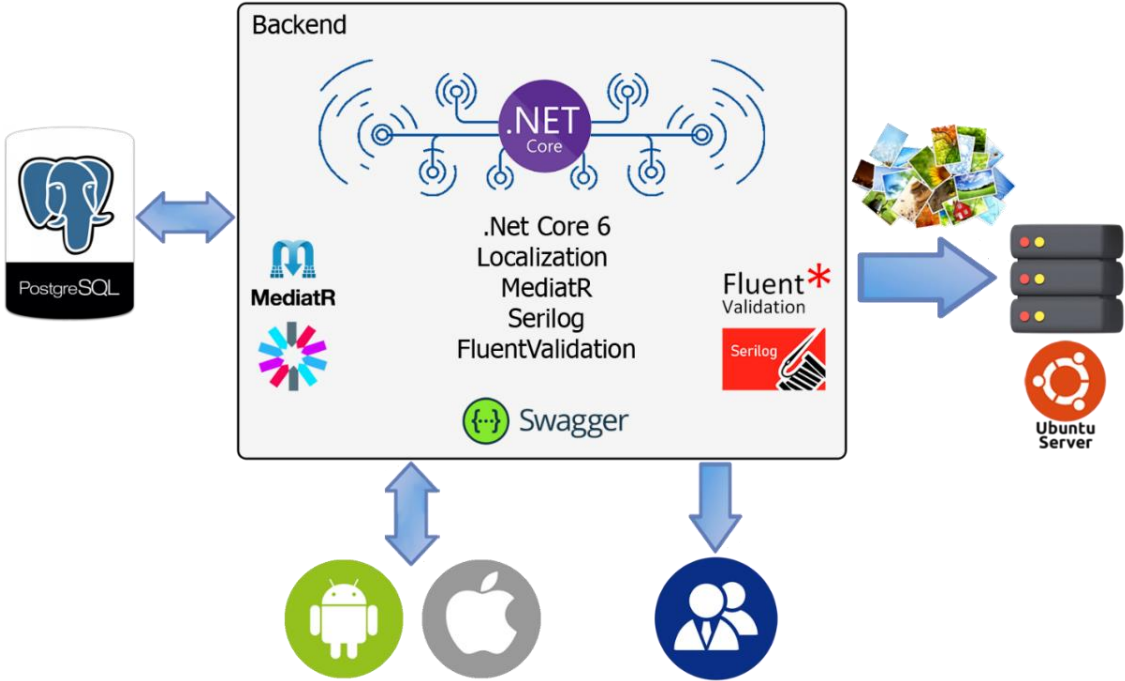


Figure 5-1 EcoSnap architecture

5.1. Project Creation

There are two commonly known methods of creating web pages today: these are multi-page applications (MPA) and single-page applications (SPA).

Multi-page application (MPA) approach has been widely used by developers as a method for creating web applications from a recent past to the present. The developers have gradually given up using this approach. This model is based on creating separate html

files for each page. A request is sent to the server for the content that needs to be loaded dynamically or for transitions between pages, and then the HTML file created by the server in response is downloaded time [61]. This prevents the data transfer from working properly and causes delays especially in loading and displaying pages. As a result, users are exposed to very long waiting times by today's standards.

In today's modern web standards, SPA is the most common approach which is a more user-friendly and faster option. SPAs have gained popularity due to their ability to create fast, interactive, and responsive web applications, providing a more seamless user experience compared to traditional multi-page applications. Traditional web applications work by navigating between different pages, where each page triggers a new request to the server, causing the entire page to reload. In contrast, SPAs load the initial HTML, CSS, and JavaScript files from the server, and subsequent interactions are handled by making asynchronous requests to the server for data updates. The server typically responds with data in JSON format, and the SPA uses this data to dynamically update the content on the page without requiring a full page reload.

In this approach, even separating the frontend from the rest of the logic via API provides many benefits. Most importantly, it provides loose coupling between backend and frontend logic. It allows frontend and backend to be developed independently at different times and by different people. In addition, by using techniques such as caching, SPAs can offer limited functionality even when the user is offline or has a poor internet connection. Also, SPAs can leverage client-side caching to store previously fetched data, reducing the need for repeated server requests.

Domain-driven design (DDD) is a very efficient approach to developing applications with a SPA approach. From a technical point of view, the domain model can be used as a basic component both on the backend and frontend. For this purpose, the domain model, which is created in EcoSnap application, has formed the core of the application thanks to both its use on the frontend by generating it with OpenAPI Generator tool and its efficient use by other API layers on the backend.

Nowadays many SPA frameworks offer ease of use and extra features. Here are some of the frameworks that are widely used: React and React Native from Facebook, Angular from Google, and Vue [62]. Although these languages are JavaScript based, they have their language syntaxes. If we make a comparison among these frontend languages, React

can be accepted the most popular language for developers with over 203K GitHub stars. Vue.js, which was developed in 2016 and has 202K GitHub stars, is one of the languages whose popularity has decreased recently. Angular, on the other hand, is still one of the most common languages, with more than 86K GitHub stars, even though it has been on a huge decline lately. As it can be understood from the analysis in Figure 5-2, it is determined that only React maintains its popularity with increasing momentum, while other languages were stagnating.

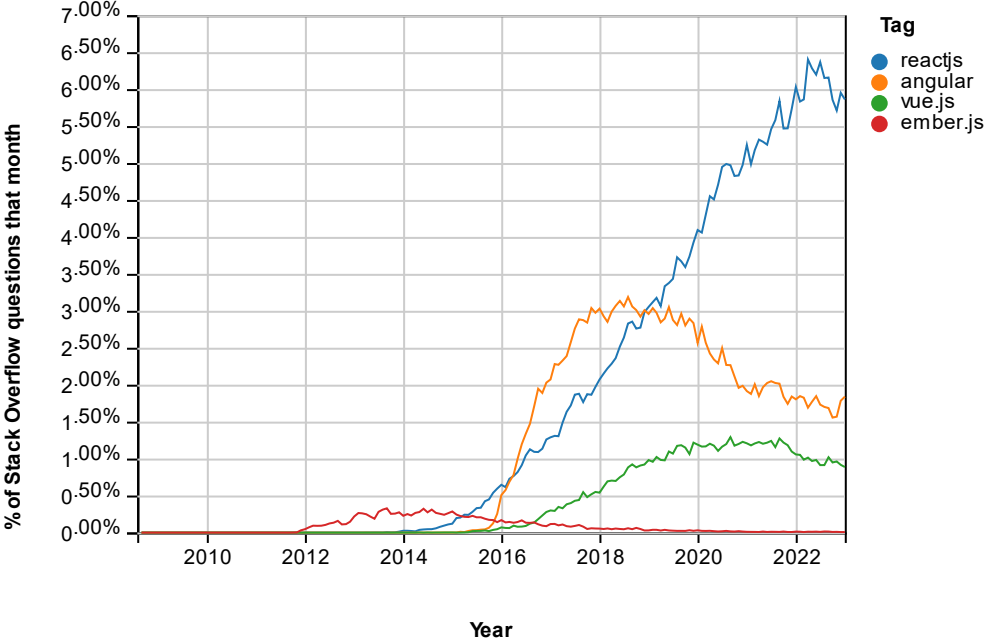


Figure 5-2 The popularity scale of the 4 most well-known Javascript frameworks

React was launched by Facebook in 2013 with the slogan "JavaScript library for building user interfaces" [63]. It has a component-based architecture, and each of these components represents pages or elements on them. Facebook makes use of these components on many of its pages. Since React uses the virtual DOM unlike other languages, it calculates the differences that may occur on the pages in the possible update processes, then transfers these changes to the actual DOM in the most efficient way. Thanks to this feature of React, the pages work more effectively and quickly.

React Native is also a JavaScript-based language developed by Facebook and designed to develop mobile applications. It is an open-source framework and is used for developing native applications running on mobile devices. Thanks to this framework, it is possible to develop applications running on both Android and iOS systems. This is called "Cross-

platform Development” which is the process of building a mobile application that can ultimately be launched on several operating systems - e.g., Android and iOS - based on one source code. Most enterprises and startups want their application to be available on many devices with different operating systems to cover as much of the market as possible. The main feature of cross-platform technologies is that the created source code of the application works on many platforms at the same time, with slight differences in the code between iOS and Android platforms. This is mainly possible thanks to cross-platform frameworks such as React Native or Flutter. Cross-platform can be summed up as “One programming language that works on the most important platforms”. Most programmers who can develop applications in the React language can easily adapt to this language. It has a lot of developers today, thanks to its being JavaScript-based and easy to write and understand. React Native apps are written with JSX syntax, a mix of JavaScript and XML-esque markup languages. The main purpose of JSX is to provide a more visual code usage by writing HTML code inside JavaScript files. It also allows us to show the elements or components included in the document structure in declarative form. In this way, more complex but easier to understand components can be created.

Communicating with the API in React is done using the Axios library. According to the latest npm statistics, it has a weekly download stat of over 40 million. Fetch API, which emerged in 2015, was not preferred because it is difficult to use and has less built-in functionality than Axios. Axios also makes it possible to make general changes and additions to incoming or sent requests, thanks to its method features such as interceptor and await/async. It was used to add the token from a single point over the headers.

A Open Street Map (OSM) tile is used to visualize mapping operations in EcoSnap. It is a project that was founded in 2004 and consists in creating and sharing a map of the world by the community. It is available to anyone and can be edited by anyone who wants to contribute to its development. OSM is an alternative to traditional maps, such as Google Maps, which are based on closed data. One of the main differences is the cost of using the service. When you embed the Google Maps module on your website, you can only generate a certain number of impressions for free. After exceeding the limit, you will have to pay for access to the service. Otherwise, the map will stop working. OSM is completely free even for commercial use.

5.2. Domain Driven Design

Throughout the development of EcoSnap, it was aimed to be a quality software. To ensure this, functionality and user tests were applied. Although developing properly working, error-free software does not mean that the software model is of the best quality. While aiming to have the least faulty codes, a well-designed model takes things to the next level. By far, the most popular software architecture design model for business applications is Big Ball of Mud (BBoM). It is haphazardly structured, sprawling, sloppy, duct-tape and bailing wire, spaghetti code jungle [64]. The model of complex business practices, which started with enthusiasm and beautiful dreams, may turn into this model over time. Instead of modular and permanent methods, it may be desired to be solved with simple and temporary methods that can solve the problem at that moment. In such cases, the codes start to get worse and worse. Continuing improvements on the bad method make things unbearable. To maintain the quality of the software, the project should be stopped and the codes reviewed. It is necessary to update with more effective, up-to-date, and modular codes.

The Domain-Driven Design (DDD) approach was introduced by "Eric Evans", author of *Domain-Driven Design: Tackling Complexity in the Heart of Software*, to ensure the successful and in-depth application of ever-changing business conduct rules to your software project in harmony and order. With this approach, continuity and permanent solutions to the main problems that are constantly experienced can be brought in the software development phase or the projects implemented.

Evan [65] describes the principles of DDD is that focusing on the core complexity and opportunity in the domain, not focusing on the technical platform. Also, models are explored in collaboration with domain experts and software experts. We don't say to the business people you are the ones who know the business so give us a model. Or we are the ones responsible for the software so we will develop the models. It needs to be done together. Moreover, Evan [65] suggests that software should explicitly reflect that model. However, this approach brings some difficulties concerning communication at the beginning. While developers usually define the relationship between real life and programming with classes, methods, algorithms, and patterns, domain experts may not mean anything. In order to eliminate this difference encountered in communication, ideas should be exchanged about the models and elements created. A ubiquitous language is the existence of a common language between domain experts, developers, project

managers and, stakeholders, and is very effective in the success of the project. Since domain services are very important to the model, their names and usage should be part of the domain language, which is a conceptual expression called Ubiquitous Language. Their meanings and responsibilities should be consistent and logical on the part of the client and the domain expert.

5.2.1. Layers in EcoSnap Domain Design

Eric Evans in the book DDD: Tackling Complexity in the Heart of Software [65] presents a model characteristic of Domain Driven Design, which consists of the following layers as shown in Figure 5-3: Presentation/User Interface, Application, Domain and Infrastructure.

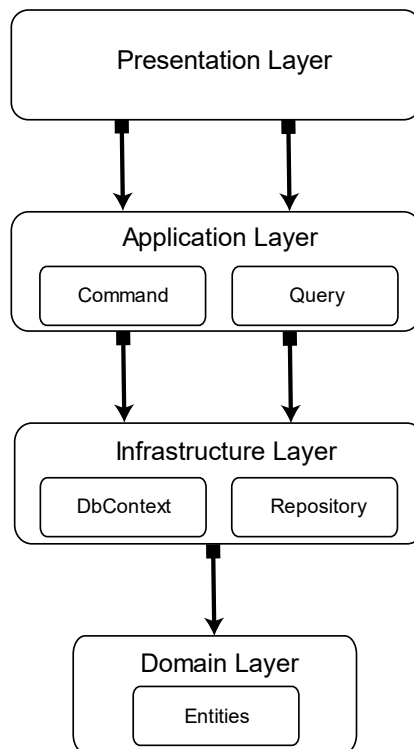


Figure 5-3 Dependencies between layers in DDD

Domain layer acts as a core component and is where the business is expressed. Instead of technical details which deal with infrastructure, Cesar [66] remarks that this layer is liable to represent business concepts, rules, and situations. In .NET projects, this layer is a class library that contains domain entities and rules about entities. Also, it must not include any dependencies on the infrastructure and should consist only POCOs.

Domain model layer of EcoSnap application consists of a base entity class and interfaces, aggregate and sub-entity classes, translation entities, and reference entities. An abstract class named `AuditionEntity` was created and thanks to this class, the information by whom and when the transactions were performed are recorded. Also, another abstract class was created to support localization and interfaces for entities.

Infrastructure layer is the layer where backend application connect to the external environments. It supports communication between layers and is responsible for storing and accessing data (persistence, storage). In addition, it allows access to other system resources, e.g. AMQP, Redis, Ceph, Elasticsearch, loggers, cache, file system, various types of systems responsible for sending messages, etc. Focuses on technology-specific decisions and deals with the implementation part rather than the purpose. In this layer, repository interfaces and other domain instances defined in the domain layer can be created.

EcoSnap infrastructure layer consists of database operation artifacts, filters, and other external operation services. A database is designed in the Code First structure and chose Entity Framework Core as ORM tool. ORM or Object to Relational Mapping is basically a software architecture that allows to use tables and fields in the database as objects. At the heart of Entity Framework (EF) Core are `DbContext` objects, which are a gateway to the database. This class is an abstraction layer between EF Core and domain models. Thanks to this abstraction, models become independent from the EFCore and will be effective even if the ORM tool changes when needed. While the application was launched, some data need to be available in the database. Gorman [67] stated that if it is desired to have default values in the database, putting them in the seed method is the best option. This way ensures that data is available in tables. There are many ways to approach working with seed data. Although it is possible to perform this process within the Fluent API, a class was created for seeding operations and exposed a static method that is triggered every execution of the program. Moreover, there are some services for external communication. E-mails are sent to users with mail service such as account activation. Photo service is used to save activity photos that send from users. Token and password services are used to securely store user data.

Application Layer contains services that are open to the external environment (presentation layers or other remote services). This layer acts as a bridge between the domain layer and the external environment. According to Evans [60], this layer should

be kept as thin as possible and should not contain business/domain rules. It should provide cooperation between domain services and coordinate tasks. Creation of Data transfer objects (Dtos), data conversion, coordination of repository calls, etc. can be given as examples of these tasks.

Ecosnap architecture have created in accordance with this structure and whose layers are shown in Figure 5-5, application layer is located just below the presentation layer. Command Query Responsibility Segregation (CQRS) pattern have used. CQRS means separation of command and query responsibilities. Although it is a pattern that has been increasing in popularity in recent years, its popularity has increased gradually after the article [68] written by Martin Fowler after hearing this pattern by Greg Young. While the Create, Read, Update, and Delete operations used in software projects are called Command, query operations correspond to Query. Implementing CQRS EcoSnap will maximize its performance, scalability, and security. The flexibility created by migrating to CQRS allows a system to evolve better over time and prevents update commands from causing domain-level conflicts. Thanks to this pattern, read and write operations are separated as shown in Figure 5-4 and this allows to use a separate database for each operation. Since read and write are separated, no need to wait for any read or write operation. In EcoSnap, these processes is performed using the MediatR library. MediatR sends the request to the handler written for the relevant method with the help of “Send” method.

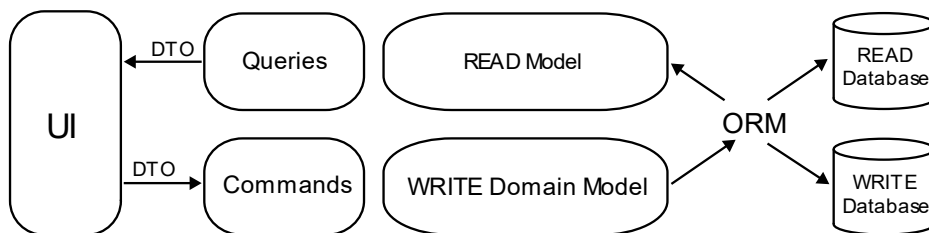


Figure 5-4 Dedicated READ and WRITE models

Also in application layer of designed model, FluentValidation is used to validate incoming requests which is a library used for building strongly-typed validation rules. Validation is the evaluation and checking of conformity in order to introduce objects into business rules. This tool was used to validate parameters used as input in all command and query classes. Moreover, AutoMapper library is used to mapping objects to each other. Instead of mapping individual objects wherever they are needed, they can be

controlled from a single place via mapper, and the necessary parsing operations can be provided through this library. It allows to get rid of complex codes and save time.

Having Exception Management in the application layer is important for the sustainability and security of the application. If bugs are not managed properly, they can be attacked from outside uncontrollably and confidential information can be exposed. A custom strategy has been designed for the management of errors in the application. All possible error types and details are given in response to incoming requests.

Presentation layer takes reference from Application layer and users do not see any models directly in the domain layer. Instead, request and response structures from WebAPI will be seen. This layer is responsible for communication with the user and the presentation of information, regardless of whether it is a web, desktop, or native mobile application [65]. It mainly contains Controllers and Views, as well as JavaScript, CSS, HTML, and other object-related requests or responses. Requests are received from the external environment through this layer, and the response is shaped and forwarded to the clients in this layer. Evans [65] stated that there is no sharp distinction between the Application and Presentation layers and that they are created as a single layer in some projects, and that the codes are separated in some projects.

Presentation layer of designed model consists of a .Net Core WebAPI project. The API application is created in REST architectural style, which is a service structure and data transfer method that enables fast and easy communication between client and server. It is also faster because it sends and receives data with minimum content and has a simpler structure compared to other alternatives. Web services written in accordance with REST standards are called RESTful services. Also, this layer contains MVC Controllers to process and respond to incoming requests. JWT (JSON Web Tokens) are used for user authentication, user identification, data integrity and information security protection in constantly communicating mobile and API systems. By using this key, it is possible to access application records when the information in them is decrypted. In addition, what the API methods do and how they are used should be clear in the documentation. Manually writing API documentation is both difficult and impossible to keep up to date. Somehow it is necessary to produce this documentation up-to-date. Swagger is used for these processes. An important purpose of Swagger is to provide an interface for Rest APIs. This allows both people and computers to see, examine and understand the features of Rest APIs without accessing the source code. An open source 3rd party application

“Serilog” was used for the logs to be recorded in the API. What distinguishes Serilog from other libraries is its very useful structured logging feature. Structured logging is a way of recording application logs with a predetermined and standardized message format [69]. That is XML or JSON format and they can be handled as data sets instead of text. As a result, these logs can be analyzed and searched effortlessly. Also, “Application Insights Telemetry” is used to monitor application status, track incoming requests, detect exceptions, automatically detect performance anomalies, diagnose problems, and helps understanding what users are doing with API application. The collected metrics and log information is stored on the server daily.

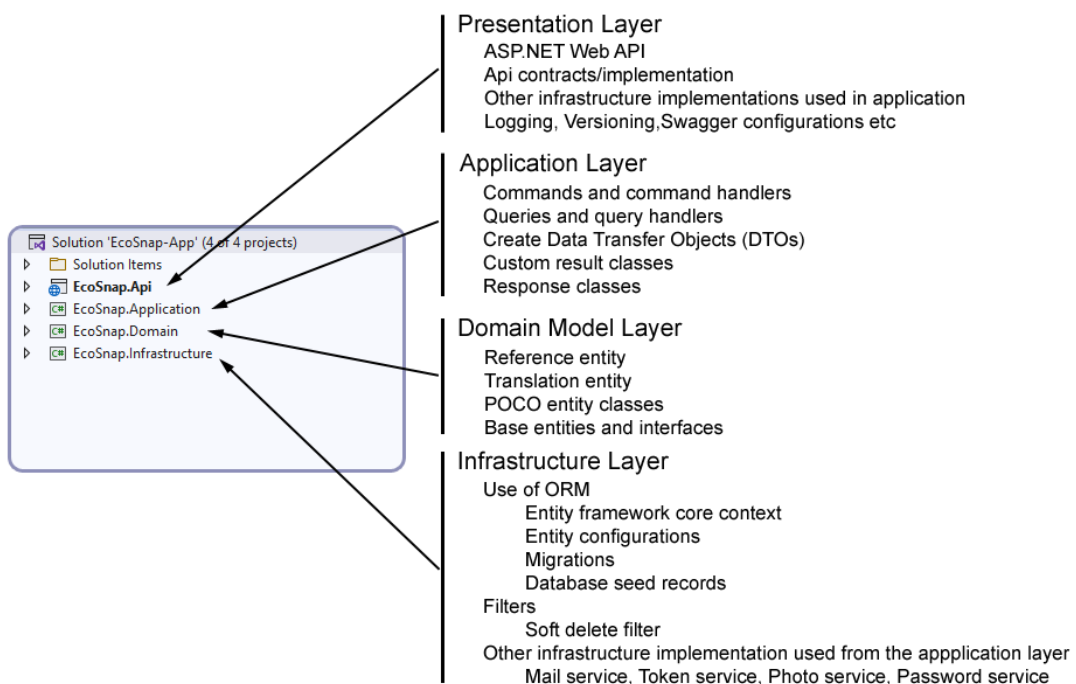


Figure 5-5 DDD layers in EcoSnap

5.3. Account Screens

These screens are used before EcoSnap activities and are necessary for personalizing user actions and controlling who created them. Users can log in to the system, register or perform password operations through these screens.

5.3.1. Login Screen

To use all screens other than account screens, each user must log in using login screen in Figure 5-6. To log in to the system, users must enter their e-mail address in the username field and the confidential word they have determined in the password field. In addition to

this option, it is also possible to log into the system with a Facebook or Google account. After clicking the login button, this payload information is sent to the backend. After checking the validity of the user information, a positive or negative response is sent by the backend. The positive response object contains the user information and token information generated to be used for the accuracy of subsequent requests. In case of negative responses, the error message and HTTP response status codes are returned. The frontend side uses this information to redirect the user to the next page, the action registration page.

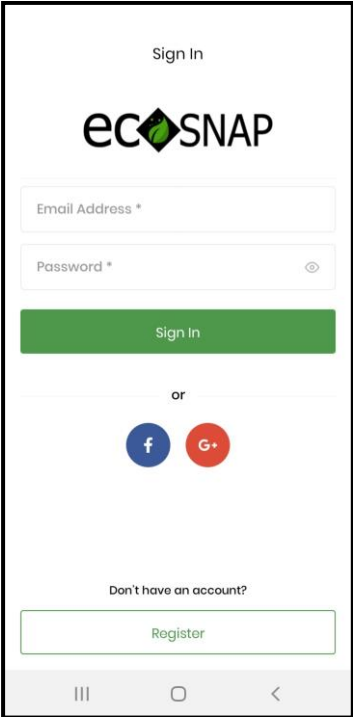


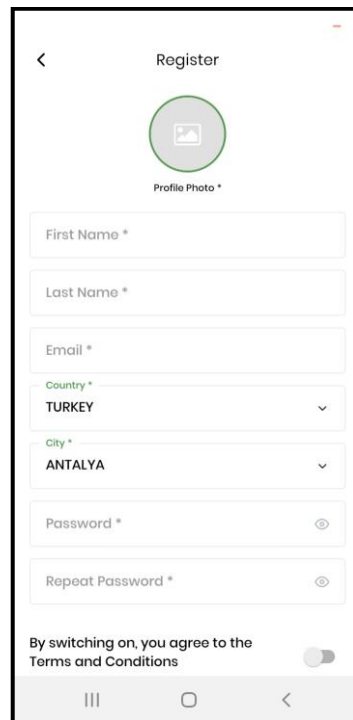
Figure 5-6 User login screen

5.3.2. Forgot Password Screen

When users forget their passwords, they have the opportunity to reset their passwords with the "Forgot Password" option. When users submit this request, a notification message is sent to the e-mail address they used during registration. With the button in the message, the page where the new password will be set will be opened. If the information is entered correctly, the password will be successfully changed and then user will be redirected to the login page.

5.3.3. Registration Screen

Registration page where the user's data is obtained and information such as username and password are determined before using the application. After the fields in Figure 5-7 are entered in the formats in accordance with the predetermined rules, information is sent to the backend. The validity of the information is also checked on the back side, and as a result, an information mail is sent to the specified email address for the activation process. In this case, the user is “NotActivated” and cannot login to the application as long as user activates the account by pressing the button in the information message. Users can login after account activation, in this case, the user will be updated with the activated status in the database. The e-mail addresses specified by the users are kept individually in the database and can only be used once during registration. The purpose in verifying by mail is to prevent the user from creating random accounts.



The screenshot displays a mobile application registration screen titled "Register". At the top left is a back arrow, and at the top center is the title "Register". Below the title is a circular profile photo placeholder with a camera icon and the text "Profile Photo *". The form consists of several input fields: "First Name *", "Last Name *", "Email *", "Country *" (a dropdown menu currently showing "TURKEY"), "City *" (a dropdown menu currently showing "ANTALYA"), "Password *", and "Repeat Password *". Each password field has an eye icon for toggling visibility. At the bottom of the form, there is a checkbox area with the text "By switching on, you agree to the Terms and Conditions" and a toggle switch that is currently turned off. The bottom of the screen shows a standard Android navigation bar with three icons: a home button, a square button, and a back arrow.

Figure 5-7 User registration screen

5.3.4. Change Password Screen

Users can update their passwords using this screen when they deem it necessary to ensure their security. After the new password is confirmed, a successful password change confirmation message will be displayed. This screen in Figure 5-8 can only be viewed by users who have logged into the system before, via the settings screen.

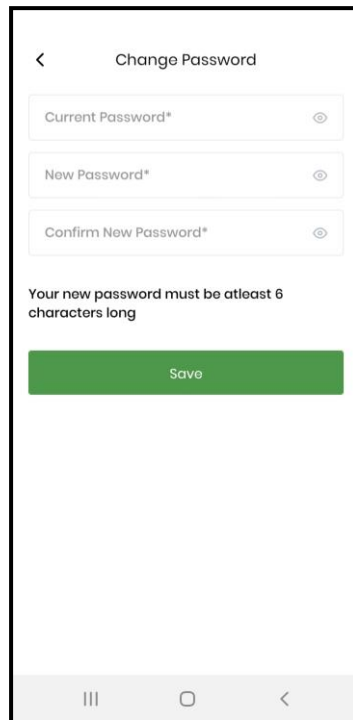


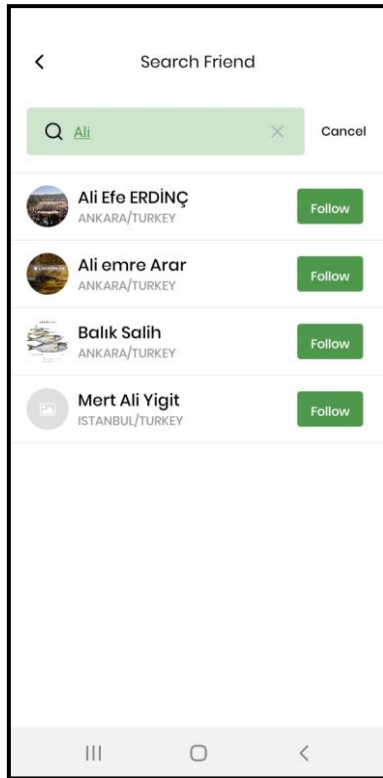
Figure 5-8 User password change screen

5.4. Activity Screens

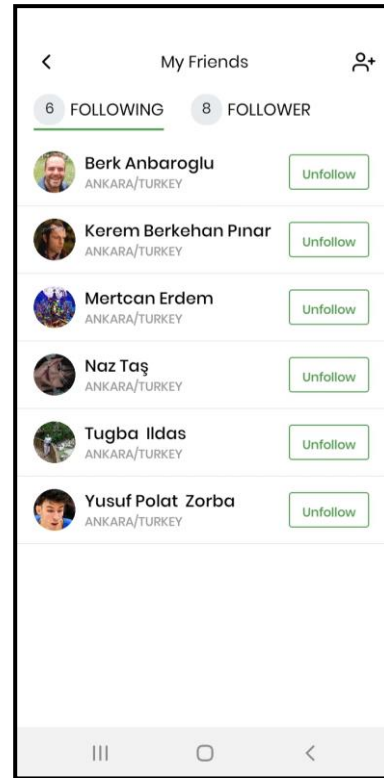
Users who have successfully logged into the system now have the opportunity to report the problems they encounter through EcoSnap activity screens. In addition, they can follow their friends and write comments on their activities or show their reactions to activities with like/unlike.

5.4.1. Friendship Screen

Inter-user communication is given importance in the application. Another familiar user can be found using the search screen in Figure 5-9-a. Users can send requests to follow each other so that they can see each other's activities. After this request, a following request notification is sent by the backend to the other user's screen. According to possible acceptance or rejection, friendships can be established between users. Users can delete a user they have previously accepted or sent a request from their list at any time using “My Friends” screen shown in Figure 5-9-b. In this way, the privacy of users' personal shares are ensured.



(a) Friend search results



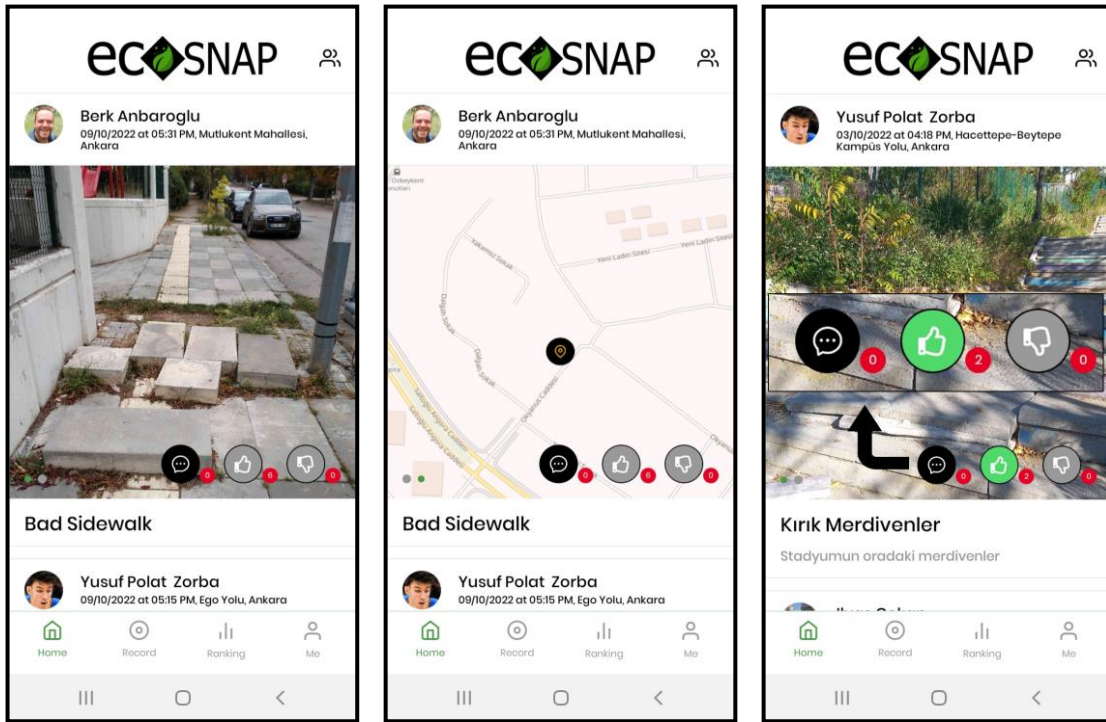
(b) Followings and followers

Figure 5-9 Friend search & followings screens

5.4.2. Activity Feed Screen

This is the default page in the application for logged-in users. On this page, users have the authority to see both the information about their activities and following friends' posts. Time, location, photo, details, likes, and comments on the event can be accessed here. A screenshot with a photograph of the reported activity is in Figure 5-10-a, and with map showing its location is in Figure 5-10-b. Through the icons on the screen shown in Figure 5-10-c, reactions to these actions can be easily created and counteractions can be taken. Activities can only be edited or deleted by their creator. Comments can be written by other users related to the problem encountered, and comments made by the post owner can be verified. In this way, points can be earned to the other side in the gamification logic. Other users can show their reactions to sharing with the like/dislike buttons on this page. These reactions are reflected by the owner of the share in the form of points, either positively or negatively. A certain number of referenced posts are made confidential to users by the system. The activities are displayed on the page with the logic of pagination

and when the screen is pulled from the bottom up, the old posts are loaded on the page ten by ten.



(a) Photo view of the activity (b) Map view of the activity (c) Reaction icons

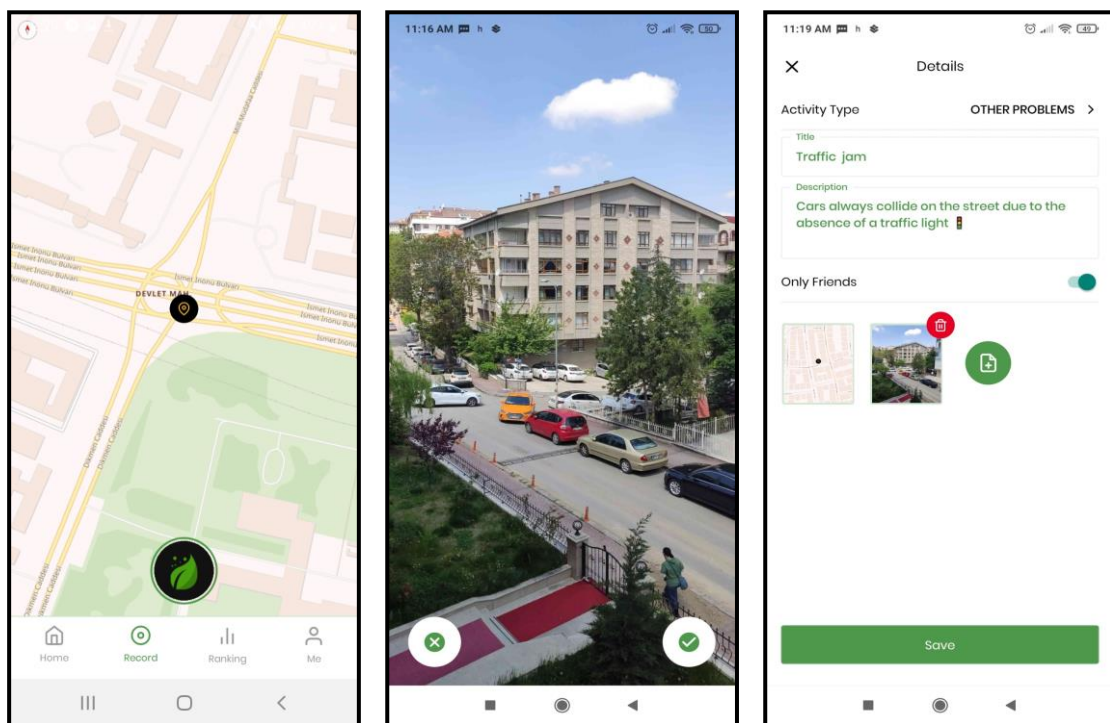
Figure 5-10 Activity feeds screens

5.4.3. Activity Creation Screen

Users can instantly share the problems they encounter by using this module. To record an event in EcoSnap application, you must follow the steps shown in Figure 5-11. When you switch to recording tab, OSM will automatically fill your map screen as shown Figure 5-11-a. OSM is a project that has become very popular in recent years and is created with geographical data collected by volunteers around the world and does not require any permission or fee for its use [70]. The system will read the user's location in the background and current location will be displayed on the map. If there is an error in the determined location, there is a way to determine the location by selecting a point on the screen. Users can take event photo using the camera screen that opens after the location is determined. There are various adjustment buttons for better-quality photos on the opened camera screen. After a photo is taken, preview screen in Figure 5-11-b will open and you will be asked to confirm the photo. In this step, if information and photo are confirmed, detail screen in Figure 5-11-c will open, where the details of the problem will

be entered. On this screen, detailed information such as the type, title, description of the problem, and to whom it will be confidential are entered. It is not mandatory to fill in this information. After the steps are completed, activity information is created and sent to the backend for the registration process. API will validate values and register them into database, then application redirects to feeds screen with a successful result message. The page is refreshed so that last record created on screen is displayed at the top. In addition, users can update these records at any time by using the edit button on the feeds screen.

EcoSnap enables users to report an array of incidents including, but not limited to: Weak Eduroam, Environmental Pollution, Bad Sidewalk, Electrical Problem, Wrong Parking, Other Problems, Waste



(a) Location selection

(b) Photo confirmation

(c) Details screen

Figure 5-11 Activity creation steps

5.5. Ranking Screen

EcoSnap includes a comprehensive gamification logic, which is thoughtfully created and includes competition between users. Xu [71] defined gamification as the use of features found in game designs, such as points, and leaderboards, in applications to increase interaction between users and to keep their motivation constant. Application users are

scored according to their actions within the system as shown in Figure 5-12. The function of this page is to display the scores of users in a certain time interval. In this way, users with high performance can be identified. The aim in adding this type of gamification to the application is that users can benefit from the points they have. It is thought that this will enable them to continue without giving up on the application.

While scoring the users, the following algorithm was used: +3 points for each activity sharing, +1 point for each like of the activity, and -1 point for each criticism of the activity. On the application, the lists are displayed to calculate the last 1-week period.

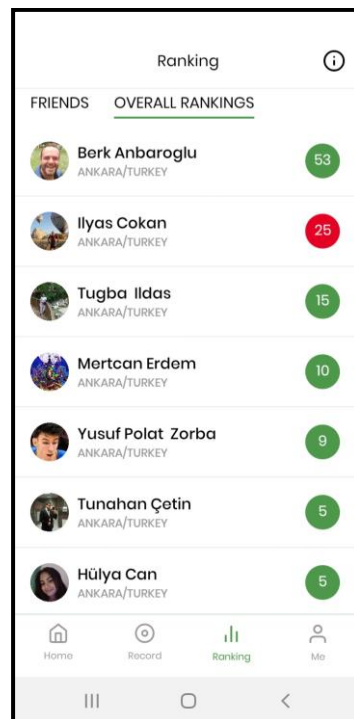
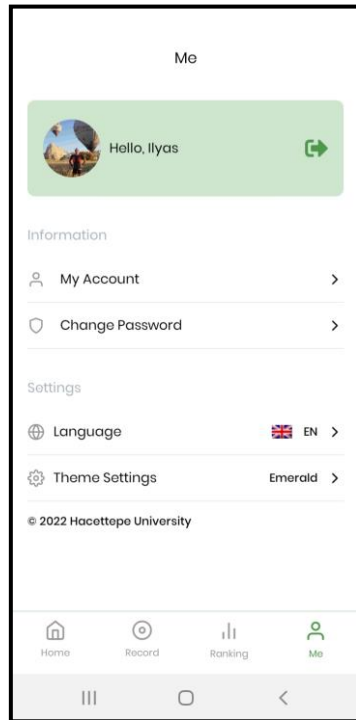


Figure 5-12 Ranking screen

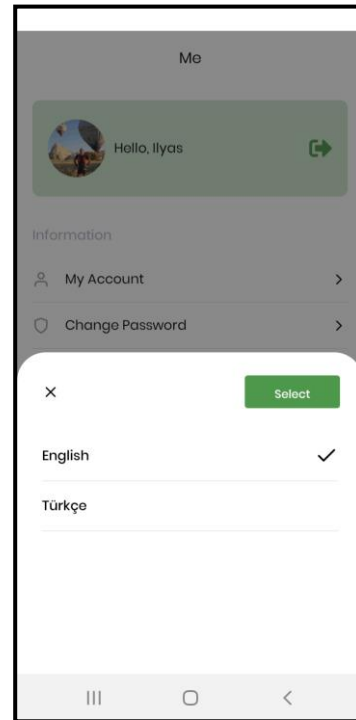
5.6. Configuration Screen

Through “Me” screen shown Figure 5-13-a, users can set their own settings on visual features on application. To make the app more attractive, various themes have been added that users think they will like. Users can choose their favorite themes and use controls in various colors and sizes. Also, EcoSnap application offers both English and Turkish language support, and language selection can be made using the control shown in Figure 5-13-b. In addition to these, it is possible to prepare configuration files for other languages and use those languages on the interface. In this way, it is possible to use the application from any desired country instead of a certain region. Thanks to the prepared

infrastructure, it is possible to send information messages about updates or possible interactions with other users to all or some of the users.



(a) Me screen



(b) Language selection popup

Figure 5-13 Application settings screens

6. RESULTS AND DISCUSSION

This chapter aims to examine the results and implications of the study on the efficiency and user experience of the EcoSnap. First of all, evaluations will be made on the data related to the use of the application by the users. Afterwards, the results of the volunteerism work carried out with the students within the scope of Hacettepe University Uni101 Course will be given. Then, the results will be evaluated by giving information about our survey work, in which the application is evaluated by the users and the requests are collected. Moreover, in order to evaluate the behavior and performance of the application, the logs collected throughout the study will be analyzed and the results will be included. Finally, the difficulties and limitations of the applied study will be discussed.

6.1. General statistics of EcoSnap

Using EcoSnap mobile application, citizens can report the problems they encounter instantly or later in their environment. During one year of development, the features described in chapter 5 have been successfully added. However, some important decisions had to be made in the life cycle of the project. In the beginning, which software language to use was an issue that needed to be carefully considered. The mobile native languages Dart and React Native languages have been examined. As a result of various tests and trials, it was decided to code the project with React Native because it contains many components such as map plugins. Another point is that during the design phase of the application, it is aimed to make the application usable by anyone with iOS and Android operating systems. However, due to the lack of stakeholders to provide sufficient financial support in the software development process, it was preferred to support Android systems as it is more widely used. Despite the problems to be solved, an up-to-date, easy-to-maintain and developable application has emerged thanks to the technologies chosen.

EcoSnap has been experienced by many people after it was announced to Hacettepe University students and our close circle. Figure 6-1 is created according to statistical data from the Google Play Console and shows the number of users owned in certain periods. The number of users is shown here is calculated by the sum of the current user, the user who quit, and the number of new users in a certain period. Accordingly, in October 2022, a rapid increase in the number of users is observed when the application was first used, but although there were decreases due to reasons such as only having tried the application

or loss of motivation, the number of users has reached the balance over time and is used by 85 users according to the up-to-date data.

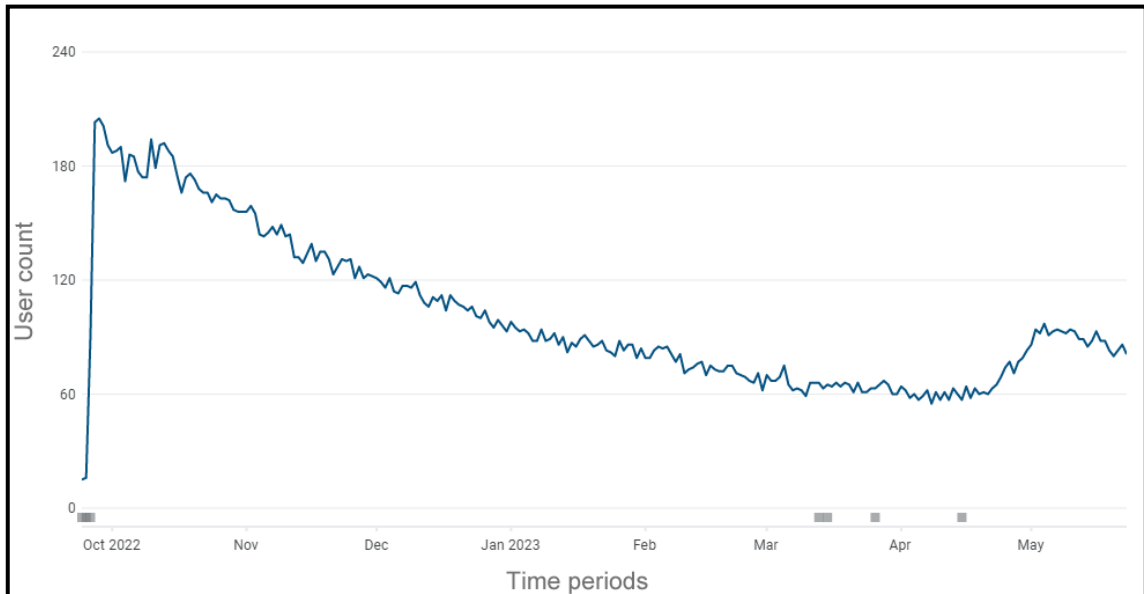


Figure 6-1 Number of users who installed the app - All users

Figure 6-2 examines the removal of the mobile application from phones and the opt-out transitions during certain periods. These fluctuations that took place in certain periods allow to have information about the latest status of the application and users. These data are useful for optimizing the application experience and reducing possible confusion in terms of stable operation of the application or showing user response to versions. According to the data obtained after the first release of EcoSnap, an average of 3.43 user losses occurred within the periods specified in application.

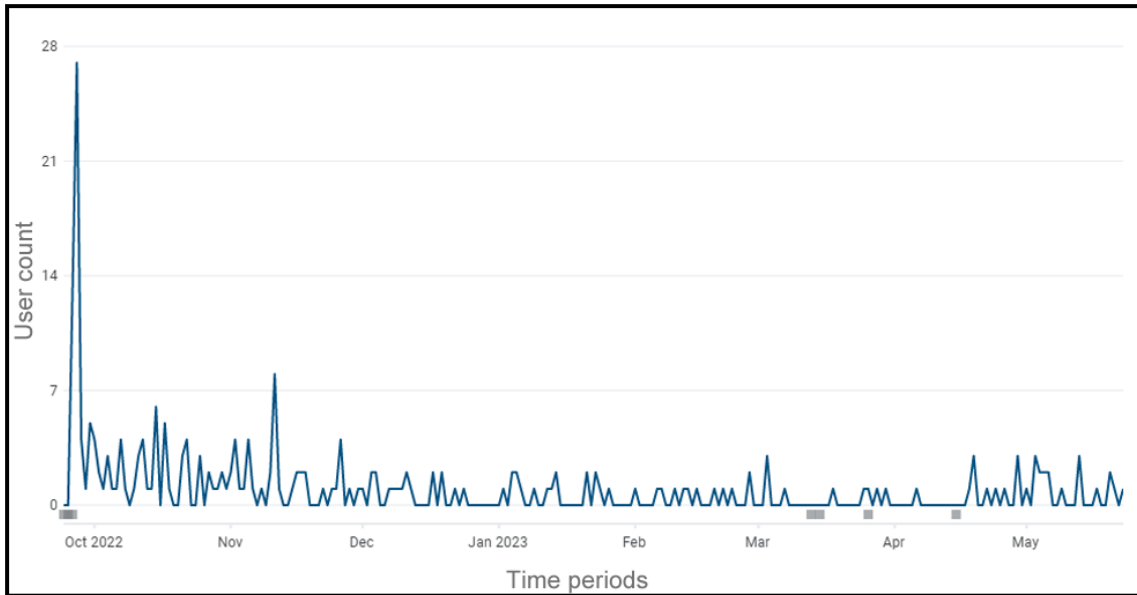


Figure 6-2 User loss over time for EcoSnap

Although EcoSnap was deleted from their phones by some users, some users continued to use the application again, as shown in Figure 6-3. According to this information, it has been concluded that recent users prefer to reinstall the application on their phones.

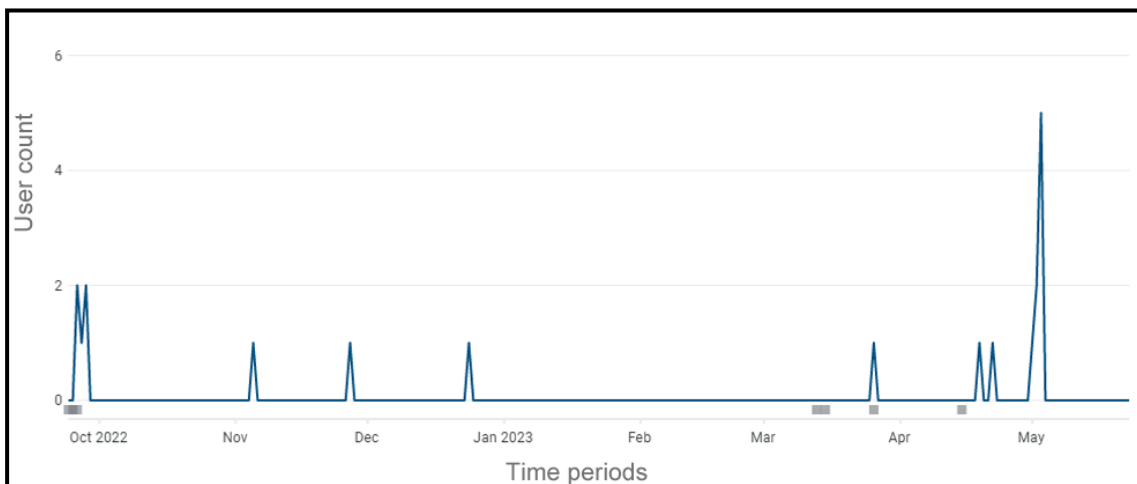


Figure 6-3 Returning users over time for EcoSnap

EcoSnap is an application open to development and adding additional features. In the light of feedback from users, it has been released a total of 36 versions by adding new features and regulations. Considering the mobile environment with high data charges, download package for Android devices does not cover a lot of space. The compressed

download size of EcoSnap is 21 MB, and the size on devices is 40 MB. This shows that it does not bring much load to the devices in terms of storage area.

EcoSnap has compatibility with a wide range of Android versions, confirming the goal of inclusivity and accessibility in development. Figure 6-4 includes the Android versions on the devices used by EcoSnap users. By supporting old Android versions, it is ensured that users with different types of devices can experience the application seamlessly. This broad support capability allows adopting the latest and oldest Android versions, getting to know existing technologies, identifying needs, and reaching users from various classes.

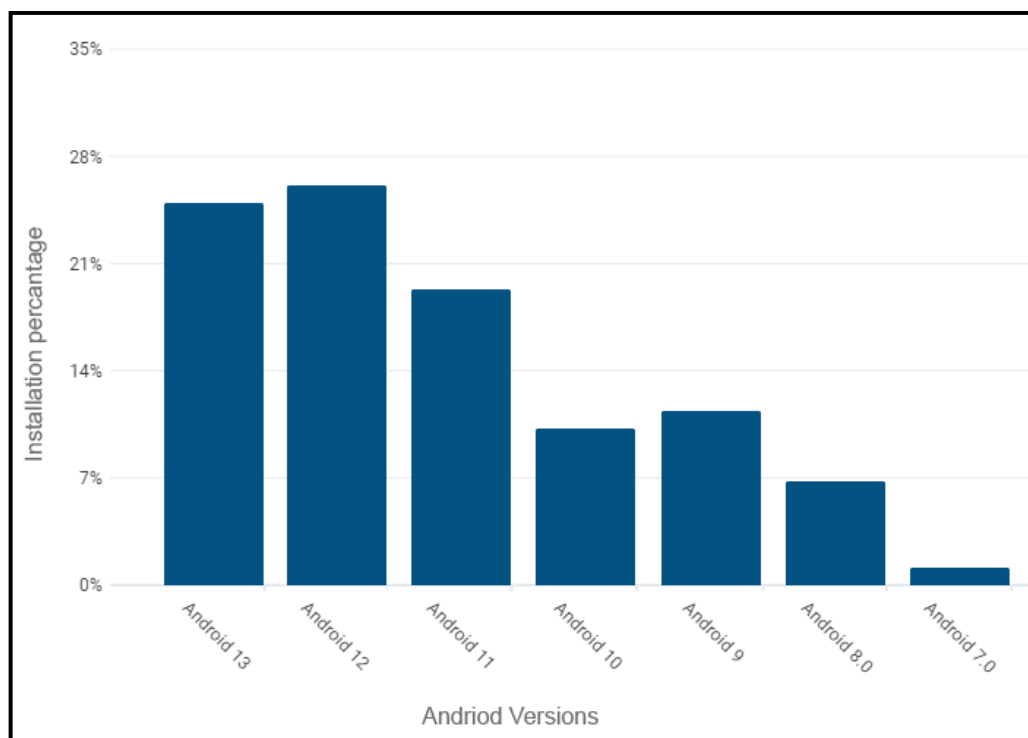


Figure 6-4 Percentage of installed Android versions

It emerges from the collected data that EcoSnap, which is called a crowdsourced participation application, is remembered by users without much difficulty. The application has been downloaded 298 times on Google Play. While 255 of the users accessed the application by searching for a name on Google Play, 38 of them downloaded it with Google Play discovery feature, and 5 of them by directing them from other 3rd party sites.

Although the reviews and ratings on Google Play page about EcoSnap provided some feedback about the application, they were not fully informative about the actual needs

and usability of the application. EcoSnap received full points from 9 users and received positive comments from 5 users.

When the database data on the extent to which EcoSnap is used by users is examined, it is observed that 229 problems have been reported by Android device users. The numerical values of the reports according to the activity type are shown in Table 6-1. When these numbers and their spatial distribution in Figure 6-5 are observed, it is concluded that many users do not pay attention to the problem type area while creating a record by paying attention to the problem type, title and explanation fields of the problems they encounter. It is thought that the most reported "Weak Wifi" problem is due to the fact that this item was put in the first place in the event creation module and users did not care much about the selection process. When the problems reported on this subject are examined, it is concluded that they actually contain data belonging to different problems. If attention is paid to the activity details and photos reported by users, it will be seen that only 5 of these reports really mention Wifi problems, while other records mention other problems. When the other selected problem types reported is examined, it is seen that these problems are related to construction, sewerage, disabled people and bad roads and they have details about them. This information can be reviewed and additional problem types can be added in the name of zoning problems or disability problems that are not currently available in practice. When the wrong parking reports were examined, it was seen that there was no mistake in the reported details and that the information was entered correctly. In the electricity problem reports, while the problems such as the daytime operation of the street lamps should be in the type of waste, the users did not pay attention to the distinction in the problems. Similarly, environmental problems were perceived only as a garbage problem and identified problems such as falling trees on the streets were reported in the other types. Another result is that it would be healthy to expand the bad sidewalks title as bad roads and sidewalks. Except for the generally examined Wifi problems, other problems were collected with reliable data, and it was seen that there was a harmony between the subject titles and the photographs. Based on these information, users mostly complain about bad sidewalks. The information in Figure 6-7 shows that the users are generally clustered in Beytepe campus and in the city center. In addition, the detected problems were reported not only from certain regions, but also from many parts of the city, which shows that the problems exist in many places.

Table 6-1 Problem counts by type

Problem Type	Report Count
Weak Wifi	77
Bad Sidewalk	60
Other Problems	35
Environmental Pollution	32
Wrong Parking	14
Electrical Problem	9
Waste	2

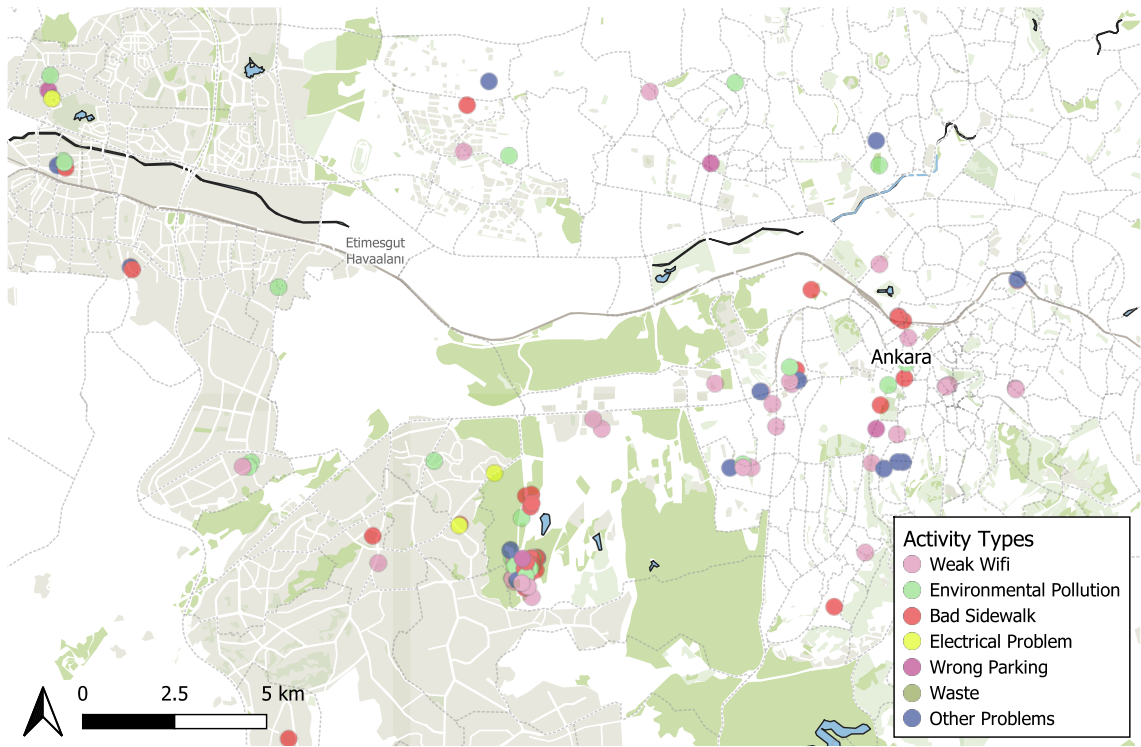


Figure 6-5 Distribution of reported problems in Ankara

When the locations of all the collected reports are examined, it is seen that the records are concentrated in the central region of Ankara, as seen in Figure 6-6. Also, it is observed that there are users who have reported on Aydin and Kars provinces outside of this area. It is thought that the reason for this is due to the distance education of the students due to the 6 February 2023 earthquake in Turkiye. When the activities from Kars are examined, it is determined that a user made 5 reports in the evening of a day. Problems were reported

under the titles of broken street lamp, environmental pollution, road problems, dogs without a leash, and lack of doctors within a 4-hour period. Since the user is followed by a follower, he/she has not received any reaction against his posts. Sharing in Aydın has carried out by 2 users in the same district, unaware of each other. One of the users made 5 posts in the same day. The user has created an activity on street lamps, road disturbances, and garbage. The user, who has 2 followers, has not received any reaction against his posts. The second user in Aydın has created 5 activities on the same day, including the problems of garbage, sewerage, broken stairs and street lamps. Although this user has 5 followers, there has been no reaction to their posts. All data showed that location information could be collected and reported without error. Considering whether EcoSnap users actually use the application after the registration module, 29 of the registered users did not activate their accounts and did not take any action when the collected data was analyzed. 54 of the remaining 144 users have made a report at least once and 45 of them have created more than one record. It has been seen that the amount and quality of the data collected allows the precise determination of the point location and time of the problems encountered.

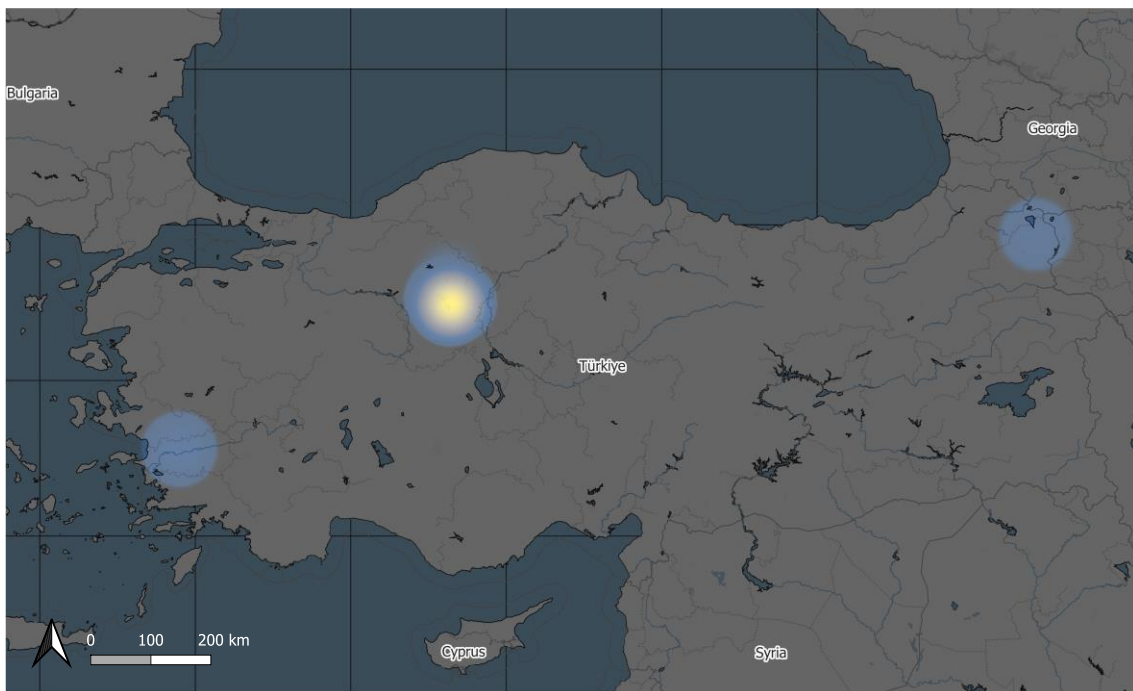


Figure 6-6 Usage areas of using EcoSnap

In the interaction of users with each other, 145 requests to following were accepted and 50 requests were rejected. In addition, users made 16 comments against each other's posts

and showed 59 like or dislikes reactions. This showed that users generally preferred to use the reaction buttons rather than writing comments.

Users are required to share photos to add further support to the event while creating an activity. Since the sizes of the photos are kept as small as possible, there are no problems encountered by the users both during the sharing and storing them on the servers. In addition, another conclusion drawn from the data collected from the use of EcoSnap is that some shared data contained invalid and incorrect information as seen in Figure 6-7. Although real reason is unknown, it is thought that these shares were created by people who use EcoSnap only for testing purposes. The filtering of such false posts will be provided through kudos buttons included in the application. Such posts, which receive a certain number of negative kudos from other users will be automatically blocked by the system. Although it is not currently available in EcoSnap, it is among the measures that can be taken to completely block users who share this type of sharing from system.

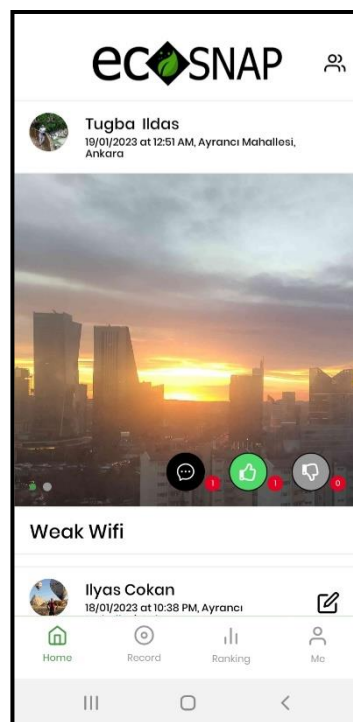


Figure 6-7 An example of an incorrectly shared photo

6.2. Use case Hacettepe University Uni101 Course

After EcoSnap coding phase, it was introduced to the students for the first time in the Hacettepe Uni101 course held in Yıldız Amphitheater on September 27, 2022. A presentation was given to three different cohort of students: i) Computer Engineering, ii)

Medicine, and iii) Nursing. After that, the rapid increase in the number of users was observed as shown in Figure 6-1. 92 of these students registered to EcoSnap on the presentation day and after. However, only 7 reports were made by these users in the following days. As shown Figure 6-8, in most of these records, they are data for experimental use. After this process, it was observed that there was a rapid decrease in the users as shown in Figure 6-2.



Figure 6-8 Photo reported by the user during the Uni101 course

This experience demonstrates that a single large event to describe the application is not sufficient for its sustained use.

6.3. Survey

A web-based survey is prepared in order to obtain EcoSnap users' opinions about the application, to evaluate the latest situation, and to identify deficiencies. Google Forms, a free web-based service that enable the creation and sharing of online surveys, quizzes, applications, and feedback forms, was used to collect user-feedbacks. It offers a range of question types (text box, multiple choice, checkbox, rating, etc.) and users can edit these questions, make some questions mandatory as needed, and add additional explanations or instructions.

The survey in Appendix 1 was applied in April and May 2023 for a period of four weeks, after obtaining ethical compliance from from Hacettepe University, Graduate School of

Science and Engineering. The survey consists of 34, mostly multiple choice, questions. The average completion time of the survey was anticipated to be approximately 10 minutes. The survey does not contain any questions that will reveal people's identities. Therefore, information such as age, gender, exact location cannot be determined. Questions can be grouped under four main headings:

1. Questions that measure one's sensitivity to the environment,
2. Questions regarding the determination of environmental problems in order of importance and the evaluation of the services provided by the administrations
3. Questions that determines user experience on the use of EcoSnap
4. Questions that determine people's feedback and requests

The survey was completed by 16 people at the specified times. Almost all of the participants stated that they are sensitive to the problems around them. While most of them try to solve a problem by intervening themselves, a quarter of the participants prefer to solve it through official means. Since most of the participants are likely to live in urban areas, most of the people complained about the bad roads and the batons. In parallel with this answer, they stated that they participated in volunteer activities such as planting saplings. They pointed out that the municipalities were indifferent to these problems that people stated and that their complaints were resolved by the relevant authorities for more than a month. As a result, people believe that even if they believe that their environment is in bad shape, they can be improved with a lot of effort. For Ankara, the city where EcoSnap was first tested, the biggest problems participants have mentioned are as follows: Parking problem, garbage and lack of green space or parks.

According to questions about EcoSnap's non-functional features, participants were satisfied with the initial feel of the interface. The majority did not indicate a problem in the appearance and harmony of colors. Also, many have found it easy to use. One participant stated that it would be beneficial to automatically identify problems instead of reporting by selecting them. This outcome suggests that the application can be used easily without the need for any documents or training. Although the application's installation and registration module is generally welcomed, one of the participants stated that s/he found the area of acceptance and terms for obtaining the user's consent during the registration process confusing. Regarding the question 21 about the suitability of the name of the application and what it means to them, the participants found the name appropriate and answered the application for the environment. Most of the participants

stated that it would be useful for the question that measures the usefulness of EcoSnap in solving people's problems and reaching goals. They have marked that they will use it to report their problems and to follow the problems around them.

According to questions about the functional features of EcoSnap, the participants stated that there is no significant problem that could prevent their use and that it works smoothly. A large majority of the participants stated that they believe that the application will be sufficient to solve environmental problems with its current features and that they see it as a quality application. Although almost all of the participants stated that they would continue to use the application, in another question they gave answers that do not match this. Most of the participants stated that they would use the application for long periods of time, such as once a week or once a month, instead of using it frequently.

Although our findings are unique to Hacettepe University and users in our environment, this study offers implications for the design and implementation of similar platforms in the future. As a result of the survey, it is concluded that the most important factor in ensuring the continuity of the application is the motivation of the users and gamification. Despite the support of the users, it was observed that the response of the local governments to the reported problems caused cooling and withdrawal from the application after a while. The results show that the local government should have an idea to support community participation throughout the entire implementation process.

6.4. Log Analysis

Logging plays a crucial role in application development by capturing essential information about the application's behavior and performance. It enables developers to monitor the application in real-time, identify issues, and make data-driven decisions for improvements. Logs provide valuable information during the troubleshooting process by capturing error messages, stack traces, and exception details.

In line with these goals, logging has been also performing in EcoSnap application. Serilog, a logging framework that collects log data and offers comprehensive features for analysis, is used for this process. By logging metric data such as request response times, error types, it is possible to get an idea about the performance bottlenecks of the application. It can be used after making the necessary configuration settings by referring to Serilog to the Api application. It gives opportunity to store on an existing server, file or console. In EcoSnap log mechanism, logs are recorded daily in JSON files as shown

in Figure 6-9 and logs are kept for one year. In this way, it is ensured that the files are replaced with new ones in annual cycles without increasing the data size on the servers. A sample of the collected logs is shown in Figure 6-12. When the event takes place, many data such as the path of the request, the result code and the time taken for the response are recorded.

log20230425.json	485,784	JSON File
log20230426.json	174,977	JSON File
log20230427.json	78,812	JSON File
log20230428.json	105,974	JSON File
log20230429.json	576,715	JSON File
log20230430.json	392,471	JSON File
log20230501.json	329,437	JSON File
log20230502.json	483,611	JSON File
log20230503.json	4,011,745	JSON File

Figure 6-9 Log files collected daily

When a month log records collected from users using the EcoSnap application are examined, it is seen that a total of 9085 records are written. In Table 3-1 prepared using this data, API application methods and average response times for requests are given. API incoming requests are answered within 175 ms on average. The longest response times are experienced in the methods of updating the reported record, generating the report, and recording. The delays experienced here are primarily related to the size and number of photos uploaded by the user. There has been more delay as users are allowed to upload multiple photos in the editing module and only one photo is allowed to be uploaded in the add and save module. In addition, the details of the location information transmitted by the user are brought through the external service, which has increased this delay. In other requests made, the process has performed without too much delay. When the numbers of the requests made to the API are examined, the method called by the icons to refresh the kudos/comment numbers is used the most. Apart from this, the calls to fetch region-based activity and fetch single activity are mostly used by the feeding/flow page.

Table 6-2 Number of requests to the server and average response times

Api Methods	Average of Request Duration (ms)	Request Count
/v1/api/account/activate	24.147	30
/v1/api/account/change-password	47.795	10

/v1/api/account/login	21.481	366
/v1/api/account/login-external	193.453	22
/v1/api/account/logout	11.078	59
/v1/api/account/register	4181.801	27
/v1/api/account/term-policy	1.452	37
/v1/api/account/update-info	17.281	4
/v1/api/account/update-profile-photo	118.541	8
/v1/api/account/users-by-name	6.212	244
/v1/api/activity	29.058	638
/v1/api/activity/add	3733.564	269
/v1/api/activity/by-id	19.577	15
/v1/api/activity/by-region	6.411	871
/v1/api/activity/delete	16.098	8
/v1/api/activity/edit	10843.006	34
/v1/api/activity/friend-activities	12.545	362
/v1/api/activity/most-active-users	35.015	89
/v1/api/activity/reactions	3.740	4552
/v1/api/activitytype/list	30.882	355
/v1/api/city/list	33.377	144
/v1/api/comment	9.163	10
/v1/api/country/list	13.208	126
/v1/api/friendship/approve	246.718	25
/v1/api/friendship/delete	15.926	1
/v1/api/friendship/followers	12.039	243
/v1/api/friendship/following-ids	4.451	40
/v1/api/friendship/followings	11.389	243
/v1/api/friendship/request	216.180	41
/v1/api/kudo	9.472	13
/v1/api/kudo/add	66.350	9
/v1/api/kudo/delete	15.186	2
/v1/api/login	14.848	188
Total	175.418	9085

When the log records were examined, people use the interface to pull data from the API instead of sending data to the API. According to Figure 6-10-a showing this, 9 out of 10 calls fetch data. Apart from this, data addition methods occupy a large numbers. Deletion and updating methods are not used much. In addition, when the response codes in Figure 6-10-b given by the API to the requests of the users are examined, the responses are given with the 200 (OK) status code, which means the API return successful mostly. Also, some users receive 401 (Unauthorized) and 405 (Method Not Allowed) responses due to unauthorized user calls. The reason for this is understood from the logs that the users

forget their passwords and try to log in with the wrong username/password. It is understood that the other 400 (Bad Request) and 415 (Unsupported Media Type) errors are the result of requests sent by users who use the API for testing purposes other than the EcoSnap application.

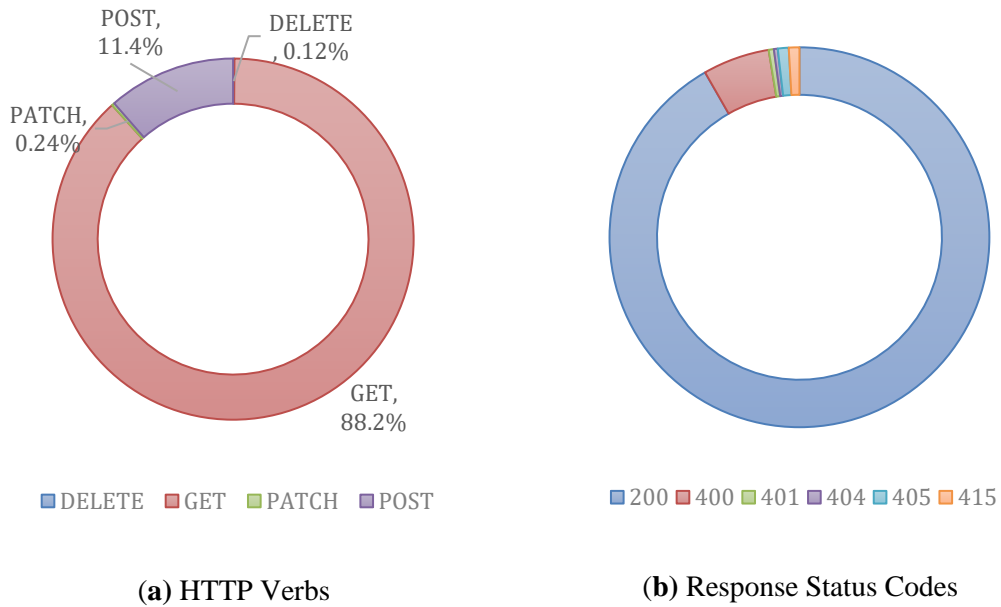


Figure 6-10 The used HTTP verbs and server response status codes

When the data about the behaviors of the users is examined, the result in the figure has emerged. In Figure 6-11, hourly Api call numbers expressing the time intervals users use the application are shown. Accordingly, EcoSnap was used between 1-2 PM hours at most. Again, between 1-5 PM and 7-21 PM covers the times when usage is intense.

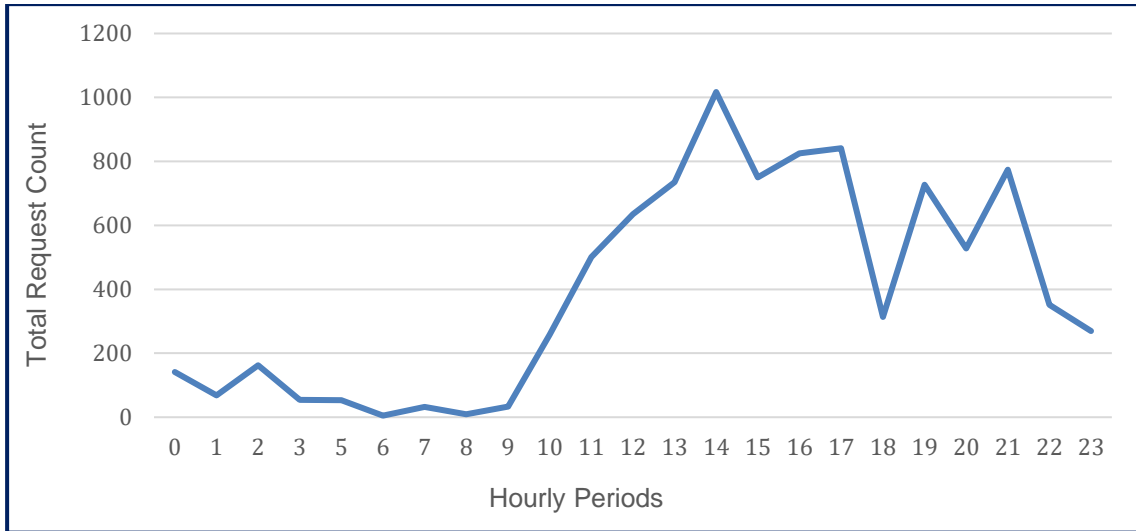


Figure 6-11 Hourly distribution of user requests

Another result that emerges when the Serilog data is examined is that some users set username/password carelessly. Many log messages have been encountered stating that the password shown and entered in the figure is incorrect. In EcoSnap, a module will be designed for password reminder purposes.

```

04 May 2023 20:50:46.638 ● Exception NotFoundResult '1' (Data: null, Errors: ['Username not found'], ResultType: 'NotFound')
04 May 2023 20:50:37.310 ● Exception NotFoundResult '1' (Data: null, Errors: ['Username not found'], ResultType: 'NotFound')
04 May 2023 20:50:15.215 ● Exception NotFoundResult '1' (Data: null, Errors: ['Username not found'], ResultType: 'NotFound')
04 May 2023 19:31:57.732 ● Exception InvalidResult '1' (Data: {_typeTag: 'Unit'}, Errors: ['Varolan sifre bilgisi uyusmamakta'], ResultType: 'Inv...
04 May 2023 19:31:56.972 ● Exception InvalidResult '1' (Data: {_typeTag: 'Unit'}, Errors: ['Varolan sifre bilgisi uyusmamakta'], ResultType: 'Inv...
04 May 2023 19:31:54.601 ● Exception InvalidResult '1' (Data: {_typeTag: 'Unit'}, Errors: ['Varolan sifre bilgisi uyusmamakta'], ResultType: 'Inv...
04 May 2023 19:30:25.637 ● Exception AccessDeniedResult '1' (Data: null, Errors: ['Invalid password'], ResultType: 'Unauthorized')

Event Level (Error) Type (0x45878B4A) Export
[x] ActionId ef0787ae-10df-4c62-9a0e-492451c60549
[x] ActionName EcoSnap.Api.Presentation.v1.AccountController.LoginAsync (EcoSnap.Api)
[x] ConnectionId 0H1QCEf2PR257
[x] ImportId 577c2cd7-94cd-460d-8e0c-cd0db00fa41e
[x] RequestId 0H1QCEf2PR257:00000008
[x] RequestPath /v1/api/account/login
[x] result {Data: null, Errors: [...], ResultType: 'Unauthorized', _typeTag: 'AccessDeniedResult'1}

04 May 2023 19:30:22.767 ● Exception AccessDeniedResult '1' (Data: null, Errors: ['Invalid password'], ResultType: 'Unauthorized')
04 May 2023 19:28:48.398 ● Exception AccessDeniedResult '1' (Data: null, Errors: ['Invalid password'], ResultType: 'Unauthorized')
04 May 2023 19:28:32.512 ● Exception AccessDeniedResult '1' (Data: null, Errors: ['Invalid password'], ResultType: 'Unauthorized')
04 May 2023 10:47:14.018 ● Exception NotFoundResult '1' (Data: null, Errors: ['Username not found'], ResultType: 'NotFound')
04 May 2023 00:15:53.176 ● Exception NotFoundResult '1' (Data: null, Errors: ['Username not found'], ResultType: 'NotFound')
03 May 2023 23:45:14.458 ● Exception InvalidResult '1' (Data: {_typeTag: 'Unit'}, Errors: ['Varolan sifre bilgisi uyusmamakta'], ResultType: 'Inv...
03 May 2023 23:45:01.327 ● Exception InvalidResult '1' (Data: {_typeTag: 'Unit'}, Errors: ['Varolan sifre bilgisi uyusmamakta'], ResultType: 'Inv...
03 May 2023 21:47:11.885 ● Exception AccessDeniedResult '1' (Data: null, Errors: ['Invalid password'], ResultType: 'Unauthorized')
03 May 2023 21:07:15.633 ● Exception UnexpectedResult '1' (Data: null, Errors: ['Response status code does not indicate success: 404 (Not Found).]...
03 May 2023 20:11:30.031 ● Exception AccessDeniedResult '1' (Data: null, Errors: ['Invalid password'], ResultType: 'Unauthorized')
03 May 2023 19:57:54.045 ● Exception AccessDeniedResult '1' (Data: null, Errors: ['Invalid password'], ResultType: 'Unauthorized')
03 May 2023 19:55:34.986 ● Exception AccessDeniedResult '1' (Data: null, Errors: ['Invalid password'], ResultType: 'Unauthorized')

```

Figure 6-12 Log records of incorrect user login requests

As a result, the logging mechanism adopted in EcoSnap provides useful contributions in terms of the management and advancement of the application. Thanks to the logs, valuable insights has been gained about the behavior, performance and user experience of the EcoSnap application. Through troubleshooting, performance optimization, user

experience enhancement, and enhanced security, a more stable, performance and user-centric application has been achieved.

6.5. Limitations

When developing a mobile crowdsourcing application, there are several limitations and challenges to consider. In this section, the difficulties and limitations of the applied study will be discussed. One of the biggest challenges is attracting and retaining active users. Without a substantial user base, the effectiveness of the crowdsourcing model can be compromised. Convincing users to download and regularly use EcoSnap is one of the challenges. Due to the lack of appropriate incentives, users lost a great deal of interest and did not contribute consistently. Although effective gamification features have been added to motivate and engage users, having rewards that will provide financial gain can help overcome this limitation. In addition, failure to deliver the reports to the competent authorities is one of the factors preventing EcoSnap from spreading. Attempts made in this direction have not yielded any results and the necessary support has not been found. Another reason that prevented the application from spreading was that most of the students contacted were unwilling to participate in voluntary participation. Many of them used the application at a certain time and then stopped using it because they saw it as a homework and necessity. Starting out with volunteers who have had previous experience in this field at the beginning can ensure that the data obtained as a result of the application is healthier and the duration of use is wider. Some users have provided incorrect or incomplete information, resulting in potential problems with EcoSnap's functionality and reliability. Some users preferred to post off-topic instead of reporting real problems. A study on verifying the transmitted photos by processing them by the system may enable more accurate sharing and prevention of value sharing.

Different methods could have been developed for the applied survey. The application of the survey to the initially reached audiences to get their opinions after the application experience could have enabled to obtain more realistic answers. The number of forms answered in this way could have been too many.

During the application, the data was collected entirely on Android devices. Although the collected data shows that EcoSnap works efficiently in this operating system, it has not been experienced on devices with iOS operating system. We do not have any data on whether it will actually work on these devices without any problems. Some of people we

offer the application has these type devices and requests to use EcoSnap. It is possible to conduct a study on this in the future, when suitable conditions are provided.

Addressing these limitations can improve EcoSnap's functionality, usability, and success. If a solution is provided, people will participate in a more motivated way and will help the application reach its goal. As a result, all stakeholders will be positively affected.

7. CONCLUSION

Public participation GIS (PPGIS) has emerged as a subfield of GIS that seeks to promote public participation and engagement in decision-making processes related to spatial data, especially in a smart city context. PPGIS mobile applications represent a new approach in this area, enabling citizens to use their smartphones or tablets to contribute their own spatial data, knowledge, and insights.

This thesis explains the architecture and current capabilities of the EcoSnap application, which enables citizens to collect and share spatial data on environmental and social issues in their cities. It adds to existing knowledge by providing a new model of mobile crowdsourcing practices. By designing and building a working application, the viability and effectiveness of crowdsourcing in a mobile context is demonstrated.

Through case studies, citizens were asked to report on the various types of problems they encountered in their city, and valuable information was gathered, including many locations and photographs. It has been proven that the application can help to eliminate the communication gap between citizens and municipalities and to establish a sense of accountability by transmitting these collected data to the relevant administrations. By using this data, the authorities can be informed about the problems sooner and take quick action for the solution. By informing citizens about the latest situation, transparency will be ensured in municipal services.

With the application presented in the thesis, citizens have the opportunity to both report their problems and socialize. With the follow-up mechanism, they find the opportunity to follow the people they want and see the posts of these people, support and comment on them. By using the preferences presented in the application, they have the opportunity to determine to whom their sharing will be open and to whom they will be hidden. In addition, features such as gamification are added, allowing users to continue to practice in a more motivated way. Citizens were given points over the shares, and their performance compared to other users was shown. However, there is no regulation that would enable them to earn financial gain from these points.

This thesis contributes by evaluating existing mobile crowdsourcing applications or techniques and presenting a comprehensive assessment of their strengths, weaknesses, and limitations. This assessment can help researchers and practitioners understand the

latest technology available, identify areas for improvement, and guide future research efforts.

Another contribution is evaluating the performance and effectiveness of the mobile crowdsourcing application. By collecting data and analyzing the results, information is provided on quantitative and qualitative assessments of the application's performance in terms of accuracy, scalability, user engagement, and other relevant metrics. This evaluation can provide valuable insights for researchers and practitioners interested in adopting or improving mobile crowdsourcing systems.

In future research, integrating citizens, policy makers, developers, and other organizations into EcoSnap and using the application in larger habitats will certainly produce more reliable results. Although the collected data with EcoSnap can be shared over an API service, it will be an important development for everyone that the reports can be viewed in details on the maps on the website and the desired filtering can be done on the reports. However, although EcoSnap allows only photo sharing for now, the ability to record video or live sharing will also be useful in some cases.

The findings of this thesis demonstrate that the integration of crowdsourcing into PPGIS mobile applications represents an important step forward in promoting more sustainable and liveable smart cities. The implementation of a crowdsourcing feature in the PPGIS mobile application developed for this thesis allowed citizens to provide real-time input and feedback on urban planning decisions, enabling more informed and inclusive decision-making.

8. REFERENCES

- [1] UNDESA, “Policies on spatial distribution and urbanization are essential for achieving inclusive and sustainable development,” 2020. [Online]. Available: www.un.org/development/desa/pd/themes/population-policies.
- [2] R. Mohanty and B. P. Kumar, “7 - Urbanization and smart cities,” J. R. B. T.-S. U. I. P. U. S. C. T. Vacca, Ed., Elsevier, 2021, pp. 143–158. doi: <https://doi.org/10.1016/B978-0-12-816816-5.00007-3>.
- [3] A. Stratigea, C.-A. Papadopoulou, and M. Panagiotopoulou, “Tools and Technologies for Planning the Development of Smart Cities,” *Journal of Urban Technology*, vol. 22, no. 2, pp. 43–62, Apr. 2015, doi: 10.1080/10630732.2015.1018725.
- [4] “Ushahidi.” <https://www.usahidi.com>
- [5] “Burgernet.” <https://www.burgernet.nl>
- [6] “PublicStuff.” <https://www.publicstuff.com>
- [7] “BOS:311.” <https://311.boston.gov>
- [8] UN-DESA, “World Urbanization Prospects: The 2014 Revision, Highlights (ST/ESA/SER.A/352),” United Nations, Department of Economic and Social Affairs, Population Division, 2014. [Online]. Available: <http://esa.un.org/unpd/wup/Highlights/WUP2014-Highlights.pdf>
- [9] E. Park, A. P. Del Pobil, and S. J. Kwon, “The Role of Internet of Things (IoT) in Smart Cities: Technology Roadmap-oriented Approaches,” *Sustainability*, vol. 10, no. 5. 2018. doi: 10.3390/su10051388.
- [10] N. Komninos, *The architecture of intelligent cities: Integrating human, collective and artificial intelligence to enhance knowledge and innovation*. 2006. doi: 10.1049/cp:20060620.
- [11] R. Giffinger, C. Fertner, H. Kramar, R. Kalasek, N. Milanović, and E. Meijers, *Smart cities - Ranking of European medium-sized cities*. 2007.
- [12] R. Hollands, “Will the Real Smart City Please Stand Up?,” *City*, vol. 12, pp. 303–320, Dec. 2008, doi: 10.1080/13604810802479126.

- [13] J. Verplanke, M. K. McCall, C. Uberhuaga, G. Rambaldi, and M. Haklay, “A Shared Perspective for PGIS and VGI,” *Cartogr J*, vol. 53, no. 4, pp. 308–317, Oct. 2016, doi: 10.1080/00087041.2016.1227552.
- [14] G. Brown and M. Kytta, “Key issues and research priorities for public participation GIS (PPGIS): A synthesis based on empirical research,” *Applied Geography*, vol. 46, pp. 122–136, 2014, doi: <https://doi.org/10.1016/j.apgeog.2013.11.004>.
- [15] R. Sieber, “Public Participation Geographic Information Systems: A Literature Review and Framework,” *Annals of the Association of American Geographers*, vol. 96, pp. 491–507, Sep. 2006, doi: 10.1111/j.1467-8306.2006.00702.x.
- [16] M. Goodchild and A. Glennon, “Crowdsourcing geographic information for disaster response: A research frontier. International Journal of Digital Earth, 3(3), 231-241,” *Int. J. Digital Earth*, vol. 3, pp. 231–241, Sep. 2010, doi: 10.1080/17538941003759255.
- [17] I. Mergel, *Distributed Democracy: SeeClickFix.Com for Crowdsourced Issue Reporting*. 2012. doi: 10.2139/ssrn.1992968.
- [18] M. A. Shahriar, S. Sakib, and R. Palit, “CitizenConnect: Connecting Citizens with Public Service Providers,” in *2016 IEEE International Conference on Computer and Information Technology (CIT)*, 2016, pp. 637–643. doi: 10.1109/CIT.2016.116.
- [19] P. G. Ipeirotis, F. Provost, and J. Wang, “Quality Management on Amazon Mechanical Turk,” in *Proceedings of the ACM SIGKDD Workshop on Human Computation*, in HCOMP ’10. New York, NY, USA: Association for Computing Machinery, 2010, pp. 64–67. doi: 10.1145/1837885.1837906.
- [20] A. P. Dawid and A. M. Skene, “Maximum Likelihood Estimation of Observer Error-Rates Using the EM Algorithm,” *J R Stat Soc Ser C Appl Stat*, vol. 28, no. 1, pp. 20–28, 1979, doi: 10.2307/2346806.
- [21] Z. Zhai, T. Kijewski-Correa, D. Hachen, and G. Madey, *Haiti earthquake photo tagging: Lessons on crowdsourcing in-depth image classifications*. 2012. doi: 10.1109/ICDIM.2012.6360130.

- [22] G. Li, J. Wang, Y. Zheng, and M. J. Franklin, “Crowdsourced Data Management: A Survey,” *IEEE Trans Knowl Data Eng*, vol. 28, no. 9, pp. 2296–2319, 2016, doi: 10.1109/TKDE.2016.2535242.
- [23] I. Blohm, S. Zogaj, U. Bretschneider, and J. M. Leimeister, “How to Manage Crowdsourcing Platforms Effectively?,” *Calif Manage Rev*, vol. 60, pp. 122–149, Feb. 2018, doi: 10.1177/0008125617738255.
- [24] M. Dontcheva, R. Morris, J. Brandt, and E. Gerber, “Combining crowdsourcing and learning to improve engagement and performance,” *Conference on Human Factors in Computing Systems - Proceedings*, Apr. 2014, doi: 10.1145/2556288.2557217.
- [25] Z. Liu and V. Shestak, “Issues of crowdsourcing and mobile app development through the intellectual property protection of third parties,” *Peer Peer Netw Appl*, vol. 14, Sep. 2021, doi: 10.1007/s12083-020-00976-5.
- [26] R. K. Ganti, F. Ye, and H. Lei, “Mobile crowdsensing: current state and future challenges,” *IEEE Communications Magazine*, vol. 49, no. 11, pp. 32–39, 2011, doi: 10.1109/MCOM.2011.6069707.
- [27] Y. Han and H. Wu, “Privacy-Aware Participant Recruitment in Opportunistic Device to Device Networks,” *IEEE/ACM Transactions on Networking*, vol. 30, no. 3, pp. 1340–1351, 2022, doi: 10.1109/TNET.2022.3141069.
- [28] E. Nicolosi, R. Medina, C. Riley, and P. McNeally, “Crowdsourcing sensitive VGI: Constructing the hate incident reporting system,” *Digital Geography and Society*, vol. 1, p. 100003, Aug. 2020, doi: 10.1016/j.diggeo.2020.100003.
- [29] L. Pournajaf, L. Xiong, V. Sunderam, and S. Goryczka, “Spatial Task Assignment for Crowd Sensing with Cloaked Locations,” in *2014 IEEE 15th International Conference on Mobile Data Management*, 2014, pp. 73–82. doi: 10.1109/MDM.2014.15.
- [30] I. J. Vergara-Laurens and M. A. Labrador, “Preserving privacy while reducing power consumption and information loss in LBS and participatory sensing applications,” in *2011 IEEE GLOBECOM Workshops (GC Wkshps)*, 2011, pp. 1247–1252. doi: 10.1109/GLOCOMW.2011.6162381.

- [31] Q. Li and G. Cao, "Providing privacy-aware incentives for mobile sensing," in *2013 IEEE International Conference on Pervasive Computing and Communications (PerCom)*, 2013, pp. 76–84. doi: 10.1109/PerCom.2013.6526717.
- [32] C. Gentry, "A Fully Homomorphic Encryption Scheme," Stanford, CA, USA, 2009.
- [33] M. Li *et al.*, "CrowdBC: A Blockchain-Based Decentralized Framework for Crowdsourcing," *IEEE Transactions on Parallel and Distributed Systems*, vol. 30, no. 6, pp. 1251–1266, 2019, doi: 10.1109/TPDS.2018.2881735.
- [34] M. Yang, T. Zhu, K. Liang, W. Zhou, and R. H. Deng, "A blockchain-based location privacy-preserving crowdsensing system," *Future Generation Computer Systems*, vol. 94, pp. 408–418, 2019, doi: <https://doi.org/10.1016/j.future.2018.11.046>.
- [35] D. Tiwari, G. Chaturvedi, and G. R. Gangadharan, "ACDAS: Authenticated controlled data access and sharing scheme for cloud storage," *International Journal of Communication Systems*, vol. 32, Oct. 2019, doi: 10.1002/dac.4072.
- [36] J. de Beer, *Open Innovation in Development: Integrating Theory and Practice Across Open Science, Open Education, and Open Data*. 2017.
- [37] M. Zhao and A. van der Hoek, "A Brief Perspective on Microtask Crowdsourcing Workflows for Interface Design," in *2015 IEEE/ACM 2nd International Workshop on CrowdSourcing in Software Engineering*, 2015, pp. 45–46. doi: 10.1109/CSI-SE.2015.16.
- [38] C. Matschke, J. Moskaliuk, F. Bokhorst, T. Schümmer, and U. Cress, "Motivational factors of information exchange in social information spaces," *Comput Human Behav*, vol. 36, pp. 549–558, 2014, doi: <https://doi.org/10.1016/j.chb.2014.04.044>.
- [39] T. B. Phillips, H. L. Ballard, B. V Lewenstein, and R. Bonney, "Engagement in science through citizen science: Moving beyond data collection," *Sci Educ*, 2019.
- [40] A. Irwin, "No PhDs needed: how citizen science is transforming research," *Nature*, vol. 562, pp. 480–482, Oct. 2018, doi: 10.1038/d41586-018-07106-5.

- [41] J. Raddick *et al.*, “Galaxy Zoo: Motivations of Citizen Scientists,” *Astronomy Education Review*, vol. 12, p. 106, Apr. 2013, doi: 10.3847/AER2011021.
- [42] Y. Sun, Y. Fang, and K. H. Lim, “Understanding sustained participation in transactional virtual communities,” *Decis Support Syst*, vol. 53, no. 1, pp. 12–22, 2012, doi: <https://doi.org/10.1016/j.dss.2011.10.006>.
- [43] T. Mack and C. Landau, “Winners, losers, and deniers: Self-selection in crowd innovation contests and the roles of motivation, creativity, and skills,” *Journal of Engineering and Technology Management*, vol. 37, pp. 52–64, 2015, doi: <https://doi.org/10.1016/j.jengtecman.2015.08.003>.
- [44] M. Arif, N. Qaisar, and S. Kanwal, “Factors affecting students’ knowledge sharing over social media and individual creativity: An empirical investigation in Pakistan,” *The International Journal of Management Education*, vol. 20, no. 1, p. 100598, 2022, doi: <https://doi.org/10.1016/j.ijme.2021.100598>.
- [45] M. Delaney and M. Royal, “Breaking Engagement Apart: The Role of Intrinsic and Extrinsic Motivation in Engagement Strategies,” *Ind Organ Psychol*, vol. 10, pp. 127–140, Apr. 2017, doi: 10.1017/iop.2017.2.
- [46] T. M. Amabile, R. Conti, H. Coon, J. Lazenby, and M. Herron, “Assessing the Work Environment for Creativity,” *The Academy of Management Journal*, vol. 39, no. 5, pp. 1154–1184, 1996, doi: 10.2307/256995.
- [47] K. Lakhani and R. Wolf, “Why Hackers Do What They Do: Understanding Motivation and Effort in Free/Open Source Software Projects,” *Perspectives on Free and Open Source Software*, Apr. 2003, doi: 10.2139/ssrn.443040.
- [48] K. R. Lakhani and E. von Hippel, “How open source software works: ‘free’ user-to-user assistance,” *Res Policy*, vol. 32, no. 6, pp. 923–943, 2003, doi: [https://doi.org/10.1016/S0048-7333\(02\)00095-1](https://doi.org/10.1016/S0048-7333(02)00095-1).
- [49] A. Newman, H. H. M. Tse, G. Schwarz, and I. Nielsen, “The effects of employees’ creative self-efficacy on innovative behavior: The role of entrepreneurial leadership,” *J Bus Res*, vol. 89, pp. 1–9, 2018, doi: <https://doi.org/10.1016/j.jbusres.2018.04.001>.

- [50] Y. Fang and D. Neufeld, "Understanding Sustained Participation in Open Source Software Projects," *J. of Management Information Systems*, vol. 25, pp. 9–50, Apr. 2009, doi: 10.2753/MIS0742-1222250401.
- [51] Y. Zhao and Q. Zhu, "Evaluation on crowdsourcing research: Current status and future direction," *Information Systems Frontiers*, vol. 16, Apr. 2012, doi: 10.1007/s10796-012-9350-4.
- [52] H. Treiblmaier, L.-M. Putz, and P. Lowry, "Research Commentary: Setting a Definition, Context, and Theory-Based Research Agenda for the Gamification of Non-Gaming Applications," vol. 10, pp. 129–163, Apr. 2018, doi: 10.17705/1thci.00107.
- [53] C.-L. Hsu and M.-C. Chen, "How does gamification improve user experience? An empirical investigation on the antecedences and consequences of user experience and its mediating role," *Technol Forecast Soc Change*, vol. 132, pp. 118–129, 2018, doi: <https://doi.org/10.1016/j.techfore.2018.01.023>.
- [54] M. Aparicio, T. Oliveira, F. Bacao, and M. Painho, "Gamification: A key determinant of massive open online course (MOOC) success," *Information & Management*, vol. 56, no. 1, pp. 39–54, 2019, doi: <https://doi.org/10.1016/j.im.2018.06.003>.
- [55] B. Morschheuser, K. Werder, J. Hamari, and J. Abe, "How to Gamify? A Method For Designing Gamification," Apr. 2017. doi: 10.24251/HICSS.2017.155.
- [56] J. Koivisto and J. Hamari, "The rise of the motivational information systems: A review of gamification research," *Int J Inf Manage*, vol. 45, p. 210, Apr. 2019, doi: 10.1016/j.ijinfomgt.2018.10.013.
- [57] P. B. Goes, C. Guo, and M. Lin, "Do Incentive Hierarchies Induce User Effort? Evidence from an Online Knowledge Exchange," *Information Systems Research*, vol. 27, no. 3, pp. 497–516, 2016, [Online]. Available: <http://www.jstor.org/stable/26652509>
- [58] A. Aparicio, F. L. Vela, J. González-Sánchez, and J.-L. Isla-Montes, "Analysis and application of gamification," Apr. 2012. doi: 10.1145/2379636.2379653.
- [59] M. Sailer, J. Hense, S. Mayr, and H. Mandl, "How gamification motivates: An experimental study of the effects of specific game design elements on

- psychological need satisfaction,” *Comput Human Behav*, vol. 69, pp. 371–380, Apr. 2017, doi: 10.1016/j.chb.2016.12.033.
- [60] B. Morschheuser, J. Hamari, and J. Koivisto, “Gamification in Crowdsourcing: A Review,” Apr. 2016. doi: 10.1109/HICSS.2016.543.
- [61] Steve Smith, *.NET Microservices. Architecture for Containerized .NET Applications*, 6th ed. Microsoft Corporation, 2022. [Online]. Available: <https://aka.ms/microservicesebook>
- [62] D. M. Le, A. P. Nguyen, L. Q. Tran, H. T. Le, and H. V.-A. Tong, “Generating Multi-platform Single Page Applications: {A} Hierarchical Domain-Driven Design Approach,” in *The 11th International Symposium on Information and Communication Technology, SoICT 2022, Hanoi, Vietnam, December 1-3, 2022*, ACM, 2022, pp. 344–351. doi: 10.1145/3568562.3568566.
- [63] “React.js,” *Meta Platforms, Inc.*, 2023. <https://reactjs.org/>
- [64] B. Foote and J. Yoder, “Big Ball of Mud,” Feb. 2003.
- [65] E. Evans, “Domain Driven Design: Tackling Complexity in the Heart of Business Software,” Feb. 2002.
- [66] Cesar de la Torre, B. Wagner, and M. Rousos, *.NET Microservices: Architecture for Containerized .NET Applications*. 2020. [Online]. Available: <https://dotnet.microsoft.com/download/e-book/microservices-architecture/pdf>
- [67] B. Gorman, *Practical Entity Framework Core 6: Database Access for Enterprise Applications*. 2022. doi: 10.1007/978-1-4842-7301-2.
- [68] Martin Fowler, “CQRS,” 2011. <https://martinfowler.com/bliki/CQRS.html>
- [69] V. Legeza, A. Golubtsov, and B. Beyer, “Structured Logging: Crafting Useful Message Content,” *:login;*, vol. Summer 201, 2019, [Online]. Available: <https://www.usenix.org/publications/login/summer2019/legeza>
- [70] P. Neis, M. Goetz, and A. Zipf, “Towards automatic vandalism detection in open street map,” *ISPRS Int J Geoinf*, vol. 1, no. 3, pp. 315 – 332, 2012, doi: 10.3390/ijgi1030315.

- [71] L. Xu *et al.*, “Smartphone-based gamification intervention to increase physical activity participation among patients with coronary heart disease: A randomized controlled trial,” *J Telemed Telecare*, 2023, doi: 10.1177/1357633X221150943.

9. APPENDICES

Appendix 1. Reviewed crowdsourcing application links

Name	URL
FixMyStreet	https://www.fixmystreet.com
SeeClickFix	https://seeclickfix.com
Ushahidi	https://www.ushahidi.com
Burgernet	https://www.burgernet.nl
Street Bump	https://connectedbits.com/street_bump
BOS:311	https://311.boston.gov
PublicStuff	https://www.publicstuff.com
Love Clean Streets	https://www.lovecleanstreets.com
Snap Send Solve	https://www.snapsendsolve.com

Appendix 2. Volunteer survey

EcoSnap Kullanıcı Deneyim Formu		
No	Sorular	Seçenekler
1	Çevrenizdeki sorunlara karşı ne kadar duyarlısınız?	5 Puanlık Likert Ölçeği 1: [Duyarsızım] 5: [Çok Hassasım]
2	Çevreyi kirletenlere karşı tepkiniz nedir?	Resmi şikayette bulunmayı tercih ederim. Bizzat uyarıyorum. Tepki vermeyip, başkalarının tepki vermesini beklerim. Hiç tepki vermem.
3	Başkalarının karşılaştığınız sorunu bildireceğini düşünüyor musunuz?	[Evet] [Hayır]
4	Şu ana kadar çevrenizde karşılaştığınız sorunu nasıl bildirdiniz?	
5	Herhangi bir çevre kuruluşuna üye misiniz?	[Evet] [Hayır]
5a	Hangi kuruluş üyesisiniz?	
5b	Bu kapsamda ne gibi çalışmalar yaptınız / yapıyorsunuz?	
6	Çevresel problemler sağlığını hiç etkiledi mi?	[Evet] [Hayır]
7	Yetkililer çevreyle ilgili sorunlarımızla ne ölçüde ilgileniyor?	5 Puanlık Likert Ölçeği 1: [İlgisizler] 5: [Çok ilgililer]
8	Karşılaştığınız çevre sorunlarının ortalama çözüm süresi nedir?	1 saat içerisinde 1 gün içerisinde 1 hafta içerisinde 1 ay içerisinde Daha fazla
9	Çevre bilinciyle ilgili olarak herhangi bir proje veya etkinliğe katıldınız mı? (çöp toplama, ağaç dikimi vb)	[Evet] [Hayır]
10	Çevre sorunları ile ilgili TV/radyo/podcast programlarını takip etmekten hoşlanıyor musunuz?	Evet her zaman Düzenli değil Hayır ilgilenmiyorum Cevap yok
11	Dünya çevre günü hangi gün kutlanıyor?	5 Haziran 14 Şubat 5 Nisan 30 Ekim Bilmiyorum
12	Çevremizin	sağlıklı ve iyi durumda olduğuna inanıyorum. sıkıntılı ancak biraz çabayla kurtarılabilceğine inanıyorum.

		kötü durumda olduğuna inanıyorum, ancak çok fazla çaba onu kurtarabilir. çok kötü durumda olduğuna inanıyorum, bu konuda yapılabilecek çok az şey var.
13	Gezegeenin karşı karşıya olduğu sorunları önem durumuna göre derecelendiriniz:	
	Ormanların azalması	[Çok önemli] [Önemli][Az önemli]
	Ozon tabakasının incelməsi	[Çok önemli] [Önemli][Az önemli]
	Zehirli atıklar	[Çok önemli] [Önemli][Az önemli]
	Küresel ısınma	[Çok önemli] [Önemli][Az önemli]
	Su kirliliği	[Çok önemli] [Önemli][Az önemli]
	Hava kirliliği	[Çok önemli] [Önemli][Az önemli]
14	Ankara'nın karşı karşıya olduğu sorunları önem durumuna göre derecelendiriniz:	
	Otopark sorunu	[Çok önemli] [Önemli][Az önemli]
	Graffiti	[Çok önemli] [Önemli][Az önemli]
	Bozuk kaldırımlar	[Çok önemli] [Önemli][Az önemli]
	Yere atılan çöpler / izmaritler	[Çok önemli] [Önemli][Az önemli]
	Yeşil alan / çocuk parkı yetersizliği	[Çok önemli] [Önemli][Az önemli]
15	Uygulamanın görünümünden ve verdiği hissten ne kadar memnunsunuz?	5 Puanlık Likert Ölçeği 1: [Hiç memnun değilim] 5: [Çok memnunum]
16	Uygulamanın kullanım kolaylığından ne kadar memnunsunuz?	5 Puanlık Likert Ölçeği 1: [Hiç memnun değilim] 5: [Çok memnunum]
17	Kurulum ve ilk kaydolma deneyiminden ne kadar memnunsunuz?	5 Puanlık Likert Ölçeği 1: [Hiç memnun değilim] 5: [Çok memnunum]
18	Uygulama hakkında kafanızı karıştıran/rahatsız eden ne oldu?	
19	Puan, rozet vb. kazanımlar EcoSnap'i kullanımınıza devam ettirmenizde önemli midir?	[Evet] [Hayır]
20	EcoSnap puanınızın maddi kazanç (çeşitli indirimler, kampanyalar vs.) sağlaması, paylaşımlarınızı arttırmanızda ne kadar etkili olur?	5 Puanlık Likert Ölçeği 1: [Hiç etkili değil] 5: [Çok etkili]
21	EcoSnap ismi size neyi çağırıştırıyor? Uygulamanın amacına uygun mudur?	
22	EcoSnap uygulamasının sorununuzu çözmenize/hedefinize ulaşmanıza yardımcı olacağını düşünüyor musunuz?	5 Puanlık Likert Ölçeği 1: [İşe yarayacağını düşünmüyorum] 5: [Çok faydalı olacağını düşünüyorum]
23	Uygulamayı hangisi için kullandınız?	Sosyalleşme ve yeni kişileri tanıma imkanı sunması Sorunlarımı bildirebilmek için

		EcoSnap puanı kazanıp, indirimli alışveriş yapabilmek için Çevremdeki sorunları takip etmek için
24	Uygulamanın hangi özellikleri beklentilerinizi karşılamadı?	
25	Uygulamada ihtiyacınız olduğunu düşündüğünüz ancak eksik gördüğünüz özellikler var mı?	
26	Uygulamanın sorunsuz bir şekilde çalıştığını düşünüyor musunuz?	5 Puanlık Likert Ölçeği 1: [Çok sorunlu] 5: [Sorunsuz]
27	Uygulamamızı ne sıklıkla kullanırsınız?	Her gün Haftada bir Ayda bir Daha seyrek
28	Uygulamayı amacına uygun buldunuz mu?	5 Puanlık Likert Ölçeği 1: [Uygun değil] 5: [Çok uygun]
29	Uygulamanın mevcut özellikleri ile çevre sorunlarını çözmeye yeterli olacağına inanıyor musunuz?	[Evet] [Hayır]
30	Uygulamanın genel kalitesini nasıl değerlendirirsiniz?	5 Puanlık Likert Ölçeği 1: [Çok kötü] 5: [Çok iyi]
31	Bu uygulamayı bir arkadaşınıza veya ailenize tavsiye eder misiniz?	5 Puanlık Likert Ölçeği 1: [Tavsiye etmem] 5: [Tavsiye ederim]
32	Herhangi bir ek yorumunuz/öneriniz var mı?	
33	Bir inceleme bırakmak veya Google Play mağazasında bize oy vermek ister misiniz?	[Evet] [Hayır]
34	Aşağıdaki soruları değerlendiriniz	
	İşlemlerinizi yeterli sayıda tıklamayla gerçekleştirdiğinizi düşünüyor musunuz?	5 Puanlık Likert Ölçeği 1: [En Kötü] 5: [En İyi]
	Bilgilerinizin uygulamamıza getirilmesi süresini değerlendiriniz.	5 Puanlık Likert Ölçeği 1: [En Kötü] 5: [En İyi]
	Verilerinizin kaydedilme süresini değerlendiriniz.	5 Puanlık Likert Ölçeği 1: [En Kötü] 5: [En İyi]
	Uygulamanın indirilme ve yüklenme hızını değerlendiriniz.	5 Puanlık Likert Ölçeği 1: [En Kötü] 5: [En İyi]
	Uygulamanın arayüzünü değerlendiriniz.	5 Puanlık Likert Ölçeği 1: [En Kötü] 5: [En İyi]

	Kullanılan iconların alaka durumunu değerlendiriniz.	5 Puanlık Likert Ölçeği 1: [En Kötü] 5: [En İyi]
	Uygulamanın kullanılabilirliğini değerlendiriniz.	5 Puanlık Likert Ölçeği 1: [En Kötü] 5: [En İyi]
35	EcoSnap'i kullanmaya devam edecek misiniz?	[Evet] [Hayır]
35a	Neden etmeyeceksiniz?	Bu uygulama ile çevre sorunlarının çözülebileceğini düşünmüyorum. Karar vermek için zamana ihtiyacım var. Sonradan tekrar döneceğim. Daha fazla bilgiye ihtiyacım var Sadece denedim. Uygulamayı çekici bulmuyorum.

Appendix 3. Ethics Committee Approval Letter



T.C.
HACETTEPE ÜNİVERSİTESİ REKTÖRLÜĞÜ
Rektörlük



Sayı : E-35853172-300-00002802223
Konu : Etik Komisyon İzni (İlyas ÇOKAN)

17.04.2023

FEN BİLİMLERİ ENSTİTÜSÜ MÜDÜRLÜĞÜNE

İlgi: 06.04.2023 tarihli ve E-23154132-300-00002786318 sayılı yazınız.

Fakülteniz Geomatik Mühendisliği bölümü Yüksek Lisans öğrencisi **İlyas ÇOKAN**'ın, **Doç. Dr. Berk ANBAROĞLU** danışmanlığında hazırladığı "**Şehirlerde Mekansal Planlama ve Karar Vermede Mobil PPGIS Kullanımına Yönelik Kullanıcı Görüşlerinin ve Beklenilerinin Toplanması**" başlıklı tez çalışması Üniversitemiz Senatosu Etik Komisyonunun **11 Nisan 2023** tarihinde yapmış olduğu toplantıda incelenmiş olup, etik açıdan uygun bulunmuştur.

Bilgilerinizi ve gereğini rica ederim.

Prof. Dr. Sibel AKSU YILDIRIM
Rektör Yardımcısı

Bu belge güvenli elektronik imza ile imzalanmıştır.

Belge Doğrulama Kodu: 930447A4-C416-4336-9611-4E0D2C19F38A

Belge Doğrulama Adresi: <https://www.turkiye.gov.tr/hu-ebys>

Adres: Hacettepe Üniversitesi Rektörlük 06100 Sıhhiye-Ankara

Bilgi için: Çağla Handan GÜL

E-posta: yazimd@hacettepe.edu.tr İnternet Adresi: www.hacettepe.edu.tr Elektronik

Bilgisayar İşletmeni

Ağ: www.hacettepe.edu.tr

Telefon: 0 (312) 305 3001-3002 Faks: 0 (312) 311 9992

Telefon: 03123051008

Kep: hacettepeuniversitesi@hs01.kep.tr

