



SegWaste

A transition aid to a smart, educational, and convenient way of segregating your trash

AP6/2

Destura, Stephen John
Garcia, Justin Raphael
Lagmay, Arnold Constantin
Pascua, Harold Luis

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The Philippines is currently facing a garbage crisis as the rate of waste generation in the country continuously increases the past few years. A way for us to contribute in a simple way is through waste segregation. This is effective since we can recover recyclable materials and it prevents hazardous materials from decomposing and contaminating the land¹. However, only a few people practice segregation, and the two main reasons are: cluelessness and inconvenience². People find segregation complicated and hard to practice and they also don't know its importance. Also, materials recovery facilities (MRF) are sometimes too far and inaccessible without vehicles³. With this, our team would like to develop an application which aids in the transition to a smart, educational, and convenient way of waste segregation. SegWaste will have four main features: WastEd, WastelD, WAYste, and Waste Tracker. WastEd (Waste education) will show different infographics about the environment. WastelD will be an image recognition feature which will help users classify their trash for proper segregation. Waste Tracker helps users to track their monthly and yearly wastes composition. And lastly, WAYste is a feature where we can connect users to MRFs and other recycling establishments for a more convenient recycling experience.



SegWaste

Problem Statement and Rationale

Solid waste management (SWM) has been an ongoing issue in the Philippines. In a publication by the Philippine Senate Economic Planning Office (SEPO)⁴, the Philippines generated a daily average of 37,427.46 tons of garbage in 2012 and steadily increased its waste generation over time, reaching an average of 40,087.45 tons of generated garbage per day in 2016. Expectedly, the National Capital Region, having generated 22.98% of the country's garbage, contributed the most and is followed by Regions 4A (11.08%) and 3 (9.70%).

A study by Sarkodie and Owusu⁵ also suggests that, due to the current COVID-19 pandemic, the amount of waste generated has increased worldwide. This may be attributed to the increased emphasis on the consumption of single-use products such as medical gloves and face masks to avoid being infected by the coronavirus, as well as panic buying of household supplies. This circumstance then magnifies the problem at hand and reiterates the point that a smarter and more effective method of SWM is needed.

The Philippine national government has made some initial steps toward solving the problem with the establishment of RA 9003⁶, which aims to provide ecological SWM programs. Under Chapter 2, Section 10 of this Republic Act, it is stated that the local government units (LGUs) have the main responsibility of implementing and enforcing SWM operations, with barangays being in charge of the collection and segregation of biodegradable, compostable, and reusable wastes while municipalities must handle the collection of non-recyclable materials and special wastes. However, with only 943 materials recovery facilities (MRFs) serving 964 villages or barangays out of over 1,700 barangays in Metro Manila, as reported by the Philippine News Agency⁷, it remains clear that there is still room for improvement.

As citizens, we also have a responsibility to contribute to the betterment of the environment. According to the words of former DENR secretary Benny Antiporda, "Solid waste management is not the government's responsibility alone, it is everyone's business"⁸. With this, a simple but effective way to help is to practice waste segregation.

A paper by Stępień, et al² explored the topic of waste management in the minds of young people. In their study, they found that around 59% of the people do not segregate. This can be attributed to two main reasons which are inconvenience and insufficient knowledge regarding the matter. People find segregating waste to be complicated since



there are instances when they do not know how to classify and categorize their trash. Other misconceptions include the means of handling and disposal and not knowing the importance and effects of segregation in the environment. As mentioned earlier, the amount of MRFs in Metro Manila is limited. So, inconvenience is also a factor. MRFs are sometimes too far and inaccessible without vehicles, thus discouraging people to practice segregation.

By addressing the aforementioned problem, this proposal aims to tackle several UN Sustainable Development Goals: SDGs 11 (Sustainable Cities and Communities), 12 (Responsible Consumption and Production), 15 (Life on Land), and 17 (Partnerships for the Goals). Additionally, by partnering with MRFs and other organizations, we will also be able to indirectly help address other SDGs that our partners may advocate.

Significance of the Project

Awareness on the issue of waste management in the country is present and can be seen from the multitude of concerted efforts and advocacies that tackle the problem on waste in the country. Some notable examples of existing movements that promote better waste management in the Philippines are the E-Waste Project⁹ and The Plastic Solution¹⁰. However, due to restrictions caused by the ongoing COVID-19 pandemic, their operating capacities have been reduced or, worse, suspended. Such implementations that make use of traditional waste management methods such as personal visits to facilities for on-site disposal are naturally hindered by restrictions on travel and physical distancing, and will continue to be immobilized unless novel solutions are made to address such restrictions. This innovative void in the Philippines is what SegWaste envisions to fill.

Products similar to the proposed solution exist, albeit with geographic scopes that do not involve the Philippines. There exist mobile applications similar to our implementation with SegWaste, more specifically to the WAYste feature, that connect users with local collection services. A couple examples of similar products are Recycle Coach¹¹ and Sensoneo¹², both of which provide a service for the improvement of waste collection through means such as personalized waste collection schedules and optimizing directions to pick-up points for waste collection.

In contrast, SegWaste provides more than what they offer through additional features that make up a multi-faceted application designed to provide a smart facilitation of the waste segregation process while educating the user on waste and their own



production of it. It has a high potential to create lasting and highly visible effects on the amount of waste in the country since unfacilitated waste segregation alone already offers a multitude of positive effects from the prevention of land contamination, protection of public health, and easier recycling. Due to the hazardous nature and long decomposition times of most wastes, improper or absence of waste segregation may cause irreversible effects to the environment. They also become a threat to the public most especially to those constantly exposed to them like garbage collectors, recyclers, and those residing near dumpsites. Since less wastes will go to landfills from the segregation process, these hazards will be mitigated along with making recycling easier from the cheaper costs that expediting the manual or mechanical sorting of the mixed waste¹³ will entail.

Market Study

The initial target users for our application will be residents of Metro Manila. They should have access to sufficient and stable internet connection and have smart devices capable of running the application. For these reasons, our target users must be in the Millennial and Generation Z categories and fall under the B, C, and D socioeconomic classes.

Innovation Description

The proposed innovation consists of a mobile application that has four main functions: WastEd, WasteID, WAYste, and Waste Tracker. Upon starting the application, the users will be directed to a dashboard (**Figure 1**) where they can see a preview of each function and access them. Infographics (part of the WastEd feature) will be the dominant element in this screen to immediately capture the eyes of the users. Furthermore, the users can also access their profile to configure application settings, change information, and view or exchange reward points (discussed further below).

WastEd, short for Waste Education, contains an array of resources that can help users learn more about SWM. This section contains articles and infographics on SWM, as well as information on our partner MRFs and organizations and the SDGs to which we contribute.

WasteID is the Waste Identification and Classification function of the application with the goal of helping users segregate their trash. Using the device's camera, the user may present the application with an image of an object, such as a glass bottle or a plastic bag. The application then analyzes this image and tries to identify the name of the object



(e.g. “cellphone”) and then presents the user with the correct type of garbage under which the object is classified (e.g. “e-waste”). As there will always be a margin of error in the identification of the object due to different factors such as lighting and object shape, it will be made clear to the users that this function is used to suggest a waste category, instead of determining it with 100% accuracy.

WAYste helps our users by connecting them with partner MRFs . We will coordinate with our partner MRFs to notify users of any upcoming collections, to which the users may arrange a booking. On a given collection day, only users who booked on that day will have their garbage collected by the MRF. Booked users will also be notified if their collection dates are nearby as a reminder.

In order to further motivate users into using this innovation, we decided to incorporate incentives in the form of a reward points system (discussed in the business model).

In WAYste, users are also informed of partner establishments and the incentives or promotions that they provide when users recycle. For example, users can view restaurants with zero-plastic policies and encourage customers to bring their own utensils and containers or cafés that provide discounts to customers who bring their own cups.

Finally, the application has a Waste Tracker that keeps track of the user’s donated waste in monthly and yearly bases. This can inform users the amount of waste they produce. Every MRF collection day, the collector will scan a QR code from the users where he/she will input the amount of waste that they have collected. This data will be transferred immediately to the users and integrated in their Waste Tracker feature. Another function of the QR code will be to give reward points for the user who donated at a specific collection drive (discussed in the business model).

Business Model

Firstly, we will partner with LGUs to gain sponsorship for the project. This will give us access to the MRFs whom we will need for the implementation of the application. MRFs can gain profit, themselves, by having more people donate their waste to them.

The application will have an incentive system in the form of reward points to motivate users into using this innovation. In every WAYste collection drive that the user participates in, he/she may donate any amount of waste. However, if the user reaches a certain minimum weight of donated waste in a single collection, as measured by the MRF’s



collector, he/she receives a number of points in his/her profile in the application. The collector will scan the same QR code (mentioned in the innovation description) and input the necessary parameters to credit the user with points. These points are accumulable and may be exchanged for vouchers and coupons from our partner establishments.

Our partner establishments will be businesses who promote environmental advocacies. An example would be Messy Bessy¹⁴, notable for making natural and chemical-free cleaning materials and are biodegradable. The points user gain can be converted to discount coupons for this business to also encourage users to buy from them.

Methodology

In order to realize the aforementioned innovations and the application, we would follow the detailed plan to be discussed below. A visual representation of the project methodology can be found in **Figure 2**.

Content Creation. As the main goals of the project are educating users and promoting our partners, displaying digestible and significant content are our main priorities. We would first review multiple academic studies and consult with various environmental organizations to ensure that we would be putting out credible and useful information regarding proper segregation and disposal methods. Afterwards, we would create baseline templates for infographics and articles so our partners can be guided when they produce their own content that would be included in the application.

Android/Flutter. We have decided to program the mobile application using Android Studio. We would first program the application for the developers' Android devices and later on test other common devices for compatibility using physical devices or built-in simulators. A simple companion website can also be made using Flutter in the future. This website would only contain relevant information about the project and application, important educational content about waste management and partner organizations, and a direct contact to the developers for partnerships, suggestions, and others.

UI/UX Designing. In designing the wireframes of our applications, we would mainly use the design tool called Adobe XD. The software includes sufficient tools and templates to create fully functional web or mobile wireframes. In addition, the software allows interactive wireframe preview and collaboration over the cloud which can be very helpful especially in the early prototyping stage. As previously mentioned, original content and assets would be made for the application, but we would still utilize resources such as



FlatIcon or Bootstrap for some of our UI elements. We would also be strictly adhering to the official material design guidelines of Android and Flutter. Once a prototype is made, we would be consulting a sample set of users to get feedback on our UI and UX before publishing. The release versions of the application would also include a systematic way for users to inform the developers regarding bugs and suggestions.

Classification System. In creating our baseline classifier model, we would utilize the dataset called TrashNet¹⁵. It was used for a final project in a Machine Learning class in Stanford University and was able to achieve an accuracy of 75%¹⁶. Afterwards, the trained model would be converted into a TensorFlow Lite model so it can be easily integrated into our application through Android Studio. We would also retrieve and process additional data from the Waste Tracking feature to improve our classification model in the future. There are already many examples, methodologies, and case studies involving Machine Learning in mobile applications. We are mainly interested in Object Detection and Image Classification using TensorFlow. A sample use case from the official TensorFlow documentation would be modified to use our trained model, and it will be integrated into our application.

Google Assistant. Upon reading the documentation, we plan to implement the following Google Assistant features: Simple App Actions, Android Slices, and Read It. App Actions and Android Slices can be used for tracking, giving users small pieces of information about their profile, and answering queries about partner organizations, specific establishments, and disposal or segregation methods. Read It will be mainly used as an accessibility feature for content such as articles and infographics. We will also be following sample codes and methodology endorsed in the documentation.

Firebase/Google Cloud. For the initial release of the application, the developers have decided to use Firebase for our backend. Its APIs are already enough to enable authentication and allow us to store and fetch all content needed. We will also utilize Firebase In-App Messaging (FIAM) to engage with our users in various ways and notify them about important announcements or reminders. In the future, we are open to using Google Cloud products if additional features require it or when our user base and database have all scaled immensely.

Process Flow. For improved clarity, we would be presenting an overview of the application and a process flowchart for each major page or feature in **Figures 3 to 8**.



Appendix

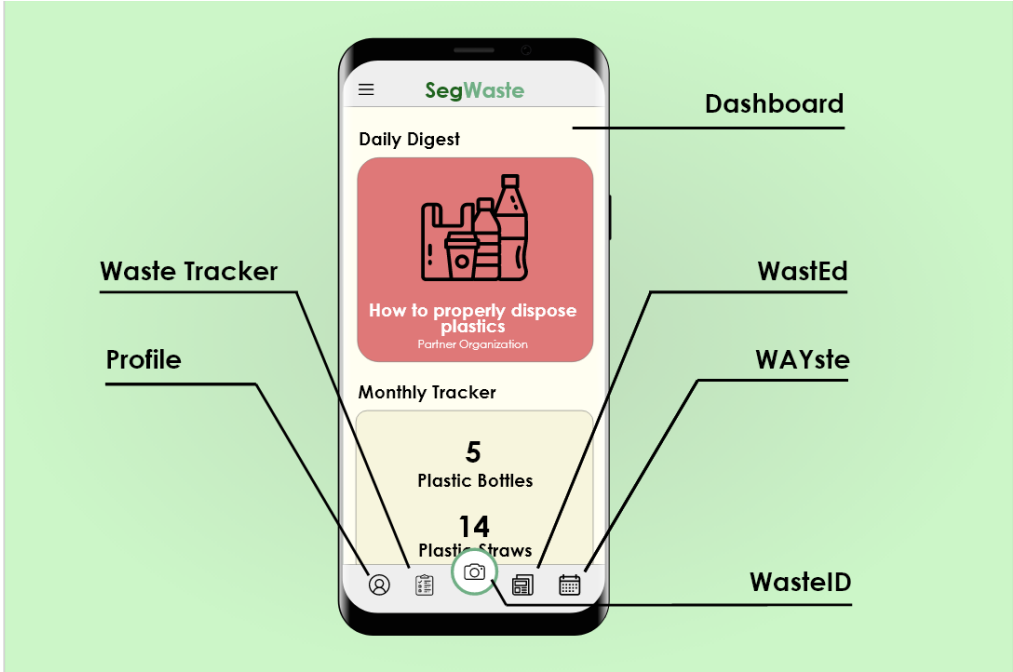


Figure 1. SegWaste overview.

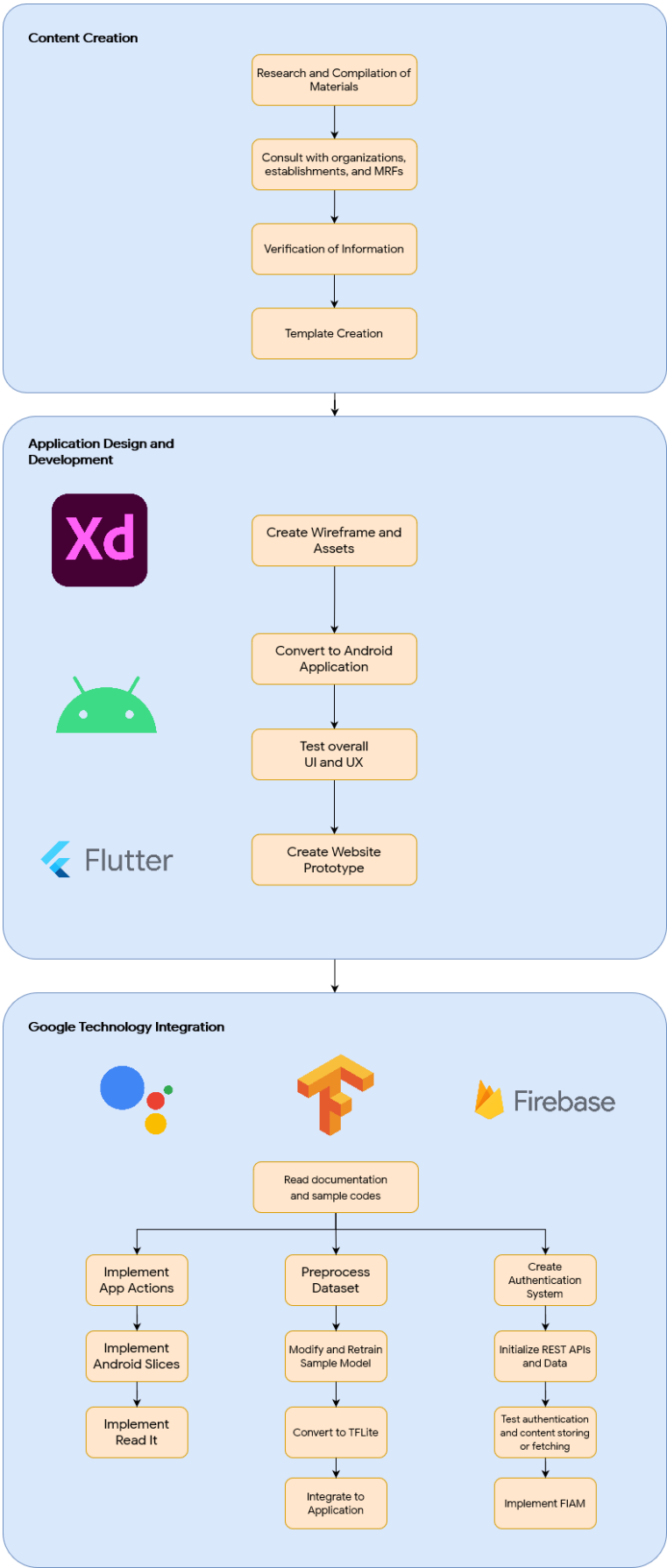


Figure 2. Methodology visual representation.

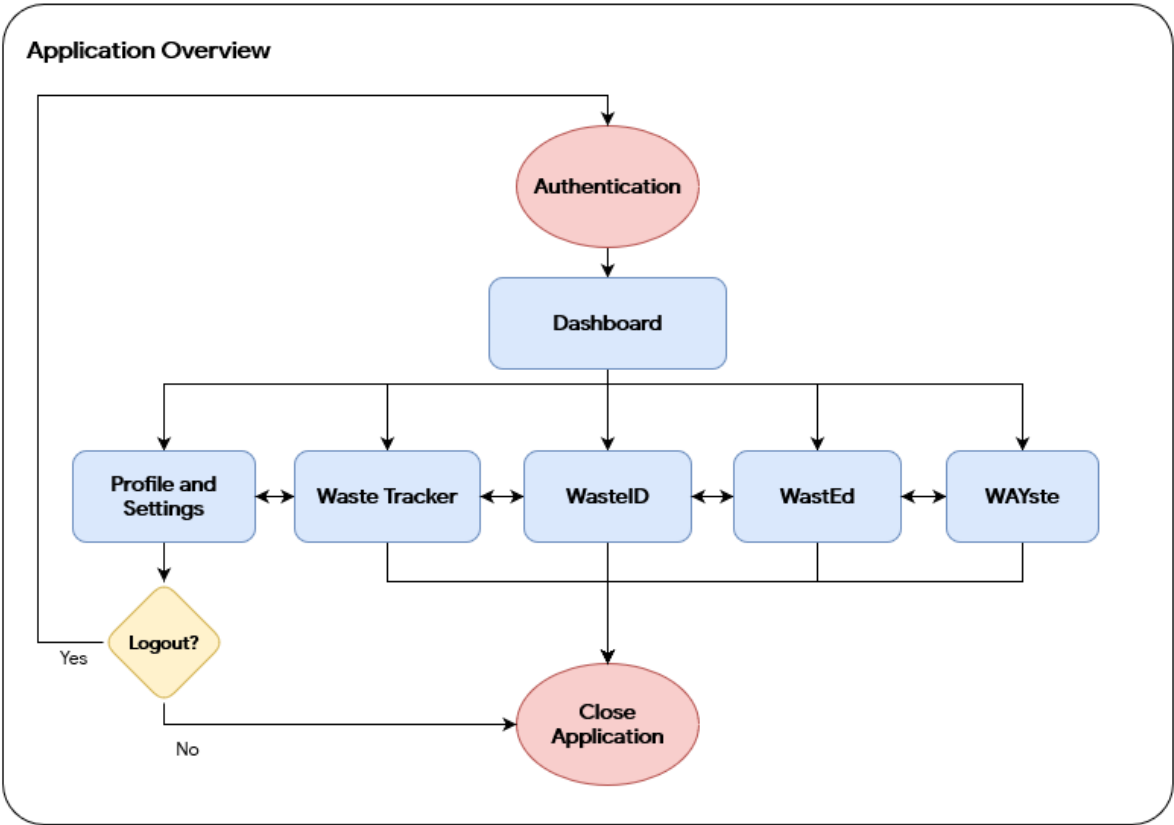


Figure 3. Overview flowchart.

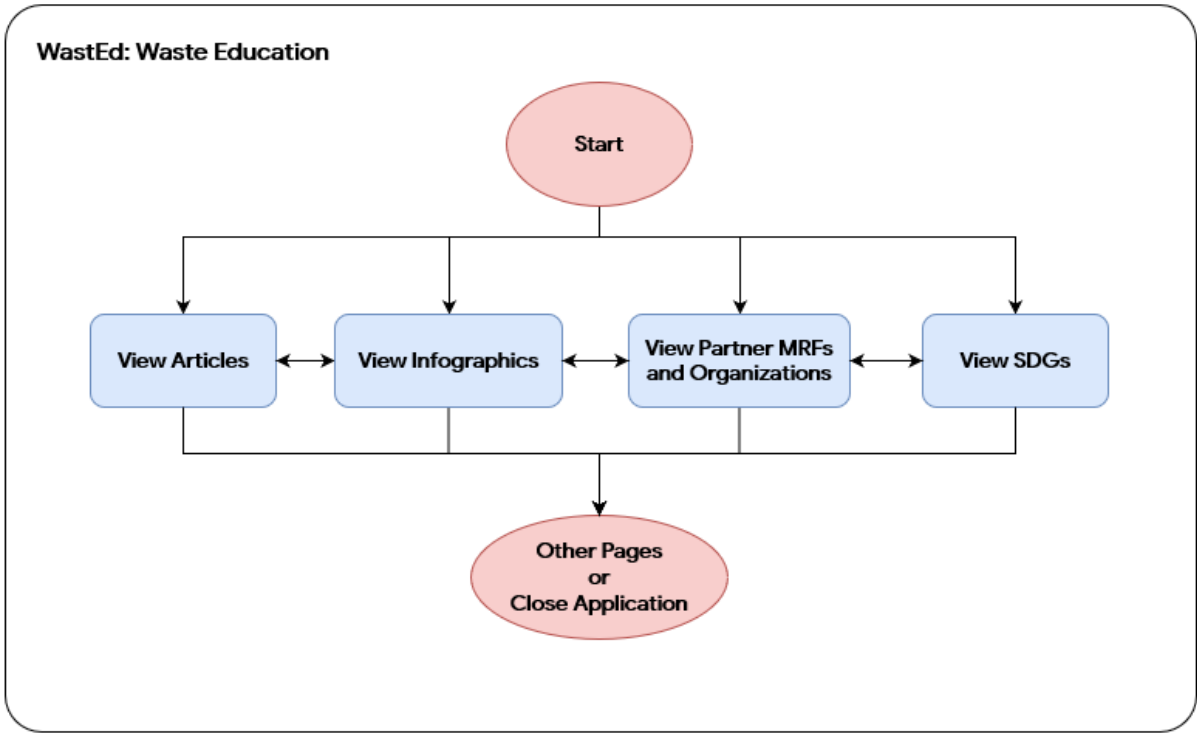


Figure 4. WasteEd flowchart.

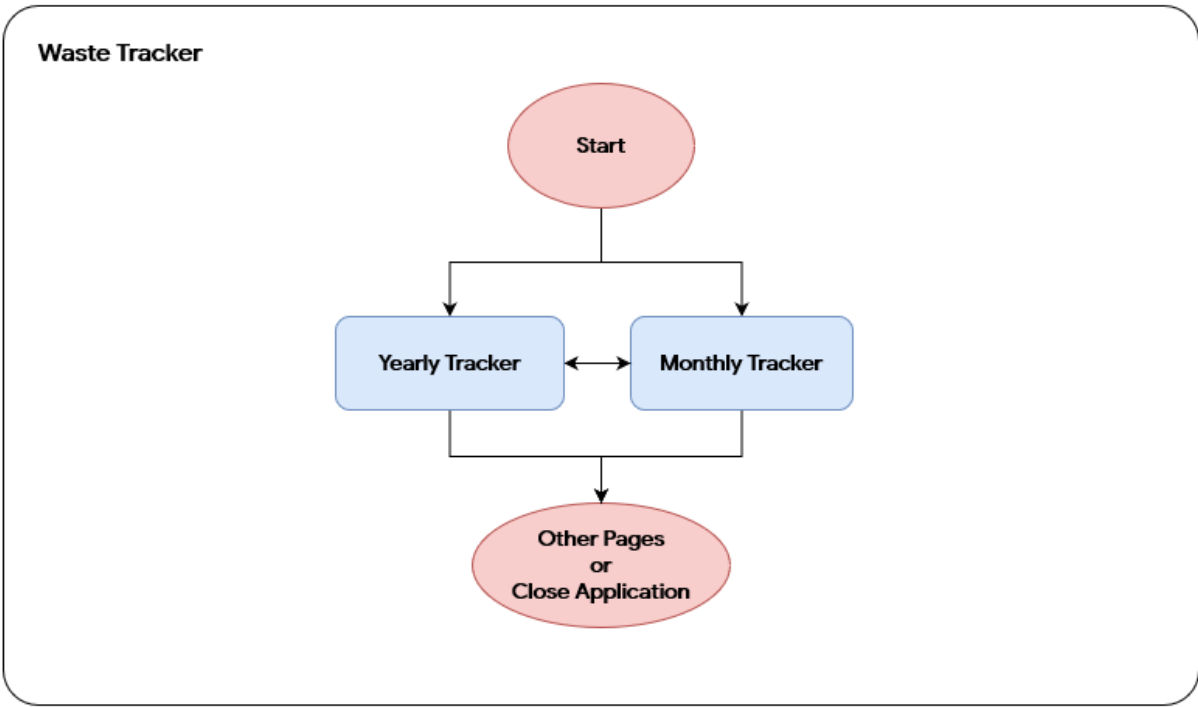


Figure 5. Waste Tracker flowchart.

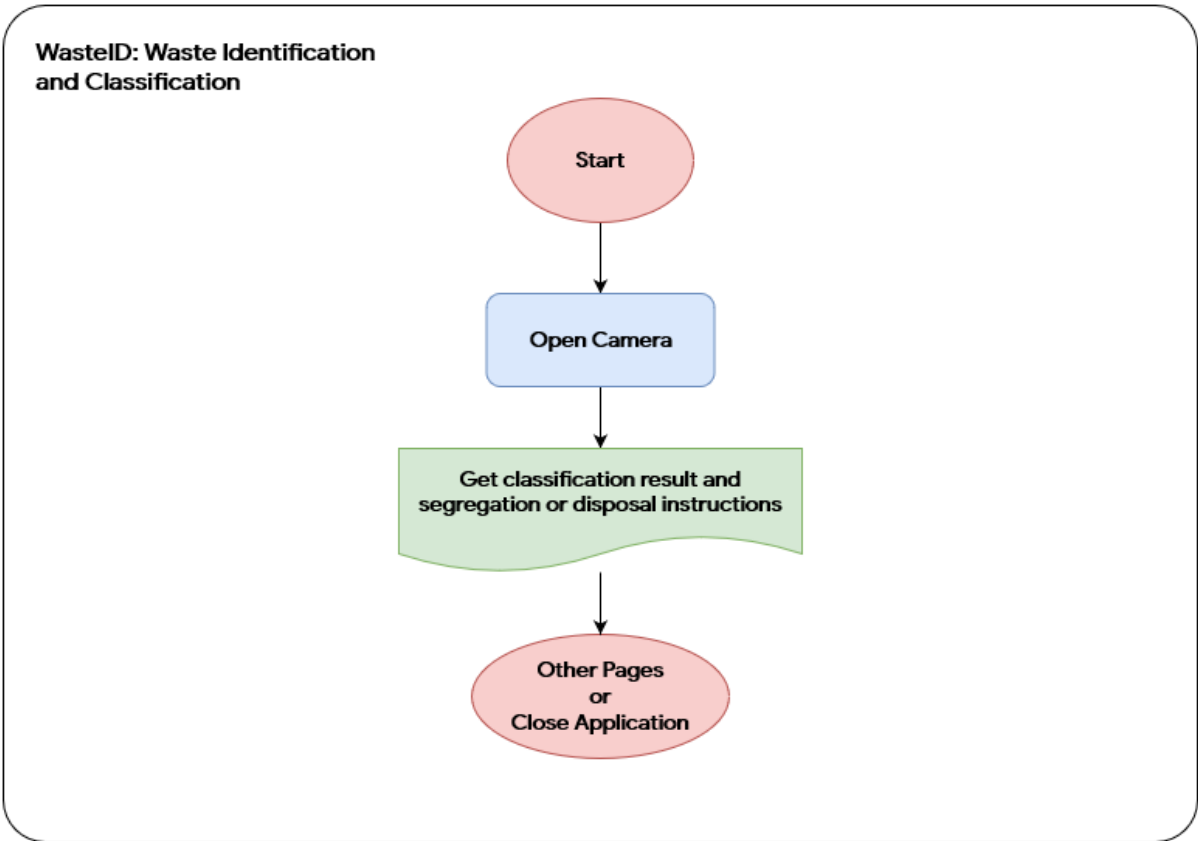


Figure 6. WasteID flowchart.

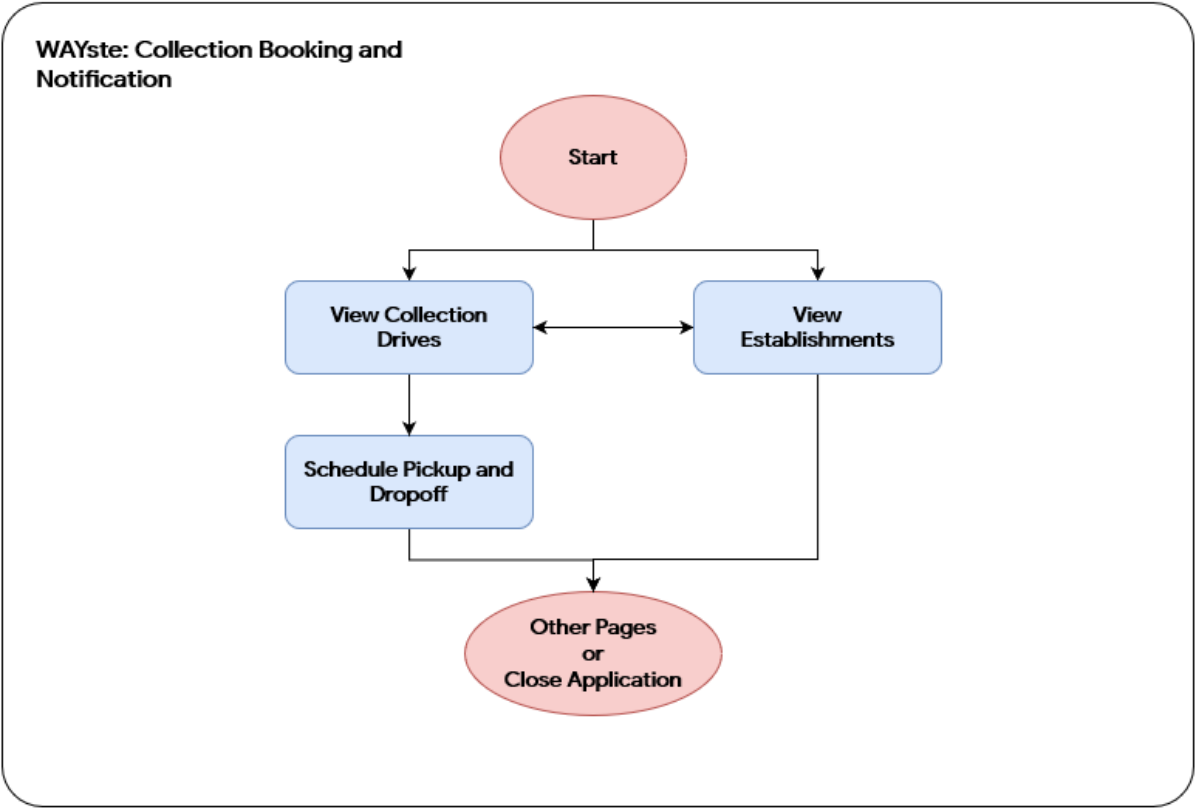


Figure 7. WAYste flowchart.

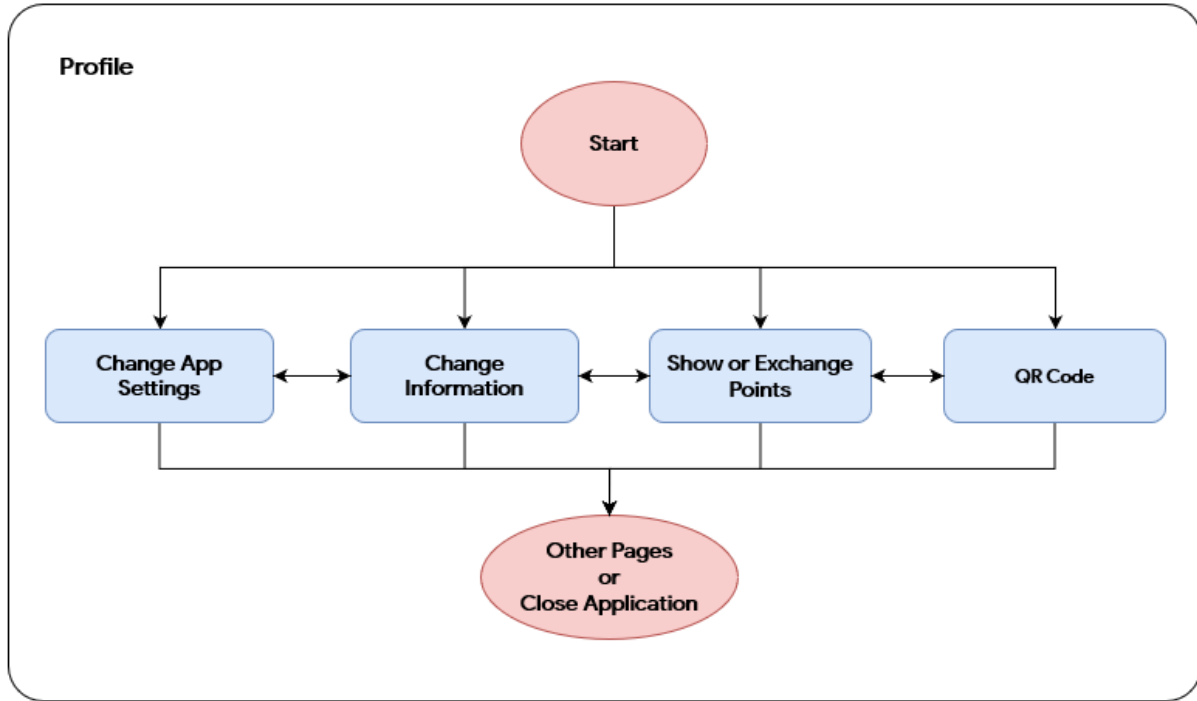


Figure 8. Profile flowchart.

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