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Utilizing Mobile Application Technologies for Enhanced Sustainable Waste Management in Urban India

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Abstract

Solid waste management is a serious issue that needs to be addressed for the well-being of our environment and society. Households are required to separate wet and dry garbage, but this is not happening in India. Instead, garbage is often dumped together, and the garbage collectors separate the collected garbage. This leads to inefficient waste management and poses significant health risks. Waste is transported to landfills and dump sites where it is disposed without proper treatment, leading to environmental pollution. The problem is exacerbated by inefficient and outdated technology. A lack of proper education and awareness about waste separation also contributes significantly to the issue. “W-Credit" is a Mobile application based on React Native Framework, proposed to improve quality of waste segregation at the households. This application motivates every individual to segregate waste into biodegradable and non-biodegradable categories at home, offering rewards that can be redeemed as coupons.

Keywords: W-Credit, Solid Waste Management, Mobile Application, Credits, Digital Incentive.

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1. Introduction

As the world's population continues to grow and urbanization increases, the amount of waste generated by households, businesses and industry also increases significantly. Municipal solid waste, which includes various types of waste such as domestic, commercial, and industrial waste, road sweepings and other debris, has become a major problem in many cities around the world. Solid wastes constitute the major composition of global wastes. Figure1 shows the composition of various types of wastes within the category of solid waste, as determined through a waste audit [10,11]. Improper handling of solid waste can cause numerous environmental and health problems. It is also challenging for policymakers and stakeholders to manage solid waste effectively [3]. Inefficient storage, collection, transport, treatment, and disposal of waste can cause air, surface and ground water pollution and create a breeding ground for pests, rodents, and other disease vectors [14-16]. Therefore, there is a need for efficient and sustainable waste management practices for the development of a healthy and clean environment [1]. Also, experts provide recommendations for improving waste management practices, including community engagement, technology adoption, and policy reforms [2].

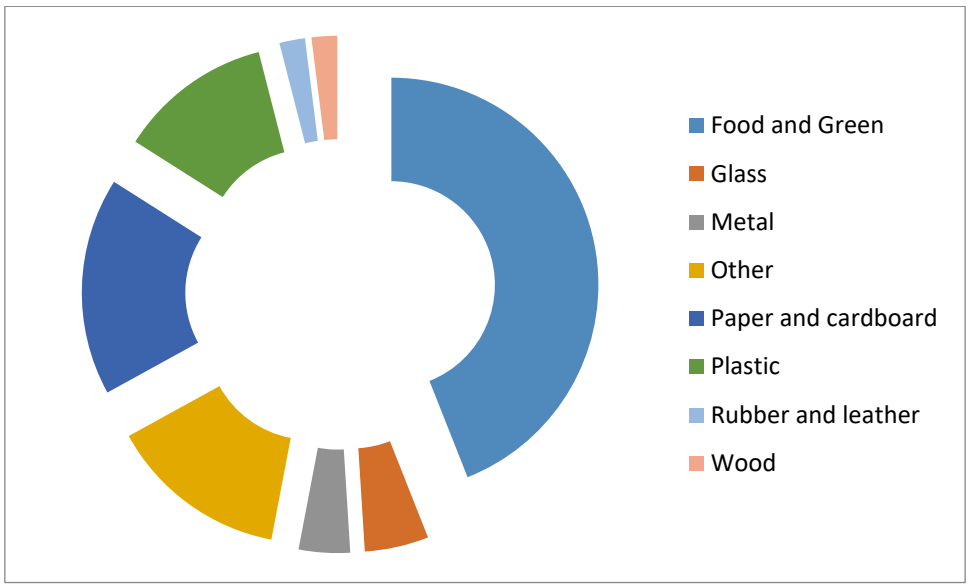

Figure1. Solid Waste Composition

The open-source React Native framework enables developers to create mobile applications using JavaScript and React. It’s a popular choice because it allows developers to use a single codebase to create cross-platform apps that function seamlessly on both iOS and

Android devices. It ensures a consistent user experience across platforms while also reducing development time.

One of React Native's main features is its ability to use native components and APIs. This allows applications feel native and achieve high performance. Developers can write code in JavaScript and JSX, a syntax extension for JavaScript, which is then compiled into native code for each platform.

React Native's effectiveness, cross-platform portability, and robust community support have made it a popular framework for creating mobile applications, enabling developers to produce efficient apps more rapidly.

Laravel is a powerful, free PHP web framework designed for creating reliable, modern web applications. It was created by Taylor Otwell and follows the Model-View-Controller (MVC) architectural pattern, which promotes a clear separation of concerns and enhances the organization and maintainability of the codebase. Important attributes and traits of Laravel comprise:

- Elegant Syntax
- Modularity
- Database Migration System
- Eloquent ORM
- Blade Templating Engine
- Routing
- Security
- Testing Support:
- Community and Ecosystem

The proposed mobile application is developed using React Native and Laravel for proper waste management practices, tracks user behavior, and incentivizes.

2. Related Works

N. Rani et al. (2021) in the review suggested that a holistic approach to waste management, including decentralized waste management, public participation, and improved governance, is needed in India [4]. N. Jain et al. (2022) highlights the potential for circular economy approaches and the role of the informal sector in waste management [5]. S. M. Joshi et al. (2019) emphasizes the need for sustainable waste management practices, stakeholder engagement, and policy reforms [6]. P. Sunil Kumar et al. (2017) provides an overview of solid waste management practices in India, including the challenges faced and potential solutions to improve the situation. The study also discusses the role of technology, policy reforms, and public participation in waste management [7]. Kishan et al. (2021) provides an overview of the current municipal solid waste management practices in India and discusses the challenges faced by policymakers and stakeholders. The research also suggests potential solutions, including the need for efficient collection systems, segregation of waste, and resource recovery.[8].Nimita et al.(2019) suggested that raising awareness among people about the significance of source segregation at generation sites such as biodegradables, inert and recyclable material, and change in habits to store, segregate, and dispose of waste according to municipal council guidelines is one solution to effective waste management[9].

2.1 Existing System

In Tamil Nadu (a state in India), the existing solid waste collection system is a manual, system, with waste collected and transported using open trucks or wheelbarrows. Waste collectors are employed by local governments or panchayat. Households are required to separate wet and dry garbage, and garbage collectors segregate the waste and collect the sorted garbage. However, in many places there is a lack of proper sorting and leading to a mix of wet and dry waste. This results in inefficient waste management and poses health risks. Waste is transported to landfills and dump sites where it is disposed of without proper treatment, leading to environmental pollution. A detailed study has been done about the solid waste management process in Madurai corporation in Tamil Nadu. For the efficient administration and for day-to-day operational purposes, the town is divided into four zones covering all the 100 municipal wards. In the city of Madurai, garbage is produced at a rate of 406 grammes per day per person, that amounts to 548 metric tonnes every day. The Table1 below depicts the amount of waste generated from different sources per day in Madurai Corporation.

Table 1. Sources of Waste

Source	Quantity(ton)	Percentage
Domestic	288	64
Commercial	108	24
Hospitals and clinics	18	4
Others	36	8

The corporation and municipalities are collecting solid waste by employing sanitary workers in clearing the garbage using hand carts and tricycles to gather waste from dustbins and dumper bins. The waste that is gathered from different parts of the city is treated at designated microsites if the garbage's are properly segregated. The unsegregated are dumped at the Vellakkal site, which is located beyond the city limits. This location is used for the disposal of solid waste produced by all sanitary wards. Site is around 10 kilometers from the city and has a total area of 82 acres. The initial waste segregation starts manually in vellakkal where wastes like tyres, clothes, cardboards and bags are separated. Next level of separation starts with 2 filters where non degradable plastic covers are separated based on their quality. The remaining mixture of degradable and non-degradable waste is treated chemically and left for about 30 days. Once the degradable waste has decomposed to a certain extent, the completely non-degradable and non-recyclable waste is separated and sent for dumping or landfilling. As a result, waste collected in a day takes around 40 days to be processed into manure. Problems arise in the warehouses where garbage is stored for 40 days due to issues like rain. Figure 2 shows the actual condition of a major segregation unit. The main difficulties identified by the corporation in the solid waste management process are:

- Only 20% of the area practices waste segregation and house-to-house collection.
- Unchecked littering along major streets, roads, and drains.
- The current capacity can only remove 80% of the solid trash that has accumulated.
- There is a lack of public awareness about waste segregation and inadequate door-to-door collection by sanitary workers.

Figure 2. Major Segregation Unit

Existing systems do not encourage households to separate waste, nor do they have systems to monitor or reward good waste management practices. This leads to poor compliance and a lack of public awareness of the importance of waste segregation and good waste management practices.

3. Proposed System

Solid waste management involves a series of activities that involves around three R's: Reduce, Reuse and Recycle [12]. The current waste management system must be integrated with technology to achieve a proper waste management system.[13]. A mobile and web-based application called W-credit is proposed to address the challenges and the limitations of the existing system. The proposed system operates as follows:

A unique QR code is placed at the doorstep of each house. The house's ID is mapped to the QR code in the cloud. When collecting the garbage, the garbage collector scans the QR code at the door using the mobile App. The W-Credit mobile application allows the mobile camera to scan the code. The application includes option to assign credit values and record the door's locked status. The respective ID of the house is awarded with a credit point based on the quality of their garbage segregation. Credit points are updated daily to the corresponding cloud account. Individuals are awarded with gift vouchers and discount coupons based on the credit points in their account. Additionally, the web Application records the attendance and the confirmation of the garbage collection and area coverage by the civic worker through the tracking system. The Figure 3a depicts the overall architecture in a simplified manner and

Figure 3b represents the work flow. The Figure 4 illustrates the basic idea of W-credit management system.

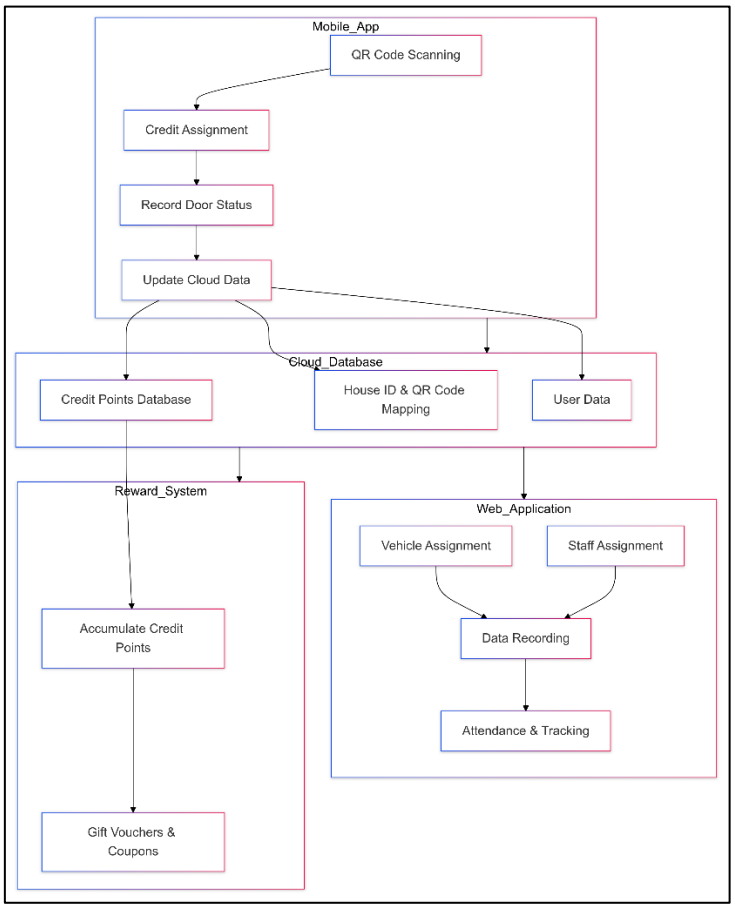

Figure 3a. Overall Architecture

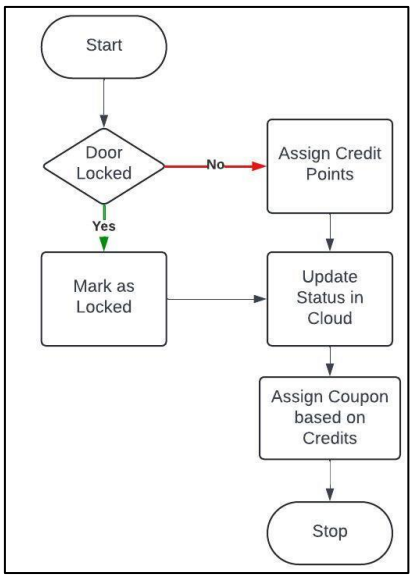

Figure 3b. Work Flow

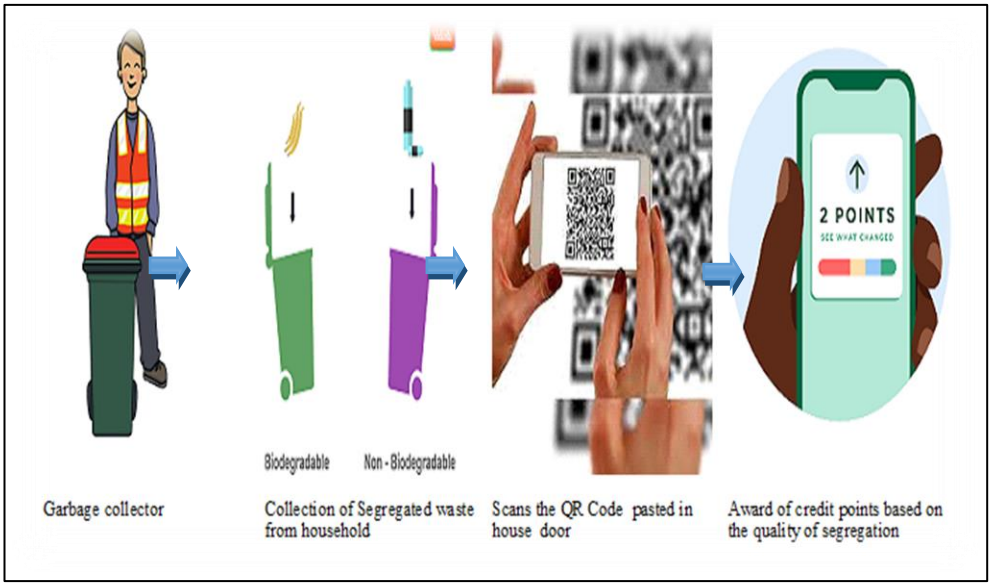

Figure 4. W-Credit Waste Management System

3.1 Implementation

A pilot project has been initiated in Thirumangalam Municipality from January 2022 to June 2022 following a demonstration to the municipality. The municipality has allotted a street of 100 houses in ward no 25, Thirumangalam, Madurai (Dt) to test the pilot project. Initially, the 100 houses were educated how to segregate the wastes at home and asked to use separate bins. They were informed about the reward system for the top scorers. From the next day, the readings were recorded through the mobile phones of the civic workers. For the ease of use of the sanitary workers, the application is developed in local language. Figure 5-8 shows the screenshot of the W-credit Application.

Figure 5. W-Credit Mobile App Version

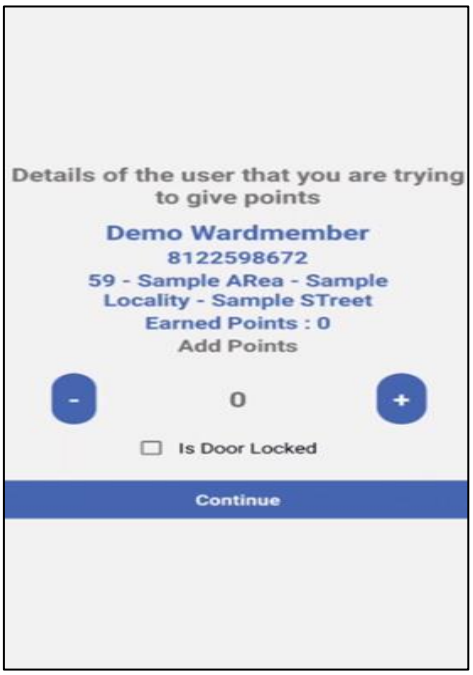

Figure 6. User View in Mobile App Version

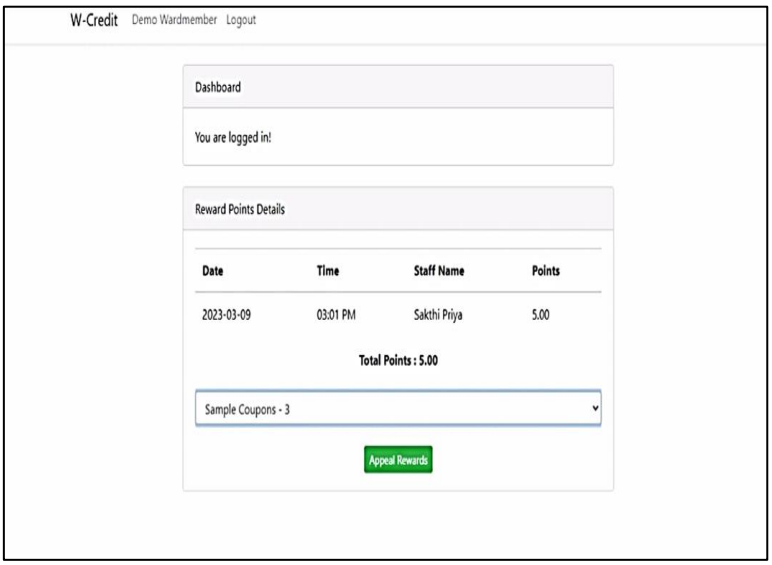

Figure 7. Redemption of Credit Points

4. Results and Discussion

Improvements were observed from the second day of the project. The people started to use two or three bins to separate waste based on their type. The garbage collectors also found it more comfortable to collect the segregated wastes at home, as it reduces their burden of segregating it themselves. The garbage collectors were able to award points to the houses based

on the quality of their waste segregation after a training given from our team. The mobile app is designed with React Native, using JavaScript and JSX, which can be converted for both Android and iOS platforms. React Native provides a comprehensive framework for developing a mobile application that records credit points using QR codes. For the web design, Laravel and PHP is used for designing the pages, for vehicle assignment, staff Assignment, record data, master data. etc. Migrations were used to create database schemas for storing credit points, user data, and QR code information.

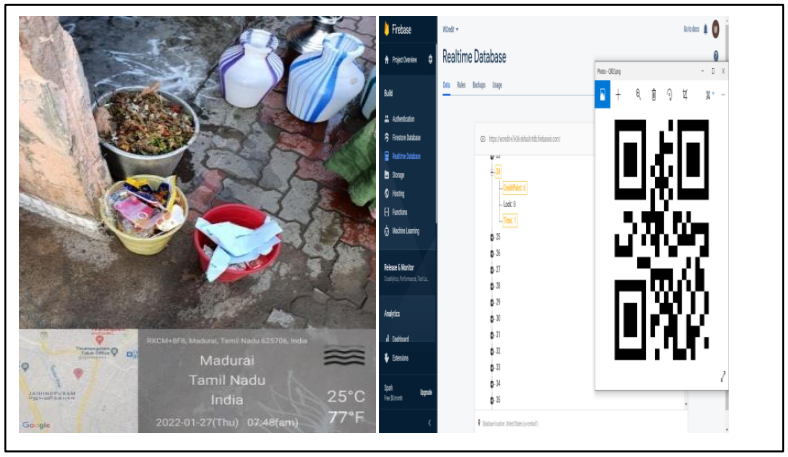

Figure 8. QR code Scanning and Credits Assignment

The improvements were recorded daily basis, and a monthly report is presented as a graph in Figure 9. Figure 9a shows the significant change in the collection of segregated waste and the reduction in the unsegregated wastage collection after the implementing W-credit. Fig 9b shows the increase in the number of households segregating garbage and using separate bins over time. The graph shows a gradual increase in the number of households adopting to waste segregation practices, indicating a social change in behavior as people followed the example set by others. Even after the completion of the pilot project, successful source segregation of waste continues to be achieved in Pasumpon Street.

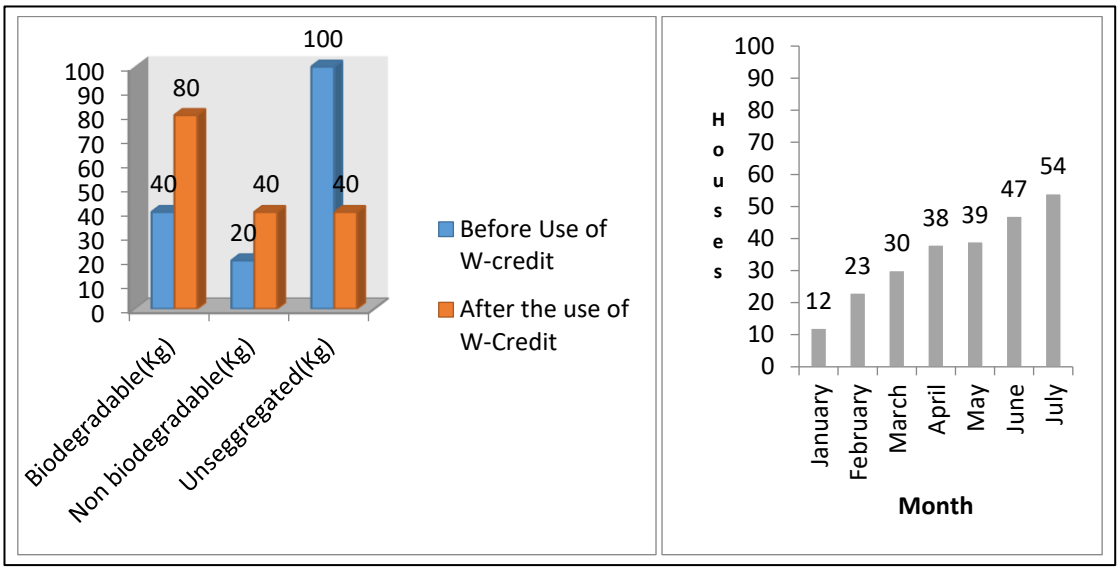

Figure 9a. Amount of Waste Collected **Figure 9b.** Behavioral Changes Found in People

5. Conclusion

A significant step in the right direction towards solving India's most challenging solid waste management issue is the launch of the W-Credit smartphone application. The effort promises to reduce the load on landfills while promoting environmental sustainability by providing incentives and encouragements for households to separate their waste into biodegradable and non-biodegradable categories at the point of origin. As the study started with a motive of motivating individuals with digital credits for segregating wastes, it achieved its objective successfully within a period of six months. While the initial motivation for individuals was the incentive, the application encourages them to maintain their waste segregation practices even after the incentives are removed. The digital solutions with rewarding schemes is a great solution for societal change which includes the involvement of individuals. In the future, the study aims to expand the impact of W-Credit throughout India, promoting a cleaner and healthier environment for present and future generations. This will require sustained efforts in education, community participation, and technology innovation.

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