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ECO EVOLVE: WASTE MANAGEMENT FLUTTER APPLICATION

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Abstract - *This project aims to develop a waste classification app using various techniques with an innovative Flutter app. The application will enable the users to register their complaints, look for the status of their complaints anytime, refer to the study resources, integrate Google Maps which can be used to locate recycling and disposal centres, and the user profiles. This system consists of different actors like users, admins, and government people. The app helps to advance waste classification with image recognition and user location data from Google ML Kit. A previous research project on this topic used CNN architectures for image classification in the waste classification process. Furthermore, sensor-based technologies also contribute to the efficiency of waste sorting systems. The project aims to support environmental conservation by offering waste management as an ecological service. This is achieved through the integration of advanced technology.*

Key Words: *Waste Management, GPS Tracking, Garbage Disposal, Flutter, Mobile Application, Google ML Kit, Firebase*

1. INTRODUCTION

Waste management is a pressing issue worldwide, hence the introduction of advanced solutions and systems to solve segregation, categorization, and dumping issues. The application of the Internet of Things (IoT), sensors, Flutter applications, and Google ML Kit seems to be the latest development in waste management strategies. The latest research has shown the capability of IoT-based solutions in remaking waste management systems. Studies like Shukla & Shukla (2017) have carried out surveys of Smart Waste Collection Systems based on IoT where the potential of IoT in enhancing collection efficiency and sustainability is stressed. Moreover, Dandge (2023) investigated the development of a Flutter-based Android platform for Smart Waste Management Systems which featured the user-friendly and integrated solutions provided by modern technologies for waste disposal optimization. On the other hand, Aarif et al. (2022) proposed a Smart Bin system incorporating deep learning and Internet of Things technologies for waste segregation purposes highlighting how advanced algorithms become an integral part of the waste classification process.

Also, the use of Google Machine Learning kit in waste management applications has gained attention over time for its effectiveness in improving the classification accuracy of wastes and the speed of the entire process. Analogous to Aarif et al. (2022), various deep learning algorithms have proved their proficiency and determined how artificial intelligence can make the sustainability of waste management practices possible. Moreover, Khatun et al. (2022) demonstrated an AI-enabled IoT system for route recommendations from a smart waste management point of view, suggesting the use of such methods in routing optimization and resource allocation.

The joining of IoT, devices that are used to measure things, Flutter applications, and Google ML Kit in waste management systems gives an occurrence that has to do with being innovative so that environmental problems can be resolved, the use of sustainable practices can be promoted and the waste management processes optimized. In this paper, through the integration and the further development of the currently existing research in waste management, we intend to dot the i's and cross the t's of the already existing waste management technologies and methods, with a particular focus on the incorporation of the latest technologies designed for advanced waste segregation and classification.

2. SCOPE

User Task: The given references point out that the goal of this step is to distinguish and select appropriate scientific methodologies and techniques that can be applied in the design of the waste classification mobile application with the help of Flutter. The employed techniques should encompass waste management methods, proper classification systems, recycling processes, and all green approaches. The aim is to exploit the successful research approaches that will help in the improvement of the waste classifying technique within the application. The chosen approaches will enable the development of functionality like report submission functionality, educative content, Google Maps interface, account management, Google ML Kit image processing, and local services. Its pursuit of an effective and purposeful solution includes the utilization of research techniques that are scientifically grounded, focused on customers, and in compliance with the green industry standards.

3. OBJECTIVE

The main aim of this project is to construct the waste classification system through a Flutter application with features for better user experience and responsible waste management. The key objectives of the project include:

[1] **Complaint Registration and Management:** Users can register complaints about waste management problems, the status of their complaints will be tracked, and they will be regularly updated till the final resolution (Harman and Yenikalayci,2022).

[2] **Educational Resources:** The mobile app will have a dedicated "Learn" screen with materials like articles, videos, and graphs which will educate users on waste management practices, techniques of recycling, and practices of conservation of the environment.

[3] **Google Map Integration:** The incorporation of Google Maps API will make it easier for the users to locate the nearby recycling centres and waste disposal facilities which is going to help them with proper waste disposal and hence promote sustainable waste management practices (Allesch & Brunner, 2015).

[4] **User Profile Management:** To ensure a personalized experience, we will design a user profile screen so that each user can tailor their waste management activities and participate interactively with the waste classification system (Lunkes et al., 2020).

[5] **Entity Management**: Implement role-based access to the system such as users, administrators, and government officials who can monitor complaints and waste management processes and also ensure effective communication among stakeholders (Zeng & Trauth, 2005).

[6] **Image Processing using Google ML Kit:** Employ Google ML Kit for image processing to analyze waste items that users provide, categorize waste materials correctly into preformed categories, and enhance the selectivity of waste classification processes (Poponi et al., 2023).

[7] **Location-Based Services:** Take advantage of the place accompaniment of users to offer personalized suggestions for nearby recycling stations and garbage disposal sites. The users can make informed decisions on waste management practices based on their geographical location (Anagnostopoulos et al., 2021).

4. LITERATURE REVIEW

[1] The scientific community is examining recycling and scrap classification globally on various issues and has a large number of publications reflecting issues in waste management practices and the public, people's attitudes, technological development, and policy implications. Min and other colleagues (2019) studied consumers' intentions to separate their waste in China bringing an Extended Theory of Planned Behaviour into practice to pinpoint individual engagement in waste management activities (Min et al. 2019). According to this case study reported by Wang and Tan (Wang & Tan, 2022) researchers in Wusheng County, Sichuan, China, exploring farmers' views and attitudes towards domestic waste classification using multi-channel propaganda and community engagement as key determinants to change waste management behaviours and (Wang & Tan, 2022)

[2] Pires & Chang (2011) reviewed the solid waste disposal systems in Europe and emphasized the optimization of waste disposal processes via systems analysis, which provides efficiency (Pires & Chang, 2011). Jin et al., (2019) adopted a science mapping approach to assess the trends in construction and demolition waste management by scrutinizing the widespread conclusions and the scope of the research applied in the field (Jin et al., 2019). The study by Hannan et al., 2015) demonstrated the state of solid waste monitoring and management systems regarding environmental monitoring as well as information and communications technology, which have their challenges and opportunities associated with them (Hannan et al., 2015).

[3] Tang et al. (2022) looked at motivation factors of urban areas' household waste sorting behaviour and also proposed the role of reward and punishment mechanisms in enhancing the practice of classification of wastes (Tang et al. 2022). Lu & Yuan (2010) made an in-depth study about success factors for waste management in the Chinese construction and demolition field, to show that the problem is becoming more critical due to the growing amount of construction waste (Lu & Yuan, 2010; Gala et al., 2020) carried out a comprehensive survey on post-consumer plastic film waste in Spain in the aim of targeting the optimal way of waste management specific to the waste sources (Gala et al., 2020).

[4] The literature constitutes several studies on new technologies for waste classification including (2018) the multilayer hybrid deep-learning method for waste classification and recycling where deep

learning methods are used to escalate the waste sorting processes (Chu et al., 2018). Moreover, the improvement of waste classification methodologies, including deep learning-based methods presented by Altikat et. al. (2021), showed that AI could be used to optimize waste management practices (Altikat et. al., 2021).

[5] (Cerchecci et al., 2018) introduce a multi-sensor node architecture for waste management in the context of a Smart City with special attention to the role of IoT in reducing waste (Cerchecci et al., 2018). In addition, Pardini et al. (2019) worked on a survey on IoT-based solid waste management solutions, emphasizing the role of urbanization and cloud computing in facing the problem of waste in urban areas. In Aarif et al., 2022, a smart waste segregation system by deep learning and IoT technologies to distinguish waste items as biodegradable or non-biodegradable was presented, which demonstrated such technologies' applicability in waste management (Aarif et al., 2022).

[6] Adding on that, automated waste separation using image processing and machine learning, as done by 's (2018) study, portrays the necessity of automation in waste management processes for proper waste segregation and disposal (Dev, 2018). In parallel, Mapari et al. discuss a waste separation and monitoring system that stresses the waste hierarchy as a critical component of waste management design. (Mapari et al., 2020;). Chitale (2023) developed a smart waste segregation system with the support of the Internet of Things emphasizing the significance of using effective segregation mechanisms to deal with waste management issues (Chitale, 2023).

[7] Accumulation of knowledge in the field of research foreshadows smart waste systems that emit IoT devices (Sairam et al., 2021) strengthening the need not only for environmentally friendly habits but also for the reduction of waste pollution using the technology. Lundin et al., in 2017, conducted research to operationalize sensor-based solutions that help monitor service and collection of waste in public trash bins. The study gave a real-life example of how sensors are used to improve waste management operations (Lundin et al., 2017). An IoT-based lead route system for the recommendation was proposed by Ghahramani et al, 2022. In that realm, smart waste management consists of the role of IoT in devising efficient waste collection routes given that storage is confined (Ghahramani et al., 2022)

[8] Concerning waste classifying and controlling the field, the recent research work found us with some viable ways of controlling waste. Residents' mechanisms of decision-making have been studied by Meng et al. (2019) which depict how residents classify and recycle their solid waste. Alongside this, useful information concerning individual participation in solid waste management has been provided. Unlike most studies about smart waste management systems that have been carried out, Wong et al. (2022) highlighted the role of IoT technologies, in which this term can be used to imply the existence of numerous and connected sensors that can be applied to solve the issue of ineffective waste management.

[9] Chu et al. (2018) introduced the idea of multilayer using a hybrid deep-learning method for waste classification and recycling meaning the technology can be used in the automation of waste sorting. Liu et al. (2019) went into the mechanisms of formal education on how urban residents applying the classifying of waste behaviours are impacted and how environmental campaigns on sustainable waste management behaviours become the main tool. Liugboja & Wang (2019) proposed a Convolutional Neural Network based AI system for waste classification that proves the applicability of AI toward efficient waste management.

[10] Furthermore, Chen et al. (2020) and Zhang et al. (2021) made determinations based on both resident intentions towards waste classification and actual behaviours, showcasing personalities dealing with waste management. Vo et al. demonstrated in 2019 a new model, transfer deep learning, which demonstrated the possibility of superior algorithms for trash separation in waste sorting procedures. According to Yang et al. (2021), a study concerning college students' readiness for commingled municipal waste collection and its association with knowledge sharing and awareness of waste classifying behaviours was conducted.

[11] In addition, Zheng, et al.'s (2022) latest paper pointed out that different factors and incentives influence people's behaviour, and categorize their waste. The more delicate approach to the obstacles and inspiring forces of solid waste separation illustrated the insight. Zhou et al. (2019) documented the novel regulations and sorting infrastructures of municipal solid waste in Shanghai and aligned such a concept with the idea of the challenges and prospects of the policy guidelines.

[12] They combined to provide insights into waste management practices, public behaviours, technological innovations, and policies framework which ultimately strives to encourage environmentally friendly waste management. To contribute to the body of knowledge on waste classification, the project aims to expand the field by creating an application with the Flutter app technology that integrates advanced functionalities and enhances waste management methods as well as the commitment towards the environment.

5. PROPOSED METHODOLOGY

To construct an effective waste classification system, my proposed algorithm is to support it by capturing images using Google ML Kit's image processing technique, and location data. The algorithm employs a sufficiently deep learning basis for high accuracy while classifying waste. The system first takes pictures of the waste items through the intermit of the application. Those pictures go through the preprocessing phase using Google ML kit to get interesting features. The employed Convolutional Neural Network (CNN) model, which is based on the work of Chu et al. (2018) and (Shi et al., 2021), believes in classifying waste items into given categories, such as organic waste, plastic waste, and paper waste. The survey search engine permits users to file complaints and get their status as it incorporates registration and tracking enhanced by the research work of (Kumar et al., 2023). Furthermore, an option page with various educational materials for the users to learn about waste management, like the case mentioned by (Vo et al., 2019), is also implemented. Google Maps API enabled the localization of recycling points and waste disposal facilities (Ziouzios et al., 2020) as one of the measures taken to increase app functionality. The platform takes care of profile management of all people (different users, administrators, and government officials) named by Altikat et al. (2021) to provide a personalized experience and efficient waste management. A proposed algorithm that blends these features is designed to be a user-friendly and effective tool that will facilitate waste classification and hence sustainable waste management within the Flutter application.

6. METHODOLOGY

Iterative Waterfall Model

The project EcoEvolve mirrors a waterfall model with such an extension as the waterfall model is clear but it doesn't provide later versioning and the iterative framework is flexible but doesn't use one structure. On the other hand, this approach empowers the organization to adopt a phased systematic approach while at the same time, they can continuously make improvements as well as adaptations based on the gathered feedback from users.

1. Requirements Gathering (Initial Phase):

- Collect and document the whole set of requirements for the project accurately. Among these elements are listing and developing the waste features and functions, providing some educational materials, and integrating the user profile in the mix with the map.

2. System Design (Initial Phase):

- Build initial system design indicating the underlying architecture along with data flow in the application. Cite the technologies and tools that will be utilized in such a way as for image processing, user complaint tracking, educational content management, and map integration.

3. Implementation (Iterative Phase):

- Initiate the implementation process with one aspect of your project, for instance, picking a waste identification starting point. Market-ready prototype whose testing is limited to this particular component is designed and produced.

- Test and retest the waste identification module with real-world data, as you will perform corrected iterations to improve its accuracy and performance.

4. Testing (Iterative Phase):

- Conduct exacting testing for every new inbuilt system. There is going to be testing done on picture recognition accuracy, adverse reaction registration function, use of educational content, and correct map integration.

- Rework the issues noticed during testing and further refinement to ensure that every item coordinates with the specification of the requirement successfully, and the operation is smooth.

5. Integration (Iterative Phase):

- Weave the various components together perfectly fitting to the overall application. Check that the data glides from one module to another and that the user interface regularly remains coherent.

6. User Feedback (Iterative Phase):

- Gather user feedback by running beta testing sessions and pilot deployments. Rely on this feedback to make incremental adjustments to the app's user-friendliness, responsiveness, and functionality to better solve the problem.

7. Documentation (Ongoing):

- It is important to keep thorough documentation during the whole project including with each iteration. These documents should Include user manuals, system architecture diagrams, and code documentation.

8. Deployment (Final Phase):

- Release the production-ready complete and refined version of the application into the production system. Make sure that, not only all the functions, such as waste identification, complaint tracking, learning materials, user profiles, and map integration, are linked and the flow is smooth.

9. Maintenance and Updates (Post-Deployment):

- As the time post-deployment passes continue to track the application's performance and collect user feedback. Use this knowledge to prioritize and set in motion bug correction, addition of new features, and modifications.

TECHNOLOGIES USED

1. Google ML Kit: Liang & Sun (2022) articulate that CLP applications would use Google ML Kit as the component for image processing and machine learning tasks, which are used for accurate waste identification and enhancing user experience.

2. Flutter: This project will be developed using highly sophisticated UI software development tools known as Flutter, providing the utmost compatibility and a user-friendly interface. (Wijaya et al., 2023)

3. Location-Based Services: The app "SPEEDY-SHIP: An Integrated Waste Management System for Intracity Logistics will be harnessing geo-location services to guide users in making considerations depending on their exact location.

4. Firebase Storage and Fire store Database: Data storage, management, and retrieval within the application will be done by ** Firebase Storage and Firebase Database which will make the data interaction as smooth as possible for the users and the effective operation of different manipulations with the data (Dahunsi et al., 2021, para. 5).

5. Google Maps Integration: Through Google Maps API, the website users will be able to locate appropriate recycling centres and waste disposal facilities (Miller, 2006).

Such technologies will help the waste management mobile app to fill in the available gap of simple methods for categorizing waste, raising complaints, providing resourceful information, and location-based services as a way to ensure that unfamiliar waste management practices and environmental sustainability are promoted.

7. SYSTEM REQUIREMENT

For Developers:

Hardware Platform:

- Processor: Core i3 or Higher
- RAM: 2GB or above
- GPU: 1GB or above
- Hard Disk: 100 GB or above

Software Platform:

- Android Studio
- VS Code

Operating System: Windows 7 and above.

For Users:

Hardware Platform

•Processor- Snapdragon 450 equivalent or above

- RAM: 2GB or above
- ROM: 16GB or above

Operating System: Android 11.0 or above

8. SYSTEM DESIGN

8.1 E-R Diagram

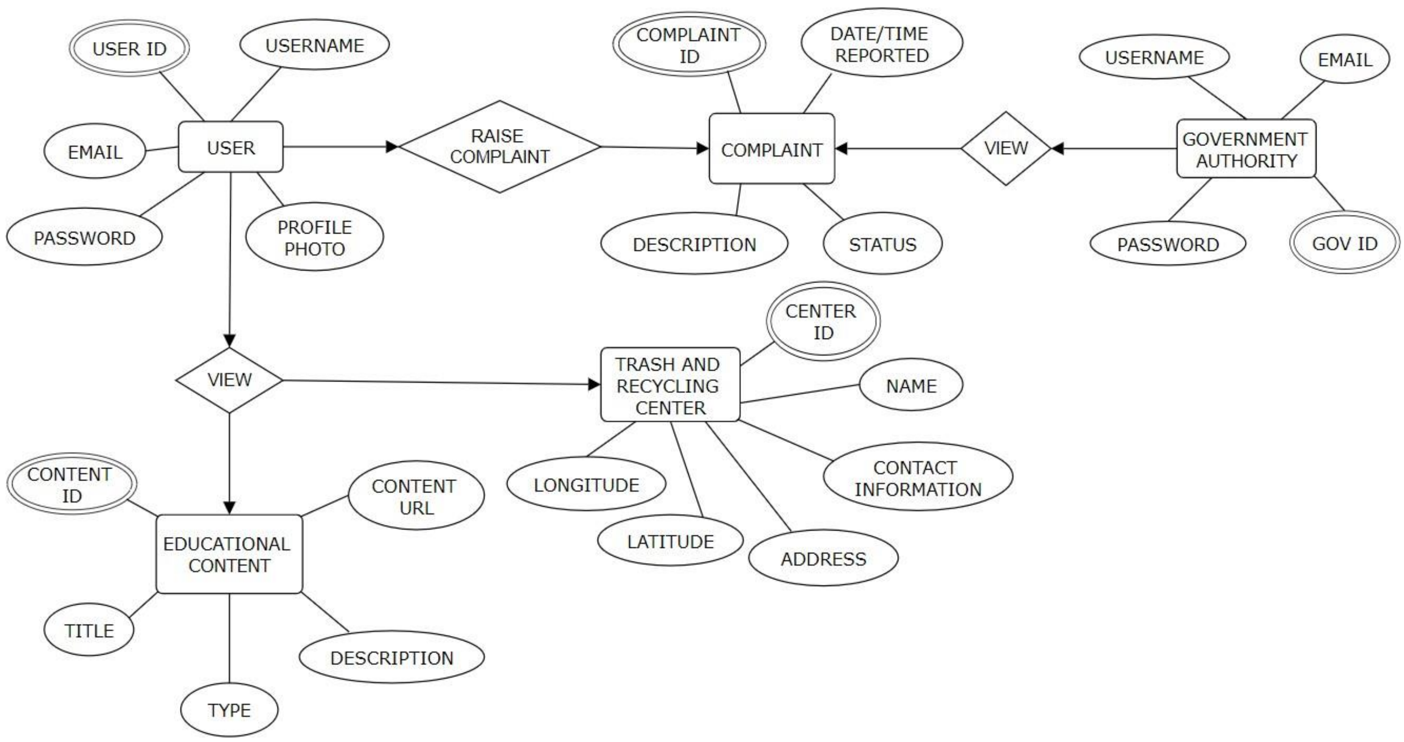

Figure 1 E-R Diagram

8.2 Data Flow Diagram

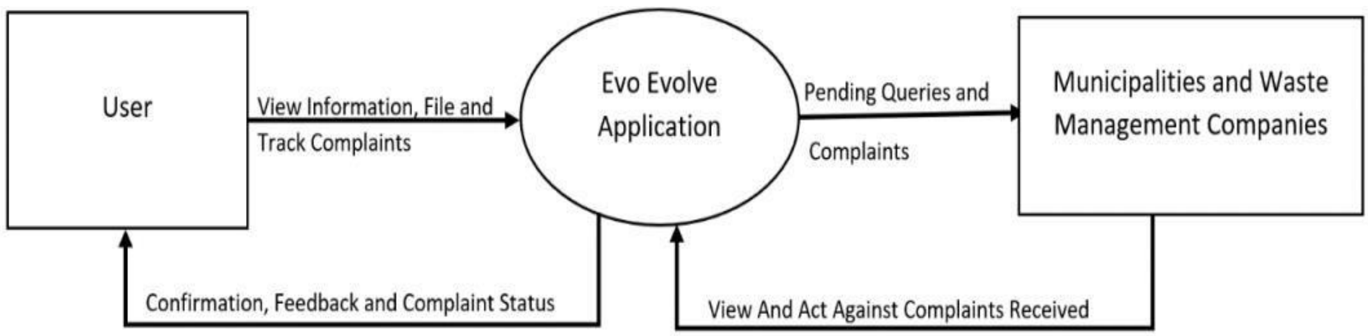

Figure 2 dfd 0 level

8.3 Use Case Diagram

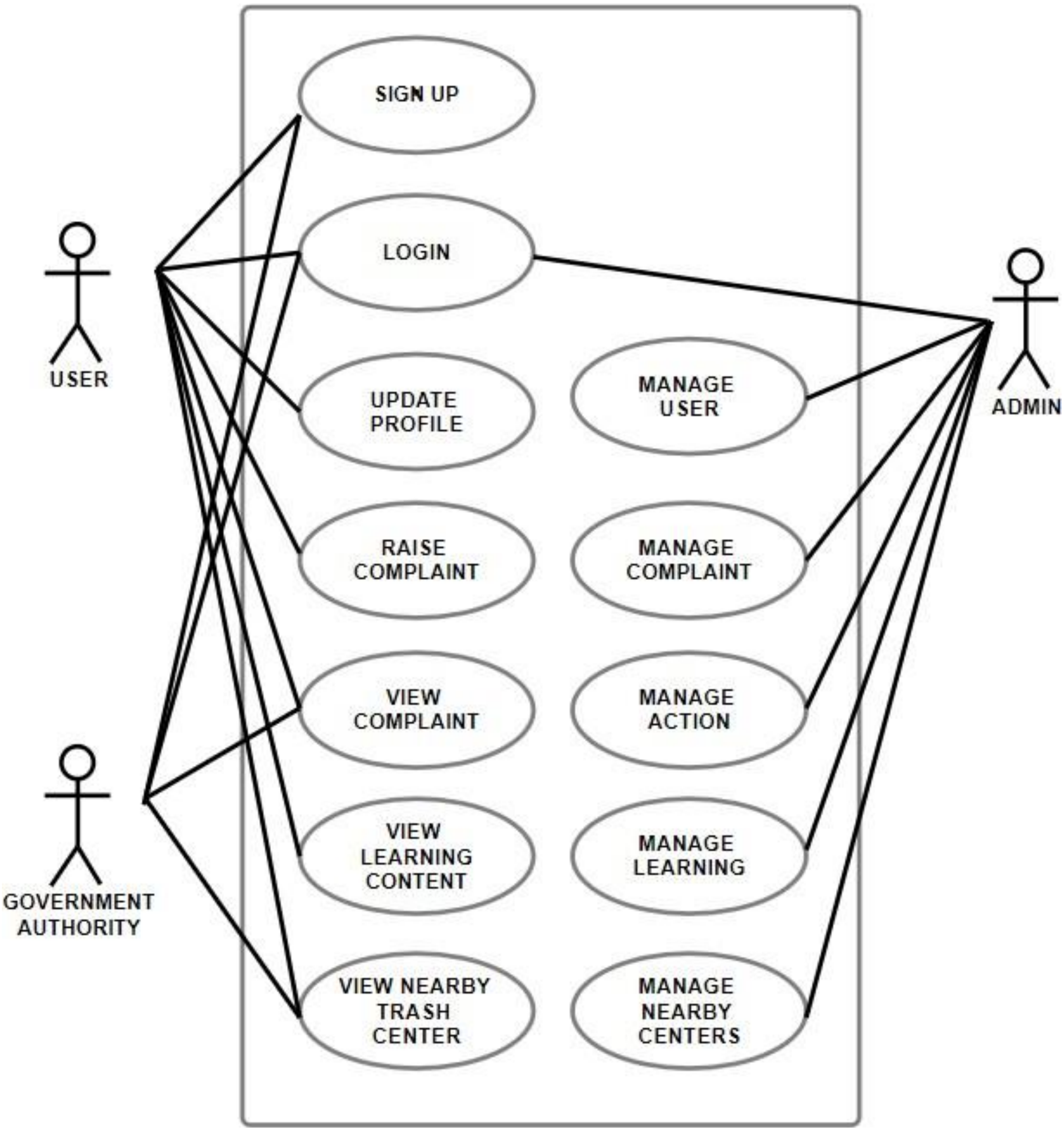

Figure 3 Use Case Diagram

9. IMPLEMENTATION:

9.1 Getting Started Screen:

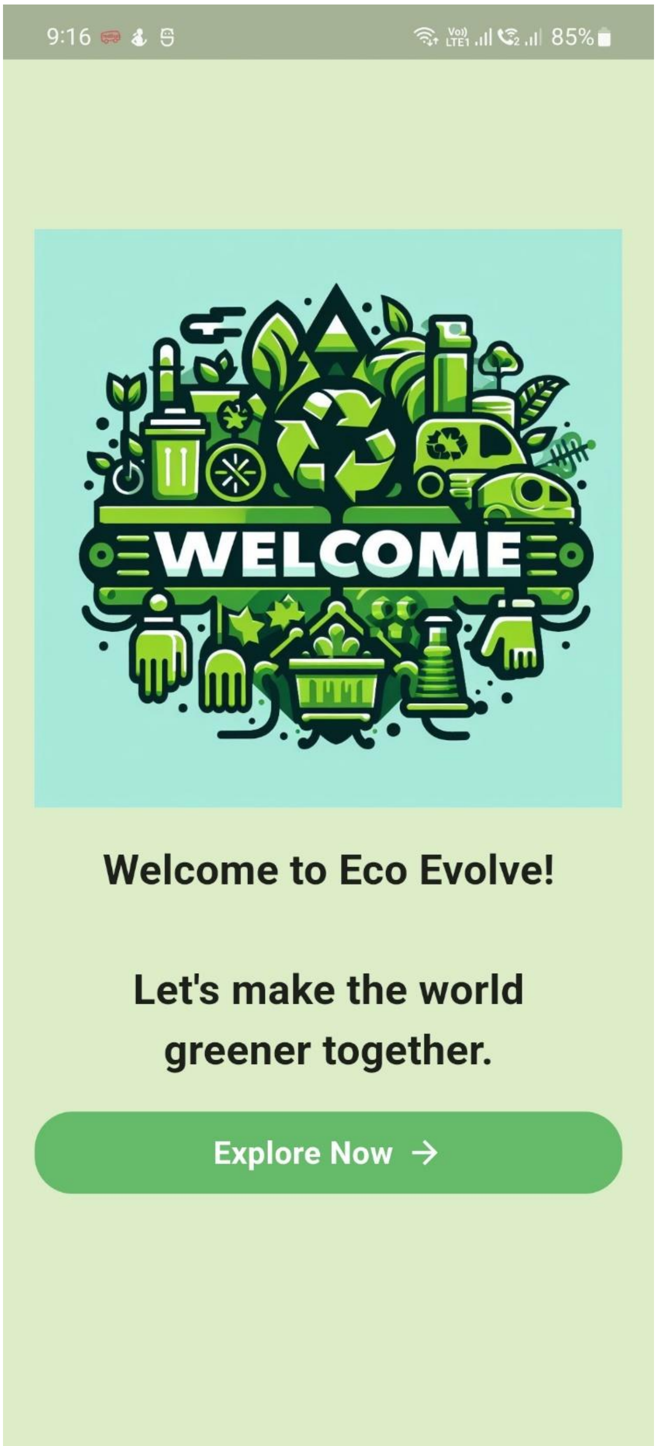

Figure 1 Getting Started Screen

9.2 Login Screen:

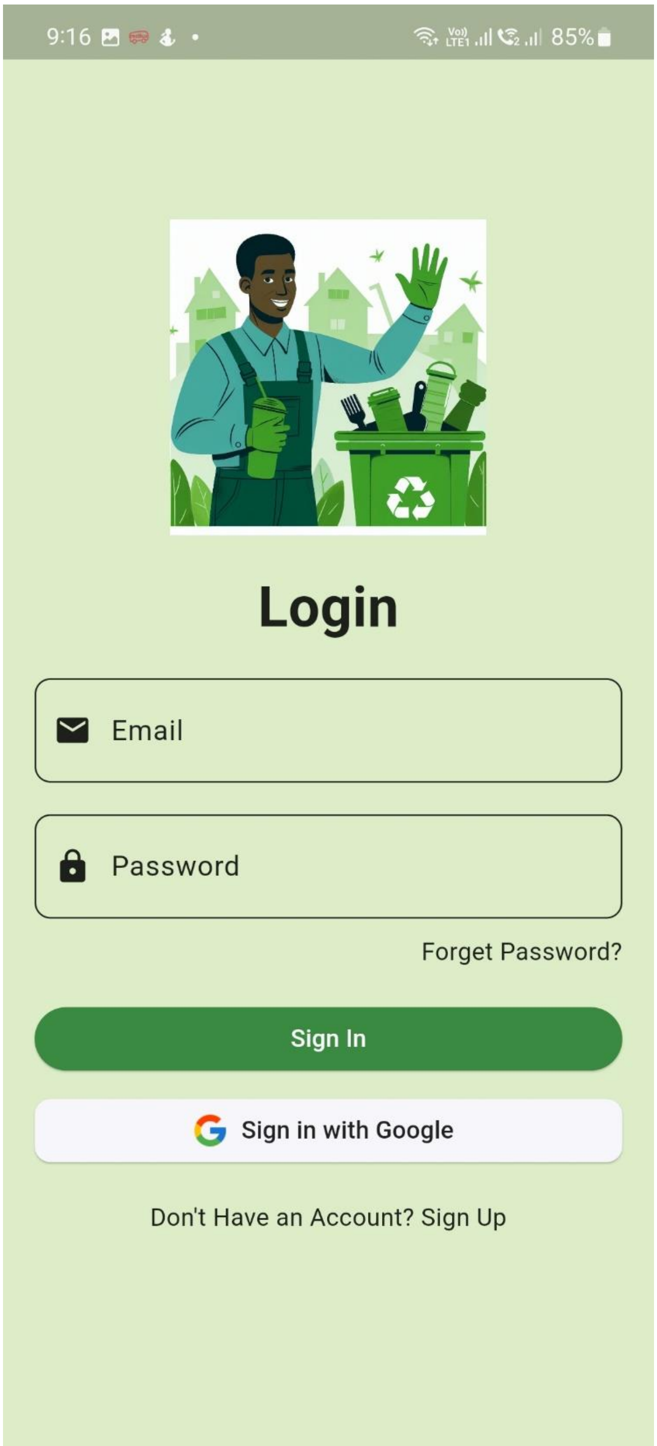

Figure 2 Login Screen

9.3 Sign Up Screen:

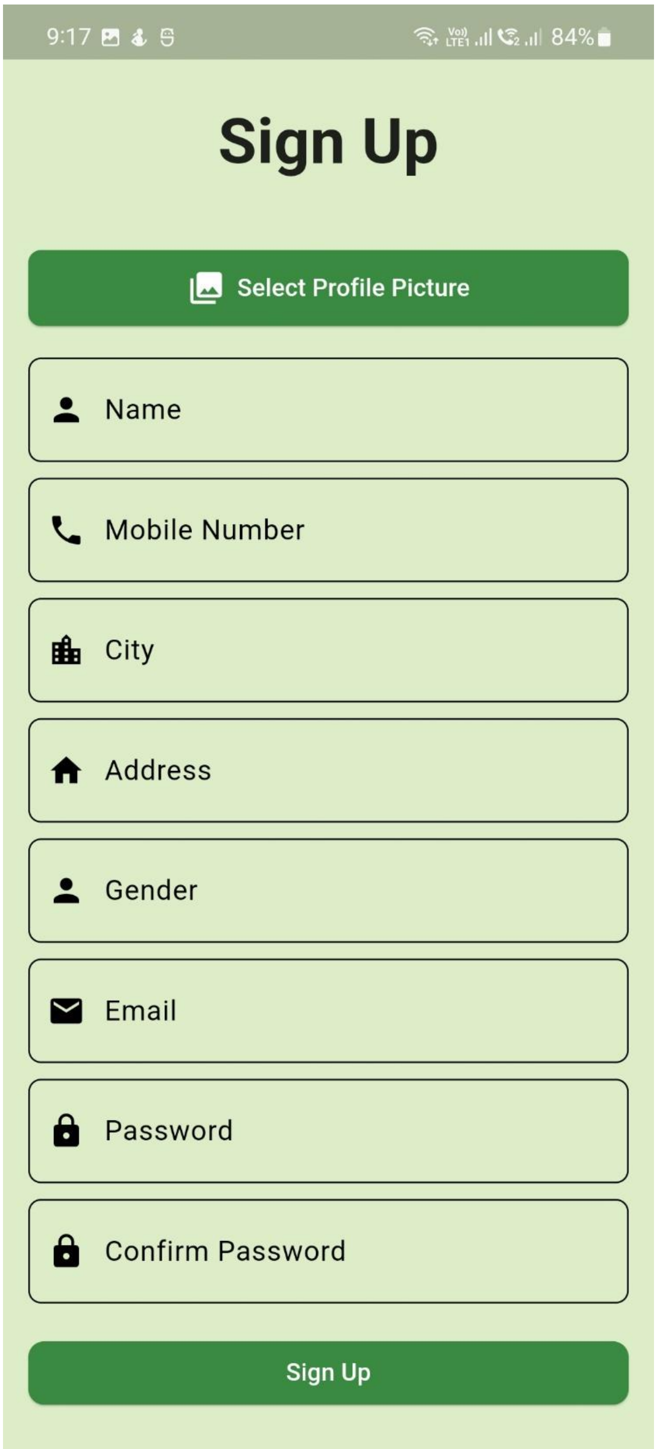

Figure 3 Sign-Up Screen

9.4 Forget Password Screen:

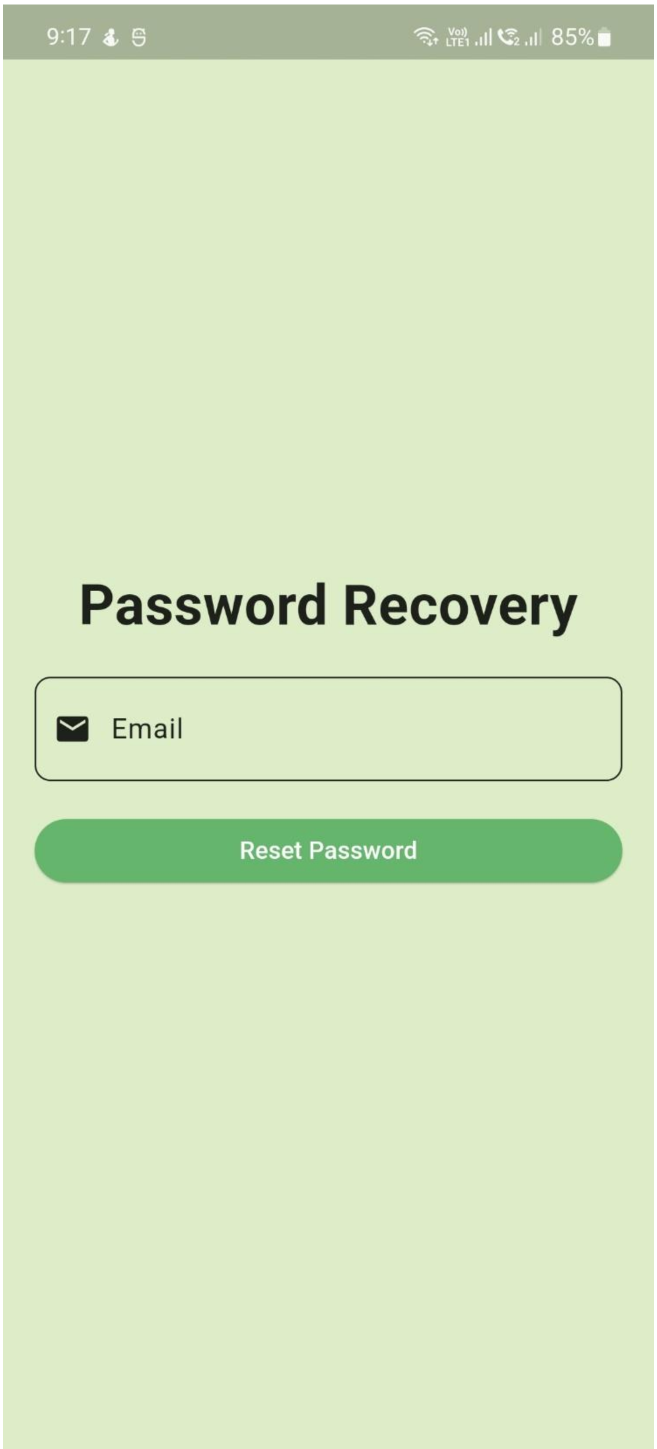

Figure 4 Forget Password Screen

9.5 Home Screen:

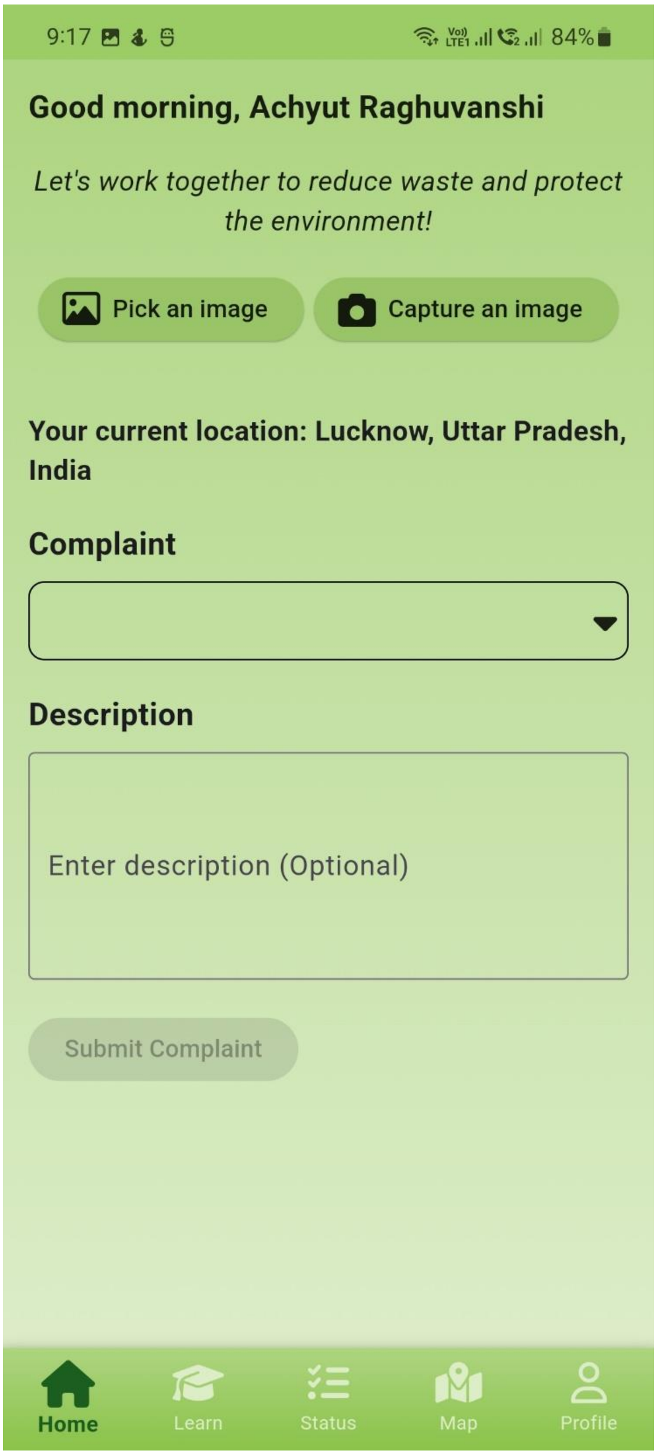

Figure 5 Home Screen

9.6 Learn Screen:

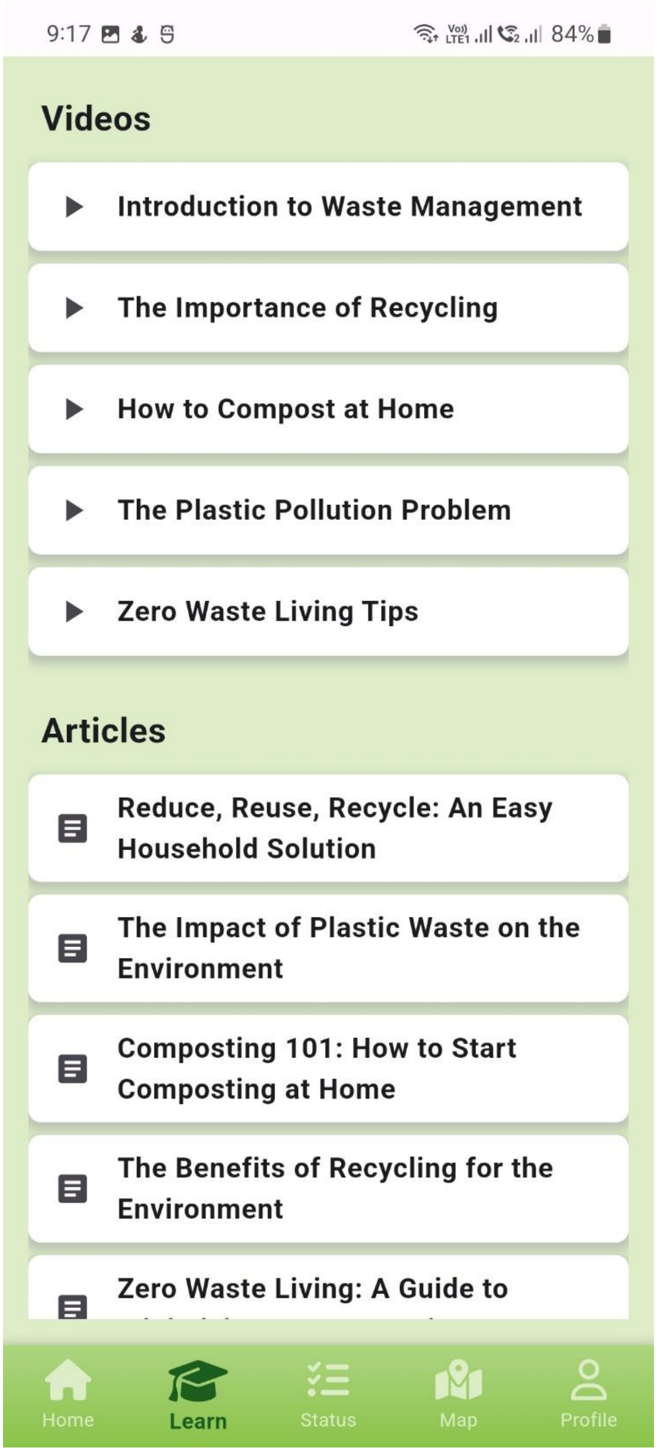

Figure 6 Learn Screen

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9.7 Status Screen:

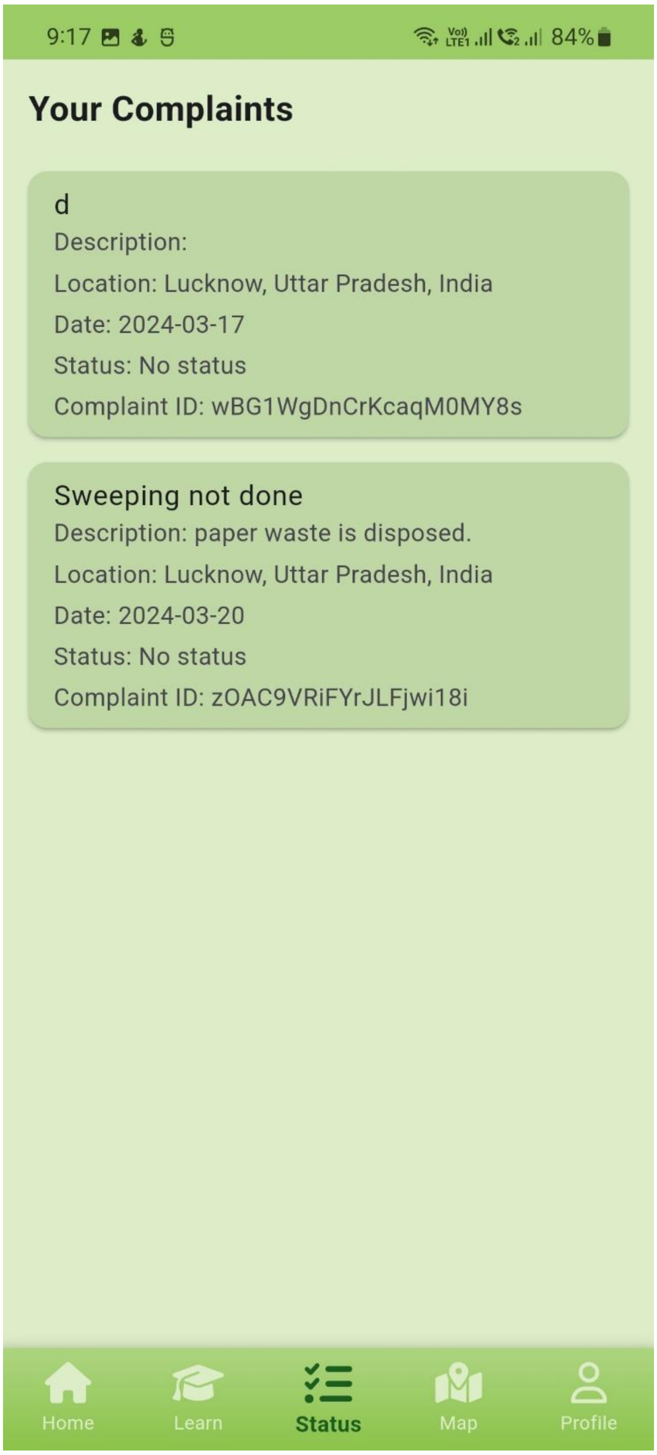

Figure 7 Status Screen

9.8 User Profile Screen:

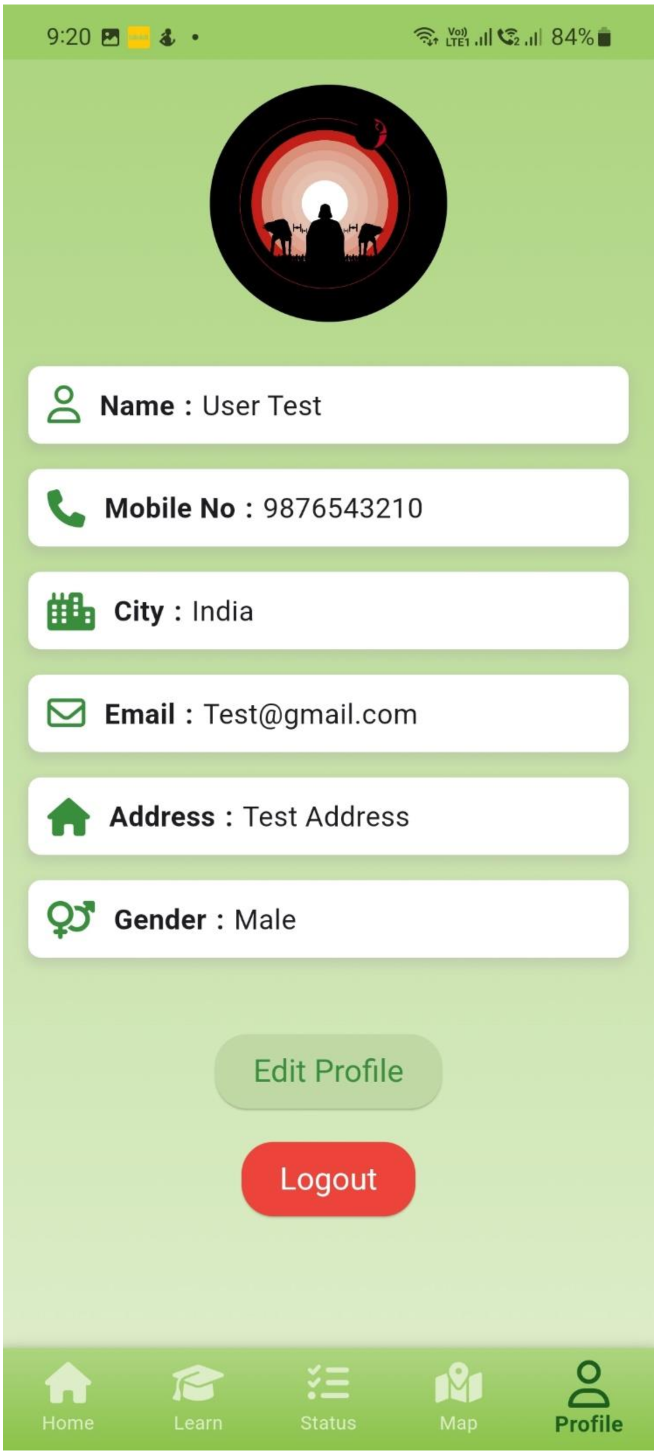

Figure 8 User Profile Screen

9.9 Edit Profile Screen:

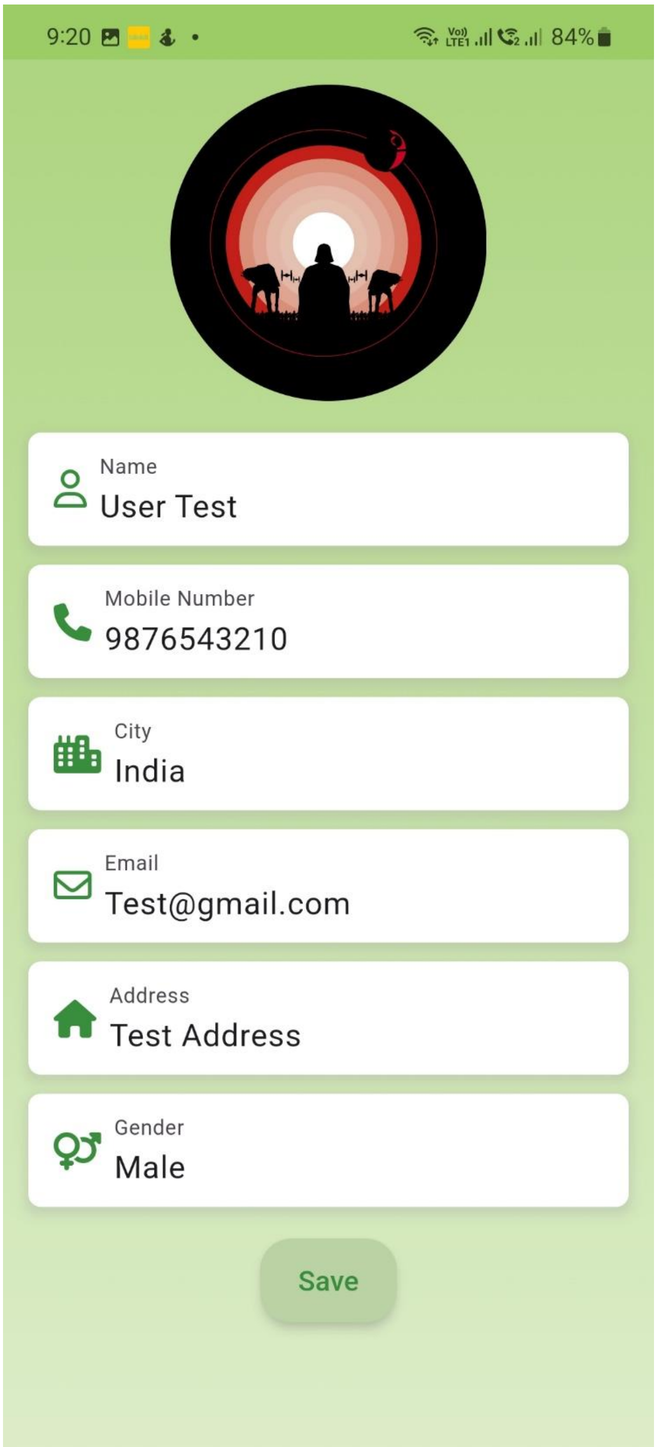

Figure 9 Edit Profile Screen

9.10 Complaint Register Screen:

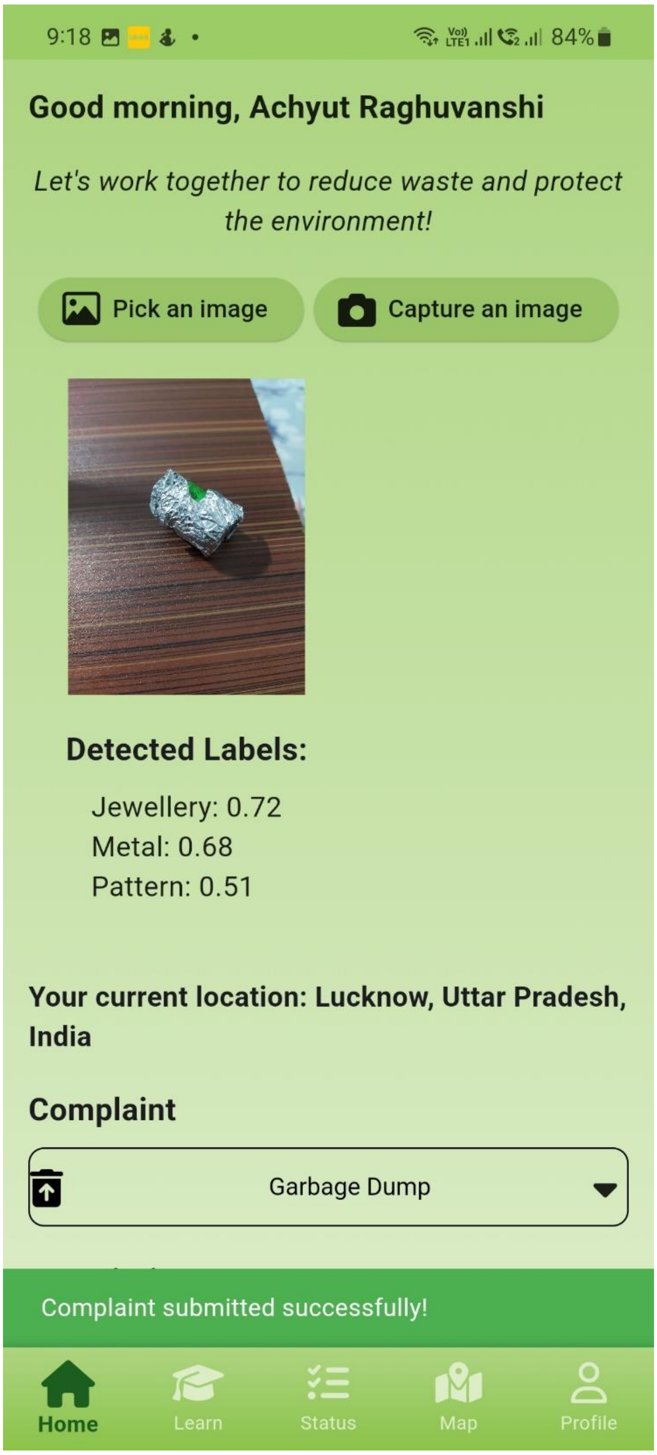

Figure 10 Complaint Register Screen

10. SYSTEM FLOW:

The first thing they see upon entering the app is a choice either to log in or register. When having a successful authentication, users will be directed straight to the Home Screen. In this case, if the user is not logged in, the login or registration screen is presented. The Home Screen presents various icons representing distinct functionalities: Home, Education, Direction, Sense of Place, and Summary. Under these functionalities, users can access specific features: the home part can be used for registration of complaints in their preferred category, in the Learning part there are educational videos or articles to be accessed, in the map section they can mark the service centre locations on a map, under Status one can observe the progress of the problem resolution, and there is a Profile section to edit the user profile. This makes it easy for users to have seamless navigation and access to all those features, which makes the app much more friendly to use and efficient.

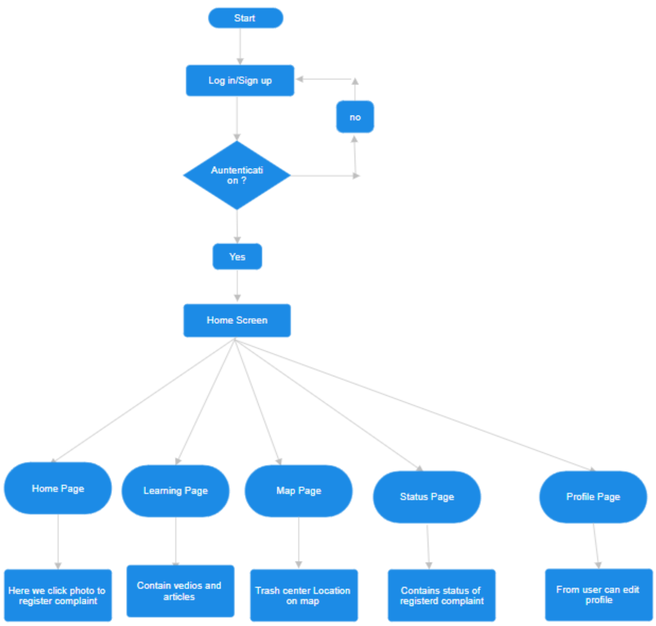

Figure 11 System Flow

11. RESULT:

The research paper introduces the successful programming of a waste management app in Flutter language supported by the integration of different types of technologies that make the app user-friendly and spread responsible waste disposal practices. Our system is based on the image processing and machine learning skills of the Google Module Level Kit which is the latest in technology. This makes the waste classification more accurate, hence improving the efficiency of waste management processes. al. (2021). The utilization of Flutter is aimed at getting an interface design and platform-cross compatibility that will boost the availability of the application (Kasteren et al., 2020). The integration of the location services allows users to identify the nearest waste places thereby filtering their choice of information site using GPS or location coordinates. (Jacobs et al., 2020). The Firebase Storage and Database for making the data easily storable in the application and to ensure the smooth interaction with data in the application are used (Bono et al., 2004). The provision of Google Maps integration ensures location-based services provision where people can easily find recycling centres near and waste disposal facilities for well-developed sustainable waste management practices (Sundram et al., 2022). The research paper shows that a specialized solution, which includes the next generation of technologies aimed at the waste management problem, can be created and, consequently, can allow an environmentally friendly approach to waste management and moral disposal practices.

12. CONCLUSION:

Eventually, the Flutter application will be launched as a comprehensive waste management solution consisting of collection, treatment, and incineration phases. Instead of old ways, there are some new features have been applied. For example, there is wearable device support, Google Maps integration, Google ML Kit image processing, and user profile management which individuals can easily distinguish and manage their garbage well. The algorithm, on the other hand, consumes expertise and data from some literature such as He et al. (2016) and Kumar, et al. (2023). It can then effectively arouse engagement and accuracy in waste classification using Deep learning models as well as the Intelligent things paradigm. Such theory message completely corresponds with the appropriate development of waste management technologies, as the literature reviews by Gruber et al. (2019) and Wong et al. (2022) point out the values of AI and machine-learning algorithms in the automatic classification of waste. This algorithm targets the main challenge of the faultless sorting process and we try to be the best among the sustainable waste management systems by the networks of sensors (Gálai et al., 2016), overpassing (Miao et al., 2016) and using some methods of medical imaging studies implementation (Shang et al., 2004). As an advanced and diverse system, GPS (green plan for a sustainable environment) relies on the studies of multiple academic disciplines and this multifaceted approach is proof of the effectiveness of the solution, as through its practical application issues of current garbage are resolved, and the effort is subsequently directed towards.

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