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# Methodology, Philosophy and Theory of Systemic Design

## Systemic Design for Household waste management in India

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### Abstract

The abysmal state of municipal solid waste management and its segregation at household level in urban India is the motivation of present study. Segregation of our waste is essential as the amount of waste being generated today has caused an immense problem. Waste segregation is included in law because segregated waste is much easier to recycle. In particular, hazardous wastes can cause long term health problems, so it is very important that they are disposed of correctly and safely and not mixed in with the normal waste coming out of your home or office. The individual component of the existing waste management framework has various challenges and issues. Thus, this research work proposes an efficient framework for household waste management and segregation system. There is a need to cultivate community awareness and change the attitude of people towards waste segregation as this is fundamental step to develop proper and sustainable waste management systems because in a world limited of adequate resources, judicious use of every resource is the fundamental step.

**Keywords:** *Systemic Design, Household waste, Waste Segregation, Sustainability, Mobile application, Rewards*

### Introduction

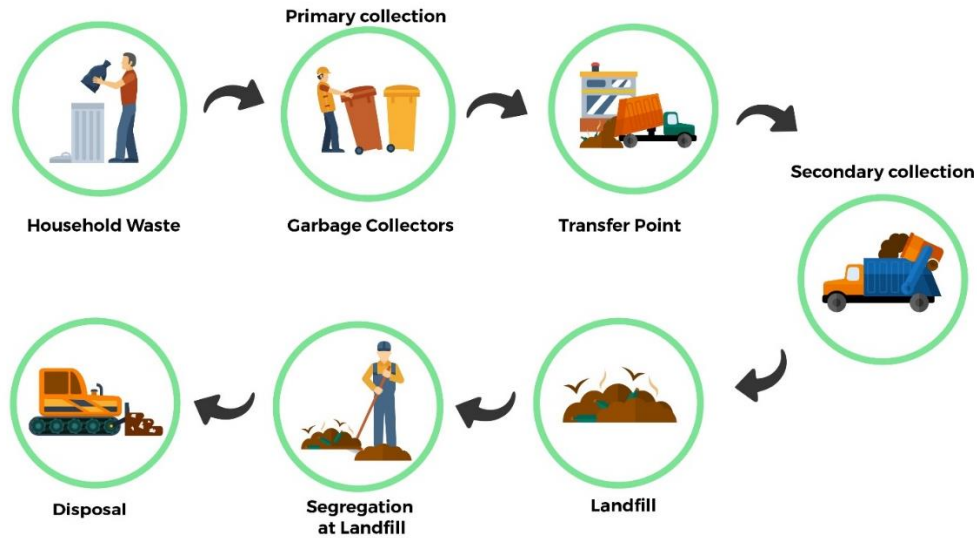
Indians are facing major natural difficulties related to waste generation and deficient waste gathering, transport, and its treatment. Current frameworks of India can't adapt to the volumes of waste created by an expanding urban populace, and this affects the earth and general well-being. The difficulties and hindrances are huge, however, so are the chances. In any case, there is a great deal of inconstancy in per capita wastage in India. Household waste is generated faster than other industrial and environmental pollutants such as methane gas, greenhouse gases, etc. (Hoornweg et al, 2013). Being the world's second-largest populous country the standard of urbanization in India has increased from 27.81 % in 2001 to 31.16 % in 2011. The rising population is putting extreme pressure on the need for food, shelter and other natural resources (Cointreau 2006) (Kathiravale and Muhd Yunus, 2008).

Municipal solid waste management (MSWM), a critical element towards sustainable metropolitan development, comprises segregation, storage, collection, relocation, carry-age, processing, and disposal of solid waste to minimize its adverse impact on environment. Unmanaged MSW becomes a factor for propagation of innumerable ailments (Kumar et al., 2009).

Studies shows that an efficacious management needs to be materialized for a better planet to live in. Effective segregation of wastes means that less waste goes to landfill which makes it cheaper and better for people and the environment. It is also important to segregate for public health.

The call for sustainable development both environmentally and economically is spelt out loud and clear. Hence, the current and future generations must ensure that all resources shall be preserved, fully utilized and well managed. Waste generation has been part and parcel of mankind's pursuit for development, be it in social or economic activities.

There are certain items that are not bio-degradable but can be reused or recycled in fact it is believed that a larger portion of the waste can be recycled, a part of can be converted to compost, and only a smaller portion of it is real waste that has no use and has to be discarded. Household waste should be separated daily into different dustbins.



**Figure 1: Current scenario of Household waste management in India**

In figure 1, it can be inferred that segregation at source is missing which results in tons of waste at dump yard (disposal point). All waste management interventions are futile if they don't address one fundamental problem: the lack of waste segregation at source. As long as people put their recyclable, organic, hazardous and sanitary waste in the same bin, the municipal corporation collects and dumps it the landfills. Almost all municipal authorities deposit solid waste at a dump yard within or outside the city haphazardly. This further results in diseases for every individual and especially to people who segregate waste at landfills. Therefore, source segregation is the essential turning point to the reduction in the amount of waste we send to landfills.

The main contribution of this paper is to be aware of future consequences of non-segregated waste. If we do not segregate, then all trash will be found on street rather than on bins. It is then collected by trucks and taken to transfer stations. Here, waste pickers try to recover as much recyclable material as they can to sell for money, after which the trash is taken either to landfills and dumped unscientifically.

Primarily, the thought is to understand why people are not segregating the waste at household level. Observation and analysis in detail of this study has led to design a solution for people who are least bothered for segregation. The idea is how people's behaviour can be changed and how my exploration can make them aware of this issue with or without the use of technology. Technological solutions like

sensor bins, mobile applications are there but will digitisation/current technology help in achieving segregation at household level in India?

So, after a lot of brainstorming around this core issue (such as campaigns, drives, re-designing policies, system designing etc.) we all agree undoubtedly that the “future is mobile”. Now-a-days, digital evolution and mobile developments are carving a new era that affects human behaviour. Interconnectivity and information flow through various types of modern means create new opportunities for cooperation and ways to work. Henceforth, in the age of technology, mobile application is the best possible solution which will help everyone to be aware of segregation and will also be notified on regular basis for segregating their waste at household level. It presents the opportunities that are involved in using mobile applications in order to improve segregation at household level through focusing on individual behaviour of the users. This mobile application system is basically built with an idea of policy that how segregation can be followed up amongst the masses. The framework reflects that each and every household will be rewarded according to their daily performance of segregation.

### ***Gap in Literature***

The existing framework of waste management includes household waste collectors, transport systems, waste collation points, manual waste segregation system and waste disposal. The existing framework is presented in above figure 1. In figure 1, it can be inferred that segregation at source is missing which results in tons of waste at dump yard (disposal point). Almost all municipal authorities deposit solid waste at a dump yard within or outside the city haphazardly. This further results in diseases for every individual and especially to people who segregate waste at landfills.

Researchers have reported that India has many challenges in the waste disposal and management system (Kumar et. al, 2017). The challenges reported in research are open dumps, household waste scattered in urban centres, disposed of unplanned in low lying areas, roadside dumping, etc. (Srivastava et. al, 2015). Major challenges and issues related to waste management in India are household waste dumped in the yards are mostly not segregated appropriately. Organic and Inorganic wastes are treated similarly and it prompts loss of potential vitality produced utilizing natural wastes. Wet waste, dry waste, e-waste, hazardous waste all are under one roof rather than be at separate places. Plastic bags are havoc to this earth because they can't be recycled either reduce and stagnation of them in water gives an open door for perilous parasites like mosquitoes to recreate. Open burning of wastes without considering the natural pain is another issue evolving with time (Lal, 1996). Poisonous gases like carbon monoxide and ammonia produced from the residential waste dumps will cause various Chronic Obstructive Pulmonary Disease (COPD) (Kathiravale and Muhd Yunus, 2008). Cattle feed plastic refuses will cause a severe threat to consumers because the consumption of plastics through heaps of garbage is their food and hence we (humans) are the sufferers.

Despite the Municipal Solid Waste Management Rules (MSWM), 2016 stating that landfills are to be used only inert, non-recyclable and non-biodegradable waste, landfills are being used as dump sites for all kinds of waste. While it makes sense for households to segregate their waste as it will reduce emissions to air, groundwater and lesser requirement of landfills but in reality households do not segregate waste at source. Also, according to Waste Management Hierarchy, whatever the income or the conditions of the country be, the environment needs protection. As such recycling and reuse is something that is essential in the current conditions. Hence, striking a balance between recycling and the recovery of energy through

incineration or composting for the production of gasses for combustion is preferred (Kathiravale and Muhd Yunus, 2008).

### **Research objective**

The objective of this research is to have identified significant problems in the segregation of multiple types of waste at the household level and propose a system design and a mobile application as a solution to manage household wastes. The mobile application is based upon the system of 'Rewards'. Through this platform, users will be getting incentives instead of disincentives upon segregation of household waste. People not only will be able to get their segregated household waste picked up by urban municipal bodies but also it will aware them, notify them on regular basis that how to segregate and what are the benefits they will get if they segregate.

## **Systemic Design Framework**

The system design for this research paper is primarily focusing on Sustainability through creating an Environment, Economic and Social impact with Users. In order to manage waste, users are supposed to segregate waste and get rewards through their engagement. Hence, a mobile application is being proposed on the concept of rewarding users if they segregate waste at household level.

### **1. Environment Impact**

Source segregation of waste has not only helped in improving the recycling of waste generated in the city, but it has also made positive impact on the environment. In addition, lowering GHG emissions and diversion of waste from the landfill further increased the positive impact on the environment.

### **2. Social Impact**

'Segregation at source' has a big impact on the waste pickers and with cleaner waste to work with, the waste worker can sort a higher number of recyclables, thereby improving the earnings. In addition, with no mixed waste, the work area is cleaner without foul smell. The waste worker gets both dignity and better livelihood.

### **3. Economic Impact**

Due to source segregation, better resource recovery from dry waste should take place. Also, Extrinsic motivation, or our behavior which is driven by the anticipation of being rewarded by others for engaging in specific behaviors will act as a positive enforcement to the task.

Since, 'Reward' describes an event that produces a pleasant or positive affective experience. Among behavior scientists, reward is often used to describe an event that increases the probability or rate of a behavior when the event is contingent on the behavior. Hence, the whole aspect (Gottfried, 2011)

This system understanding has further resulted in incorporating technological aspect in our system because digital has made our lives easier. Hence, this concept falls where system design and technology intersects with an aim to influence user's behaviour through mobile application.

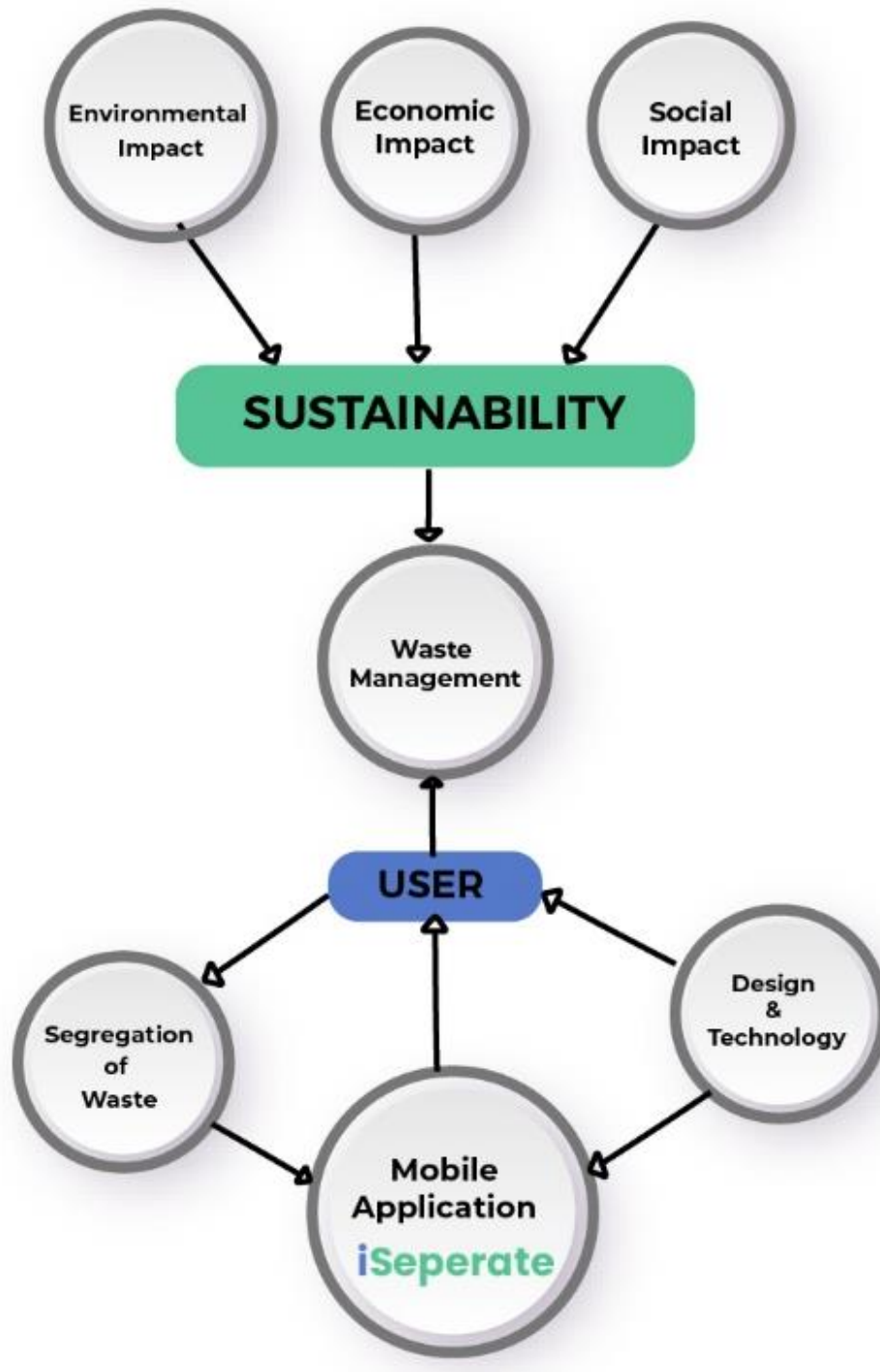


Figure 2: Systemic design framework

### System Approach

According to our design, the prototype presents 5 different areas corresponding to 5 different functions; Door to door collection, rewards system, segregation of different waste, videos to show importance of segregation at source and DIY products from recyclable material. In further stages under section Concept study, different functions have been explained.

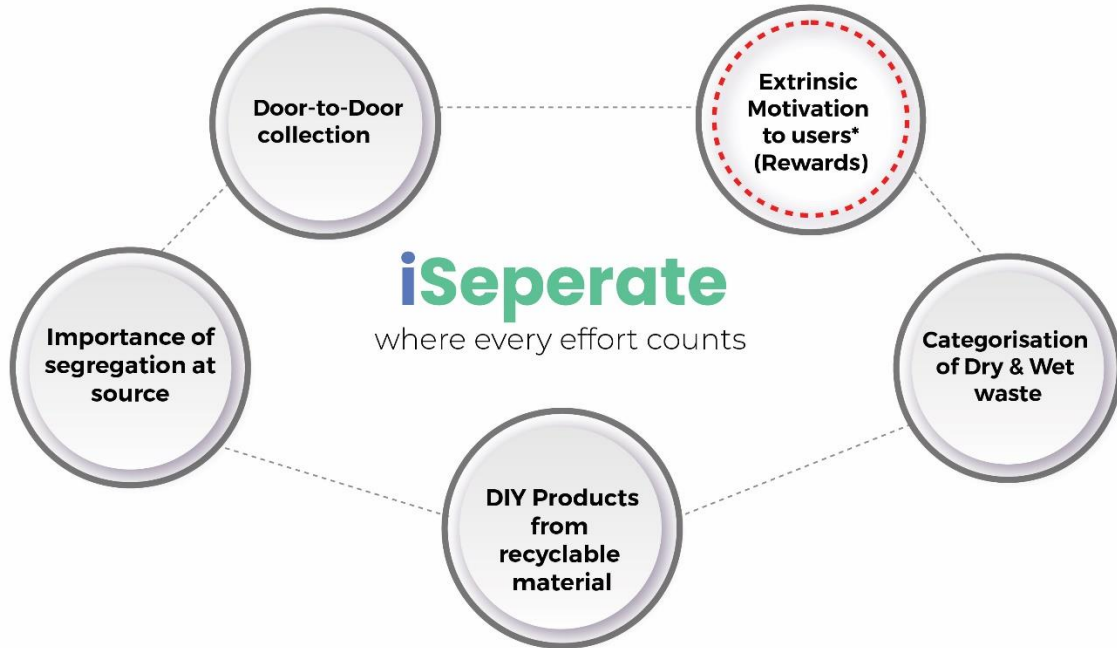


Figure 3: System Approach of “iSeperate”

### Technological intervention

Today, mobile applications are a part of our day-to-day activities. Thus, examining the current scenario of how waste is segregated and understanding the need of the hour, we proposed a design-tech driven solution considering the situation why people are not segregating waste.

The aim of this paper is to examine the unexplored challenges of mobile apps to deliver sustainable waste management emphasizing on recycling and waste prevention performance, especially for emerging developing countries. Furthermore, it presents the opportunities that are involved in using mobile apps in order to improve both the systemic performance of a specific waste management system and the individual behaviour of the users.

The whole idea to integrate design with technology is to influence user behaviour and make them do segregation which will have an impact on circular economy because recycled and segregated waste will make everyone lives easier, be it waste pickers or households.

## **Concept Study and Design of Mobile Application**

The prototype with system design has been shown to participants with an aim to consider their feedback before developing and final designing of the mobile application. This concept is just a proposed idea and finalised version will be launched post development and incorporating feedback.

### **1. Methodology**

We have shown our proposed concept (prototypes made on Adobe XD) to 6 participants for analysing the system: 2 females and 4 males, aged 25-35. All the participants for our concept study have experienced waste management and are from New Delhi. They are very well aware of consequences of non-segregated waste and were able to relate it. All of the participants own a smart-phone and use it on a regular basis to complete daily tasks, manage their schedules, interact with their own social networks, etc. The unfocused interview discussions were held in English and Hindi and consistent responses were mapped. All involved participants work in technical fields, not concerning IoT or Smart Cities and All of them can be considered experienced users of mobile applications.

### **2. . Different stages of our Application**

#### **Stage 1: Study of the goals of the application.**

The main objective has been to develop an application that adapts to the comprehensive monitoring of households which are segregating waste, carrying out a comprehensive monitoring of physical and emotional factors, so that MCD collectors and waste-pickers can improve their follow-up. Some secondary goals of the app are: (a) to improve waste-pickers lives, (b) to improve the engagement to the segregating process and (c) to improve motivation and satisfaction.

#### **Stage 2: Study of the level of prevention and the dimensions of collection of segregated waste.**

At this stage, in several meetings with environmentalists/psychologists and households, we identified which information should be collected in the app, and the different sections in which to collect it. Users were mostly interested in having a place in the application where they could get rewards on segregating. The experts agreed that it would be interesting that users are getting rewards on their monthly bills. For the different tasks the following information would be collected: (a) Time slot for collection, (b) waste is segregated or not.

#### **Stage 3: Selection of reward system**

In this stage, after analysing all the strategies defined in the methodology, we will select the following: (a) rewards, (b) progress and (c) social connectivity. Also, the tactics chosen were (1) allocating points, (2) showing progress, (3) providing feedback and (4) giving rewards. The part that we are going to focus on most is that of social connectivity, joining all strategies and tactics in a kind of personalized social network.



#### **Stage 4: Selection of personalization parameters.**

In order to get rewards, the user has to segregate waste daily. They always will get a motivating phrase so that their practice is continued and each household will be ranked on daily basis. An important part is if the user (all members from that house are not present) for any reason is not available at home then they will be notified that waste hasn't been collected but if they will hand over the segregate waste to waste-picker after few days then they will be credited accordingly.

#### **Sign in:**

House owner needs to install the "iSeperate" application with his 12-digit Aadhar number and the details will be further verified.

#### **Credit System:**

Discounts to Monthly household bills; (i) Electricity bill (ii) Water Bill

If a particular household has segregated waste daily, then that house will get an off for about 10% on their chosen bill monthly.

#### **Progress chart:**

The progress bar will reflect their daily and hence monthly progress so that it's easier for them to cross-check the credits received and how much amount they need to pay on the respective bill.

#### **Stage 5: Logical and structural design (Information Architecture)**

This stage is about the design of the functionality of the application and of how its elements will be arranged. This stage will include: (i) the advancement of a progressive rundown of assessments to be performed by the application, (ii) the meaning of the construction of application, and the improvement of mock-ups of the screen of the application. The advancement group of the task will do this stage development team of the project will carry out this stage. A full document of logical structural design, including the set of mock-ups, will be the product obtained after this proposed idea has been approved for development.

The 'iSeperate' Information Architecture is composed of several activities: one home activity after signing in and verification offers a video screen based upon two main contexts; (i) What is Segregation and Why segregation is important? (ii) How to create DIY Products from recyclable material? Followed by Home screen, the system has several other sections such as Tools, MCD Collector, Credits and Settings. The interaction flow over activities is highly dependent on user choices and is typically rooted at the main activity. (see Figure 4).

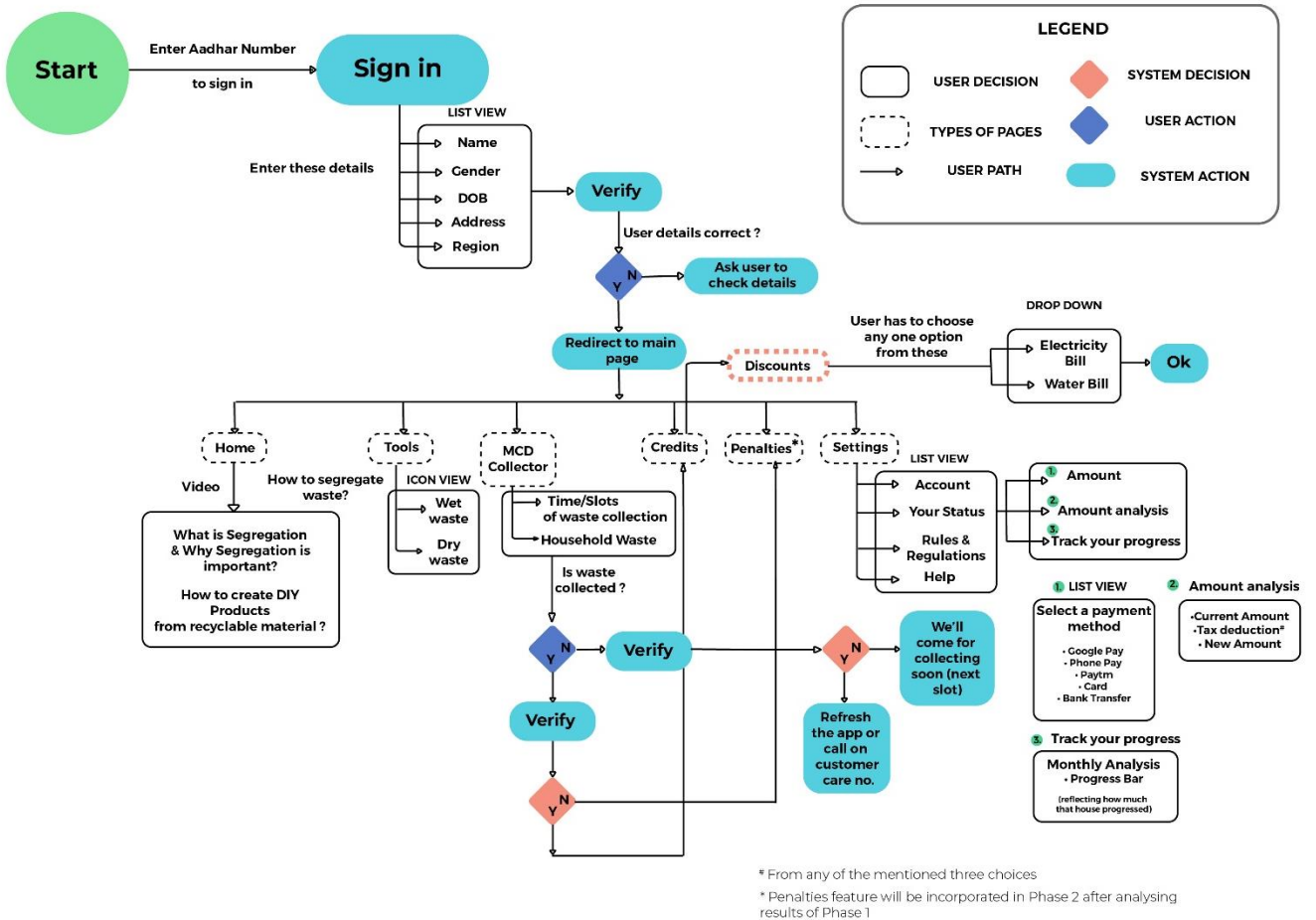


Figure 4: Information Architecture of 'iSeperate'

By building upon the previously discussed requirements, we designed an android application, namely "iSeperate" aimed at motivating users to segregate household waste through rewards. This initial design choice is open to further improvements aimed at engaging with other user intentions. The design process was deployed in two phases involving a low-fidelity paper prototype in the first, and a high-fidelity interactive prototype in the second.

### Stage 6: Visual design

This stage is tied in with planning a visual style to the components characterized in the coherent and foundational layout, which may have been altered by the personalization components in the past stage. In particular, the style guide of the application will be characterized, and it will be applied to each screen and menu in the application, so the full design gets finished. The development team will carry out this stage. Along these lines, it is fundamental that in the group there at least one member with expertise on user experience (UX) and design of mobile apps. Standards and recommendations about visual designs will be taken into account. That is, the visual design will be in line with what is recommended for apps for the specific technology being used (Android, Apple). (Navarro-Alamán et al, 2020).

### Low Fidelity Prototype:

These are paper-based prototypes and do not allow user-interactions. It's made to enable early visualisation of alternative design solutions for our proposed system.(see Fig. 5(i) and (ii))

**High-Fidelity Prototype:**

These are computer-based and take you as close as possible to a true representation of the user interface. These prototypes are assumed to be much more effective in collecting true human insights. (see Fig.6 (a)-(f))

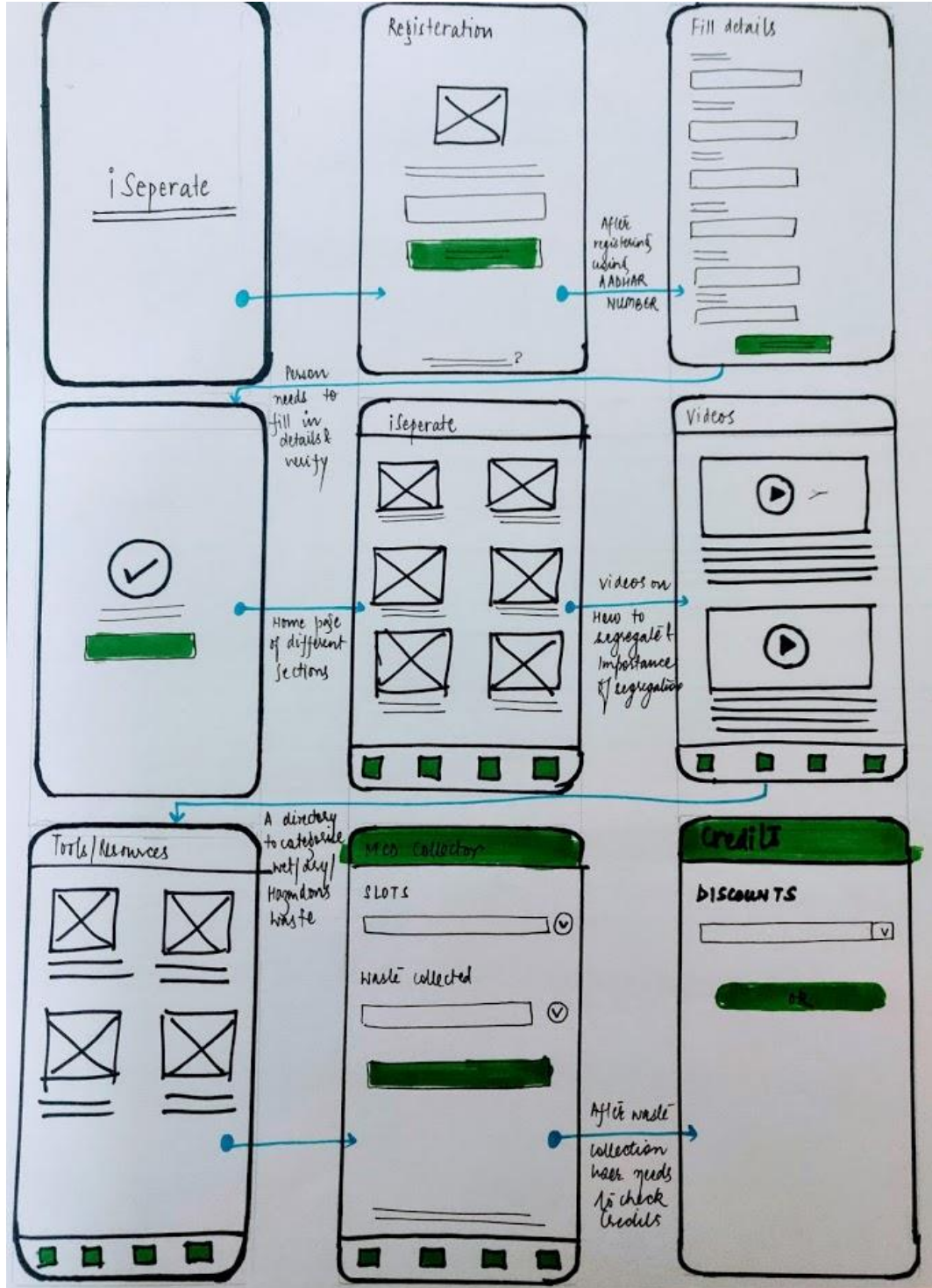


Figure 5: (i) Low-fidelity paper prototype of proposed framework for mobile application

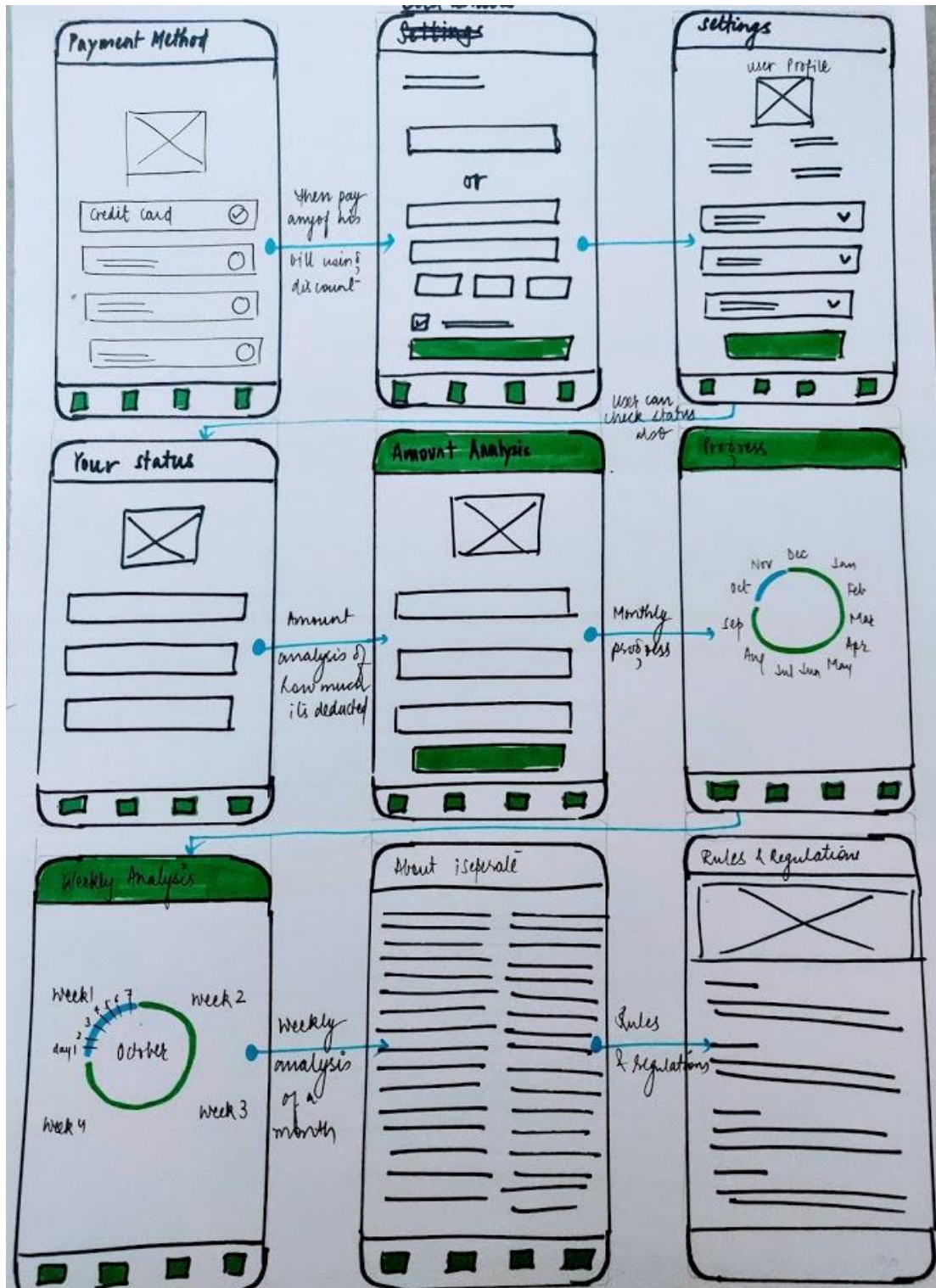


Figure 5: (ii) Low-fidelity paper prototype of proposed framework for mobile application

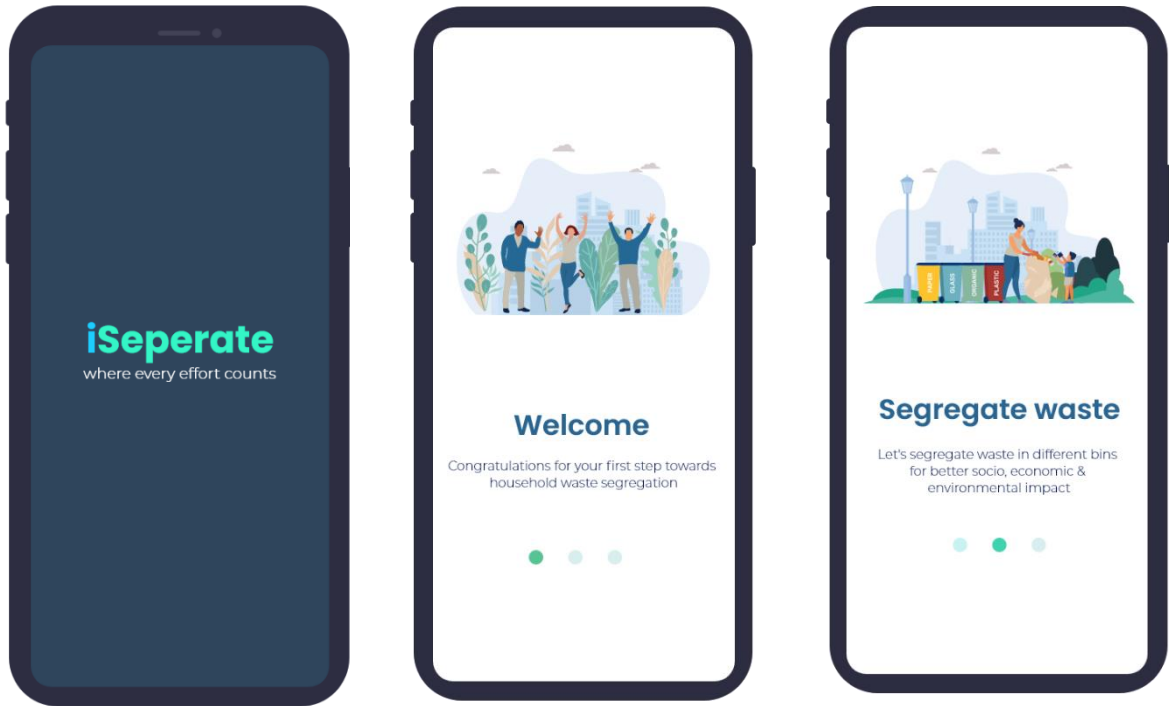


Figure 6(a): Splash screens of 'iSeperate'

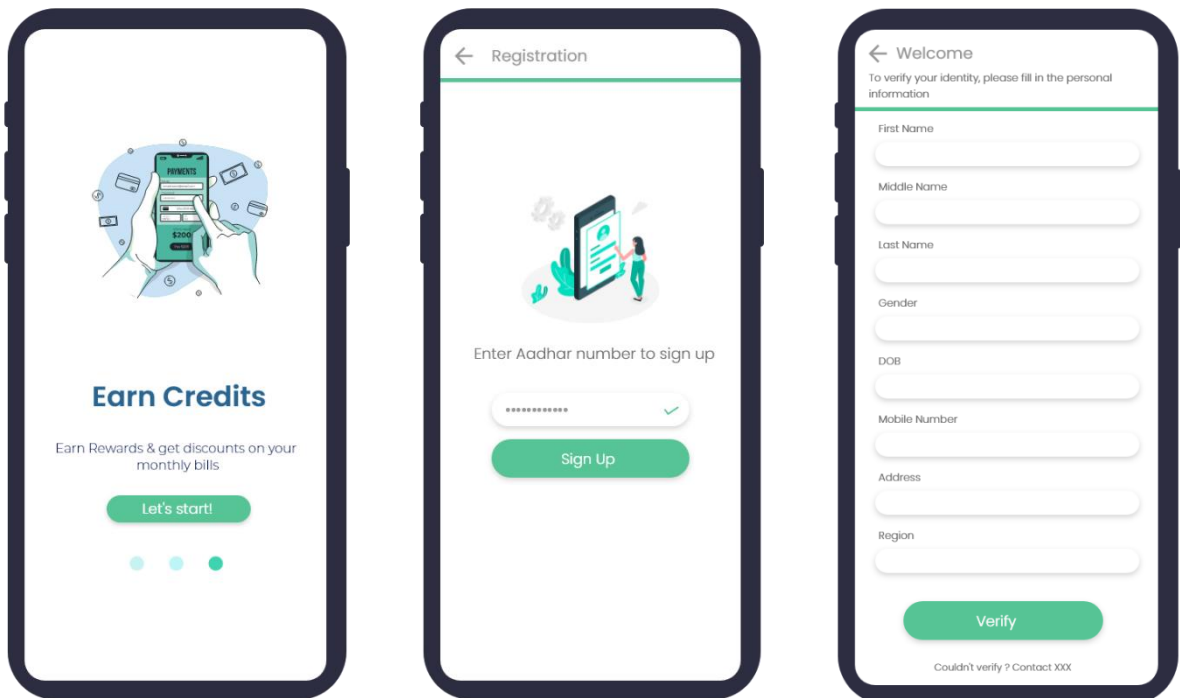


Figure 6(b): Sign up and Verify screens

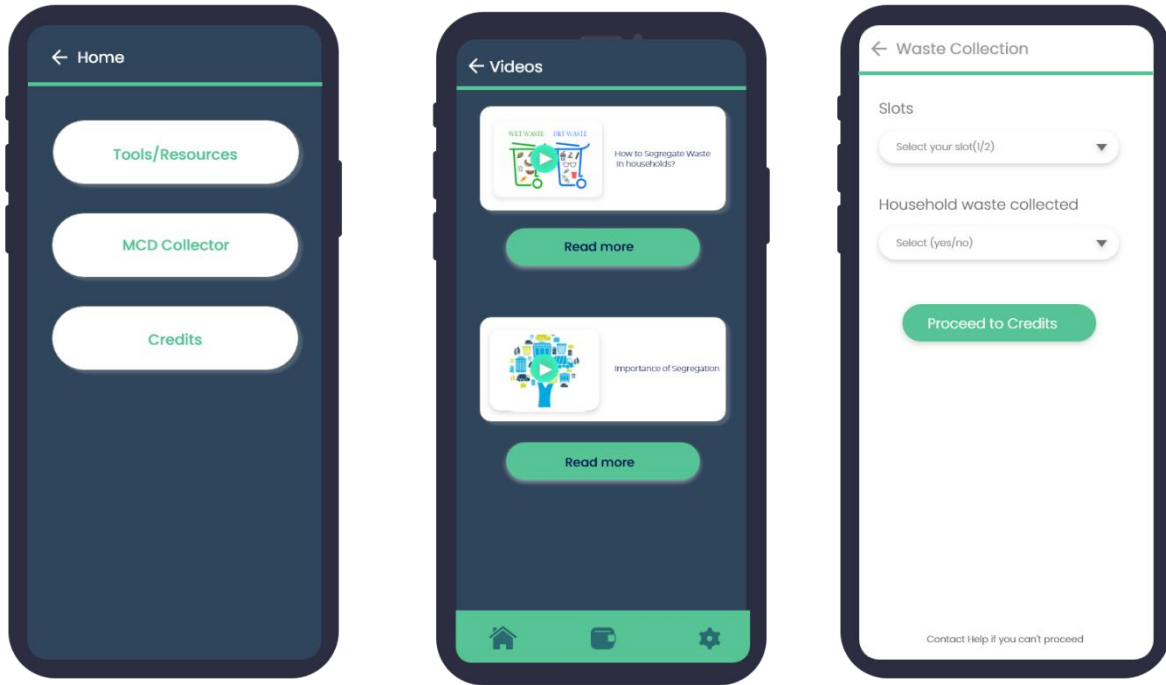


Figure 6: (c)(i) Home screen (ii) Video screen (iii) Slot selection screen

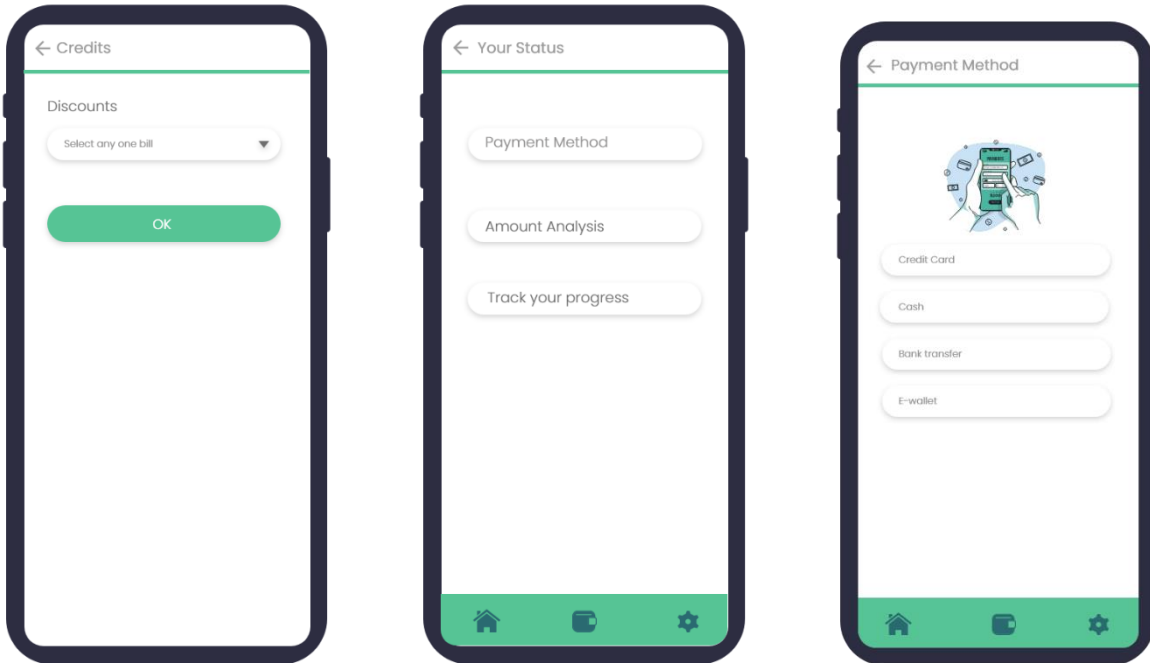


Figure 6:(d) (i) Credits screen (Rewards) (ii) Status screen (iii) Payment screen

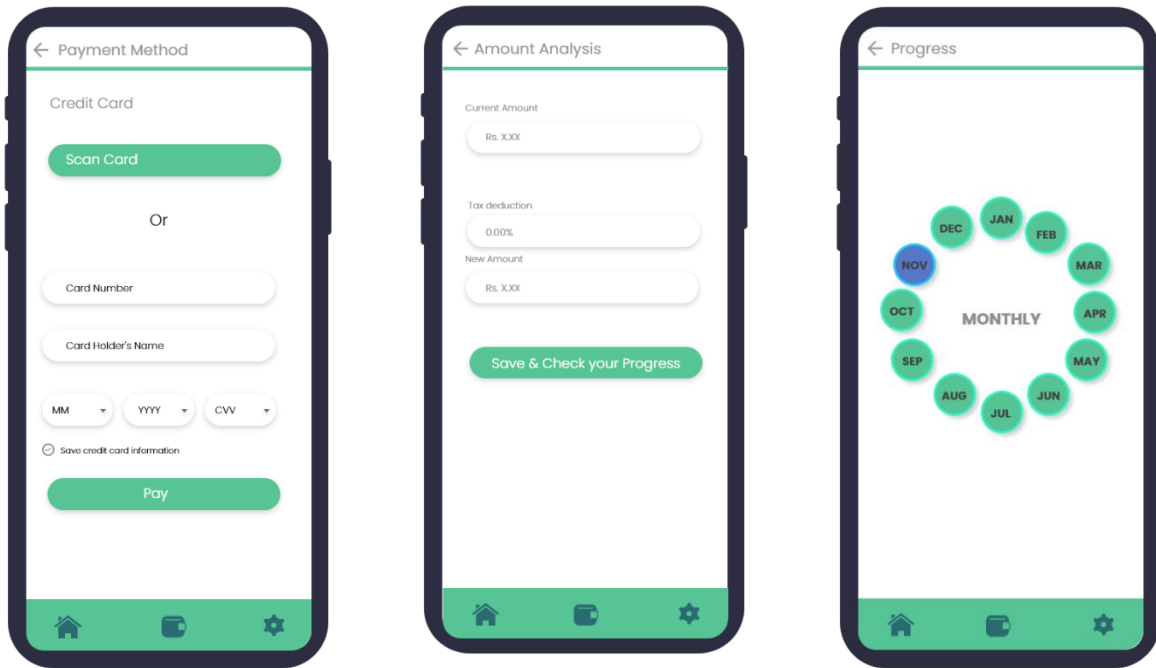


Figure 6(e): Screens for payment and Amount analysis with monthly progress

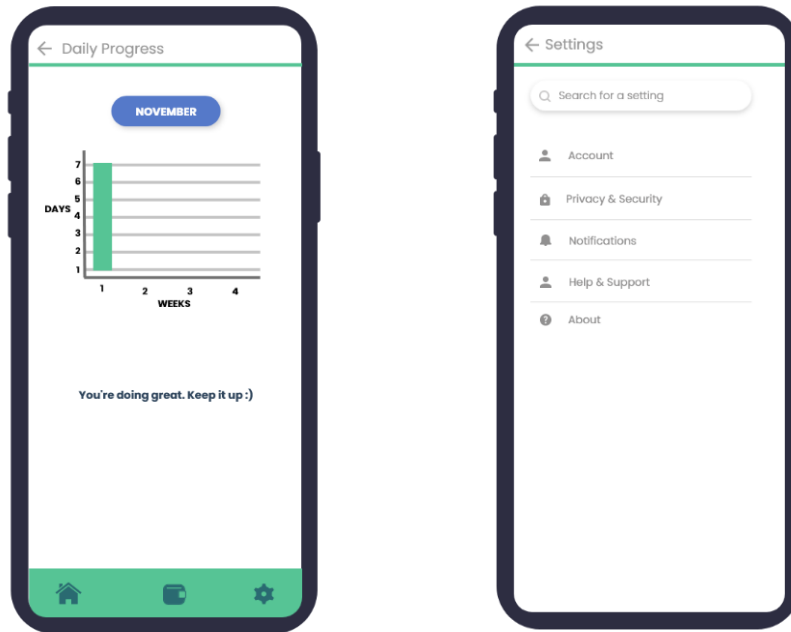


Figure 6(f): Screens for Daily progress and Settings

**Stage 7: Design evaluation**

As we are following a user-centered approach, the evaluation is not limited to the final steps of the process. Thus, we have included here a stage for the evaluation of the design previous to its implementation. In this stage, a prototype will be developed and techniques for the early evaluation of prototypes will be used. Specifically, it is recommended to perform the testing;

**Testing**

After a short introduction to the concept study, the initial “page” of the iSeperate mobile application was shown to the participant, to collect a first impression on the interface, by querying his/her agreement with the sentences:

Rating:

Appearance: 4/5

Functionality: 4/5

Intuitive: 4/5

Each user was asked to perform 4 tasks, one at time. User comments, suggestions and insights were collected both during the task execution and at the end of the test session.

Task i): Segregate household waste

Task ii): Collection of household waste by waste-picker

Task iii): Check your notification

Task iv): Check your reward status

Task v): Pay the discounted amount on your monthly bill

After tasks performance, the insights were noted in the form of user suggestions such as;

- i) User needs something in order to segregate waste and this app has the functionality of ‘Reward System’
- ii) The app can be multi-lingual
- iii) The allocation of rewards should not be confidential (It should be easily understood by the user so that the user can understand the discounts offered on monthly bills)

**Stage 8: Implementation**

Once the design of the application has been completely defined, the app is implemented. In order to carry out this stage, the suitable framework or technology will be chosen depending on the devices and context in which the application will be developed. The use of multiplatform frameworks will be considered, in order to reach a wider range of audience.

**Stage 9: Implementation evaluation**

Once the application has been developed, the implementation is evaluated. A full usability test will be the ideal way to test the usefulness of the application and the satisfaction of end users. Questionnaires



and interviews will be used when needed in a pre-test and/or post-test basis. As it is usual in this kind of methodologies, depending on the result of the evaluation, some of the previous stage may be carried out again to make the necessary changes to improve or correct the identified items.

## Discussion and Conclusion

The results of the preliminary concept study indicate that participants considered the application was easy to use and provided useful information. They further added that the application is intuitive and users will definitely feel engaged because it's primarily based upon reward system.

Videos on 'How to segregate waste & Why to segregate waste' were helpful to some of the participants because they were not aware of segregation of waste. The option of getting discounts ('Credits') on their monthly bills act as a motivation for them to daily segregate waste. Furthermore, the option of making DIY products out of discarded waste got a great feedback. Most of the participants mentioned that this is a great idea to extrinsically motivate people to segregate waste because appreciation in the form of rewards keeps them doing the same job.

This mobile application will further be assessed at next phase also when Penalties along with Credits will be Incorporated in the system although the earlier responses are promising.

Due to the limited size of the user sample and to the small number of tasks to accomplish, quantitative results are not particularly significant, however some evidence for possible improvements emerge such as multi-lingual functionality in the system will make it more inclusive.

This research has focused on creating a methodology to engage households, to use periodically waste segregation applications for their own well-being, by means of reward methods. It is essential, as we have also seen in the literature, to analyze users and that rewards gets focused on the user.

Emphasizing the importance of incorporating the user profile into the methodology is essential for making an appropriate design of the application.

The presented system could be adapted later to everywhere and not only households. In this way, we would need to analyze user's characteristics and needs. In order to adapt the system, a new study should be done (based on the presented methodology) to adapt the reward system. The resources must be oriented to the users who will use the application.

In the future, one of the main objectives of the project is to incorporate penalties option with rewards if the segregation of waste is not done properly. In this way, we will have more users on our application who will start segregation and hence there will be an increase in rewards.

When the proposal has been tested by sufficient number of users, a study will be carried out to check if the information/motivation has been useful to the users using rewards to motivate them for segregation of waste. (Navarro-Alamán et al, 2020).

Hence, this system will benefit economically, socially and environmentally in a sense that Extrinsic motivation, or our behavior which is driven by the anticipation of being rewarded by others for engaging in specific behaviors, will make the person do more. Also, with no mixed waste, the work area is cleaner without foul smell and The waste worker gets both dignity and better livelihood socially and lastly lowering GHG emissions and diversion of waste from the landfill further increased the positive impact on the environment. "Solid waste management is everyone's business. Ensuring effective and proper solid waste management is critical to the achievement of the Sustainable Development Goals,"

Moving toward sustainable waste management requires lasting efforts and a significant cost. Is it worth the cost? Yes. Research suggests that it does make economic sense to invest in sustainable waste management. Uncollected waste and poorly disposed waste have significant health and environmental impacts. 'When waste is managed at source it becomes a resource.'

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